TheSkyX Professional and Serious Astronomer Edition User Guide

Revision 2.9, February 2014

Disclaimer

Information in this document is subject to change without notice and does not represent a commitment on the part of Software Bisque. The software and/or databases described in this document are furnished under a license agreement or nondisclosure agreement. They may be used or copied only in accordance with the terms of the agreement (www.bisque.com/eula). It is against the law to copy the software on any medium except as specifically allowed in the license or nondisclosure agreement. The purchaser may make one copy of the software for backup purposes. No part of this manual and/or databases may be reproduced or transmitted in any form or by any means, electronic or mechanical, including (but not limited to) photocopying, recording, or information storage and retrieval systems, for any purpose other than the purchaser's personal use, without the express written permission of Software Bisque.

Charts created with *TheSkyX* are for personal use only. They may not be published in any form without express written permission of Software Bisque, Inc.

TheSkyX includes routines from Astronomical Algorithms Software, © 1991 by Jeffrey Sax, and option to the book Astronomical Algorithms by Jean Meeus copyright © 1991 by Willmann-Bell. ISBN 0-943376-35-2. Non-exclusive use has been specifically granted, in writing, by Willmann-Bell, for use in *TheSkyX*. Serial Number U11A445. Photographs in the AAO folder of *TheSkyX's* media are copyright Anglo-Australian Observatory (AAT images) and/or ROE/AATB (UK Schmidt Telescope images) and are reproduced with permission. Photographs from the Anglo Australian Observatory telescopes are by David Malin.

The photograph of the Milky Way is licensed from Digital Sky LLC.

TheSky, TheSkyX, TheSkyX Serious Astronomer Edition and *TheSkyX Professional Edition* are trademarks of Software Bisque, Inc.

Selected "in-place" photos are copyright Robert Gendler and are reproduced with permission. Winter Star Party panorama photographs courtesy Art Mullis.

Software Bisque acknowledges the usage of the HyperLeda database (http://leda.univ-lyon1.fr).

Mac and the Mac logo are trademarks of Apple Computer, Inc., registered in the U.S. and other countries.

All other product names are trademarks of their respective owners and are used solely for identification.

Portions of this document written by Andre Bormanis and Woodrow W. Grizzle III.

Table of Contents

Welcome to TheSkyX

Many of you have never seen the sky. Not really. If you live in a city or suburb, a pale blue or grey dome looms overhead while the Sun is up, and a darkish brown curtain hangs down at night, with maybe a few sparks of light poking through here and there if the clouds haven't gathered and the glare from buildings and cars and billboards isn't overwhelming. The Sun and the Moon are unmistakable of course, but the spattering of stars you glimpse are probably strangers to you. Some of them might even be planets – for most people, it's hard to tell the difference.

All of this is about to change. You have in your hands an extraordinary tool for revealing not just new worlds, but the entire universe. The night sky is an incredible wonderland of diverse and spectacular objects and phenomena. Some of these breathtaking sights are created by tiny particles that ply the fringes of our atmosphere. Others are immense, ancient structures, incomprehensibly far away.

TheSkyX Professional Edition or *TheSkyX Serious Astronomer Edition* will bring all of these amazing marvels and more to your desktop. It will help you learn the fundamentals of astronomy, the most ancient science, and teach you how to recognize just about everything in the real sky. Whether you're looking up from the streets of a light-polluted city, or taking in the view from a remote, pitch-black mountaintop, or controlling your distant observatory from Internet, *TheSkyX* will help you understand what you see and find what you're looking for.

You'll also enjoy experiences that are only possible through the magic of simulation and virtual-reality programming. Faster-than-light flights through the solar system, out-of-this-world views of the Earth and Moon, and the orbital tracks of hundreds of satellites are just some of the animations built into *TheSkyX*. Trips through space and time that were once possible only in the imagination will be vividly brought to life on your computer screen.

TheSkyX has something to offer everyone, from the absolute beginner to the most knowledgeable amateur astronomer. This User Guide will help you navigate the basic features and tools our unique program has to offer.

The sky is waiting for you. Let's get started!

Getting Started

TheSkyX Professional Edition and *Serious Astronomer Edition* (hereafter referred to simply as *TheSkyX*) are available for either Mac or Windows operating systems. Operating system specific versions are sold separately, so please make sure you have the right product for your computer before proceeding.

Throughout this document, *TheSkyX Professional Edition*-specific features are accompanied by the Professional Edition graphic below.

PROFESSIONAL

Updating Your Computer's Video Driver

If you use Windows, Software Bisque *strongly recommends* updating your computer's video display driver before installing and opening *TheSkyX*. *TheSkyX* takes advantage of software called *OpenGL* to show 2D and 3D planets, animations, and photos at video-quality frame rates. To enjoy *TheSkyX's* entire feature set, and for the best overall performance, make sure that your computer has OpenGL version 1.5 or later installed.

A utility application called *TheSkyX Compatibility Test* can be run on your computer to determine the OpenGL version. This app can be downloaded from TheSkyX Compatibility Test page on the Software Bisque web site.

The following window appears when *TheSkyX Compatibility Test* is run and your computer is not running OpenGL 1.5 or later:

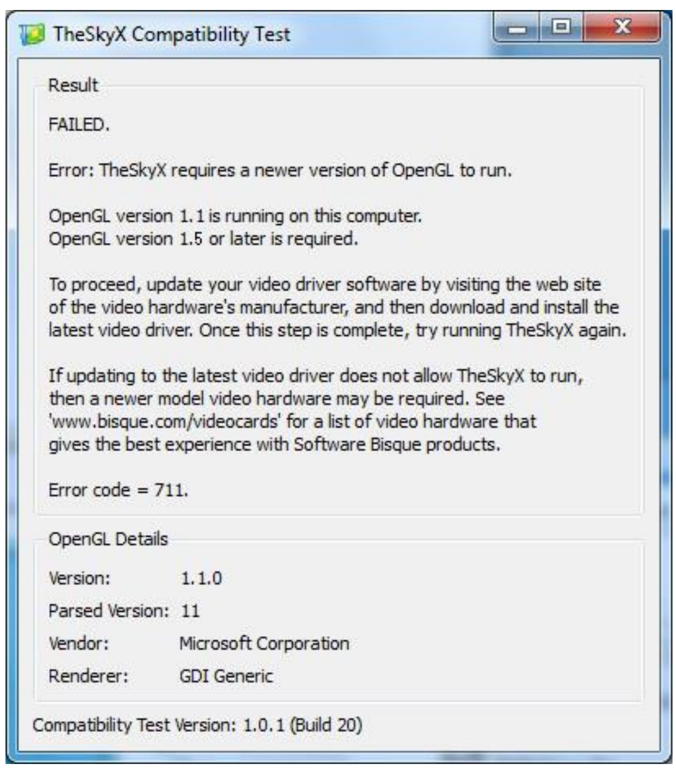


Figure 1: TheSkyX Compatibility Test window that appears when OpenGL version 1.5 or later is not present.

Installing Mac Video Drivers

The latest version of OpenGL is included with the OS X software updates. Click the ***Apple*** menu then click the ***Software Update*** command to make sure your Mac is up to date. That's it.

Windows 8, Windows 7, Windows Vista and Window XP Video Drivers

For 32- and 64-bit editions of Windows computers, the latest version of OpenGL is distributed as part of your computer's *video driver* (the video driver is software that communicates with the video display hardware).

In order to obtain the latest version of OpenGL, you must install the latest video driver directly from the original equipment manufacturer (OEM) of your computer's video display adaptor.

Notebook and Netbook computers integrate video hardware (from third-party video hardware manufacturers) directly on the computer's motherboard. For these systems, the computer's manufacturer distributes the video driver, not the video hardware manufacturer.

Most video driver software is updated frequently, so chances are you don't have the latest driver installed on your computer right now.

To Properly Update the Windows Video Driver and OpenGL

To properly update the Windows video driver and OpenGL, first determine the make and model of your computer's video display adaptor. Both are listed in the Windows *Device Manager* (see Windows Help for details about accessing the Device Manager from your version of the Windows operating system).

- ***Do not use Windows Update to try to obtain latest video driver***. Windows Update installs the video driver from Microsoft, not from the hardware or computer manufacturer.
- In general, ***do not use the video driver that is supplied by Microsoft Windows*** as it often does not include the latest version of OpenGL or the latest video driver for your video hardware.

Next, visit the Downloads page of the ***video driver manufacturer:***

- AMD (ATI)
- Intel
- NVIDIA
- S3 Graphics

Or the computer manufacturer's web page for Netbook and notebook computers. From there, download and install the latest video driver according to the manufacturer's instructions.

After installing the latest Windows video driver, you're ready to install and run *TheSkyX*.

Running TheSkyX without OpenGL

TheSkyX can be run on a computer that does not have, or cannot support OpenGL 1.5 or later. For example, video driver software that supports OpenGL 1.5 or later for older video hardware simply may not exist. Or, some remote control applications, such as Windows XP Pro's Remote Desktop, cannot run applications that use OpenGL graphics acceleration.

When *TheSkyX* is launched for the first time, it determines if a suitable version of OpenGL is installed, then configures the display mode accordingly. To manually configure *TheSkyX* to run without OpenGL, click the ***Preferences*** command from the ***Tools*** menu (Windows) or the ***Apple*** menu (Mac) to show the ***Preferences*** dialog. Select the ***No OpenGL*** option from the ***OpenGL Detection Mode*** list and then click ***Close***. Restart *TheSkyX* for this setting to take effect.

The following features will not be available when the ***No OpenGL*** option is selected:

- 3D Solar System (page 148)
- 3D Stars (page 134)
- Milky Way photo (page 160)
- Object symbol transparencies (page 192)
- Photographic panorama horizons (page 208)
- Planets rendered using 2D ellipses instead of 3D-like photographs
- Satellites From Above Earth (page 158)
- Solar and Lunar Eclipse Viewer (page 150)

Minimum System Requirements

Please review the minimum system requirements before installing *TheSkyX* on your computer.

Mac

TheSkyX Serious Astronomer Edition for Mac can run on any Mac desktop or laptop computer with OS X 10.4.8 or later with a 1.25 GHz or faster G4 PowerPC processor, or a 2 GHz or faster Core Duo processor. You also need at least 512 MB RAM, 64 MB video RAM, and 1.3 GB of free disk space, a mouse or other pointing device and a DVD ROM drive.

PROFESSIONAL

TheSkyX Professional Edition for Mac has the identical minimum requirements, except that a total of 2.5 GB of free disk space is required.

Windows

TheSkyX for Windows can run on any desktop or laptop computer running Windows 8, Windows 7, Windows Vista or Windows XP, 32- or 64-bit editions, with a 1.5 GHz or faster Intel

Pentium 4, Pentium M, Pentium D, or AMD K-8 (Athlon) or better processor. You also need at least 512 MB RAM, 64 MB video RAM, and 1.3 GB of free disk space, a mouse or other pointing device and a DVD ROM drive.

PROFESSIONAL

TheSkyX Professional Edition for Windows has the same minimum requirements, except that a total of 2.5 GB of free disk space is required.

Installing TheSkyX

TheSkyX is distributed either on DVD-ROM or by downloading the full installer from the Software Bisque web site.

If you have purchased *TheSkyX* from the Software Bisque Store and want more information about how to download the full installer, see “How Do I Download My Software?” on this page:

http://www.bisque.com/sc/pages/Download-Links-and-Serial-Number.aspx#Download

Macintosh

Like all Macintosh software, *TheSkyX* is easy to install.

- If you received *TheSkyX* on disk, insert the DVD in the DVD-ROM drive. *TheSkyX DVD* icon appears on your desktop once the media is recognized. Double click it to view the contents of the disk. To copy *TheSkyX* to your computer, drag and drop *TheSkyX* application icon to the ***Applications*** folder.
- If you downloaded the full installer from the Software Bisque web site, double-click the *TheSkyX [Serious or Pro] for Mac Full Installer* disk image to view its contents (Mac OS X may perform this step automatically). To copy *TheSkyX* to your computer, drag and drop *TheSkyX* application icon to the ***Applications*** folder.

To start *TheSkyX*, click ***Go > Applications*** from Finder (⇧⌘U), then double-click on *TheSkyX* (Serious Astronomer Edition or Professional Edition) icon.

Windows 8

To install *TheSkyX* under Windows 8 from the DVD-ROM:

1. Insert the DVD-ROM in the DVD-ROM drive.
2. From the ***Start*** window, right-click on a non-tiled region, then click the ***All Apps*** icon in the lower right corner of the window (Figure 2).

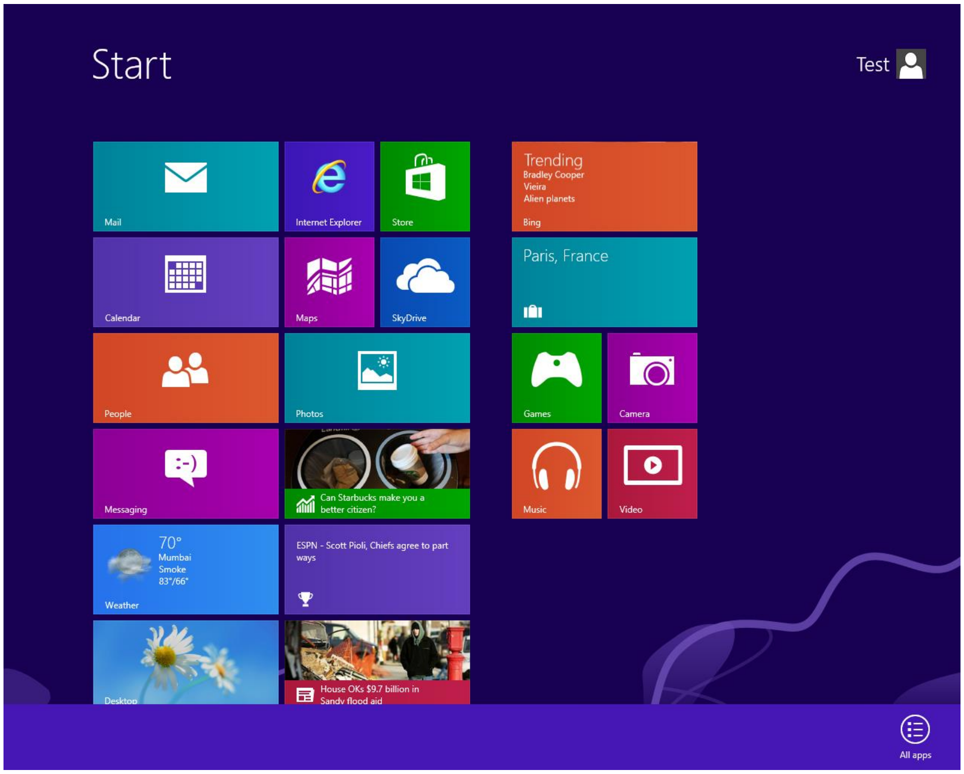


Figure 2: Windows 8 Start screen showing the All Apps icon in the lower right corner.

3. On the ***Apps*** window, click the ***Computer*** icon under the ***Windows System*** column on the right side of the screen.
4. On the ***Computer*** window, double-click ***TheSkyX DVD*** icon to view its contents.
5. Double-click the ***setup*** application icon to begin the installation. If you are signed into an account that does not have administrative privileges, you will need to enter an administrator's password to complete the installation.
6. Follow each step of the Setup Wizard to complete the installation.

Windows 7 or Windows Vista

To install *TheSkyX* under Windows 7 or Windows Vista from the DVD-ROM:

1. Insert the DVD in the DVD-ROM drive.
2. Click ***Start > Computer***.
3. On the ***Computer*** window, select the removable storage device that holds *TheSkyX* media, and then click the ***AutoPlay*** button (it's located in the tool bar near the top of this window).

Figure 3: TheSkyX's AutoPlay window.

4. Click the ***Install*** button to begin the installation process.
5. Follow the on-screen instructions to complete the installation.

Windows XP

To install *TheSkyX* under Windows XP from the DVD-ROM:

1. Log on as an administrator. *TheSkyX* requires administrative privileges to be installed under XP.
2. Insert the DVD-ROM in the DVD-ROM drive and wait for the ReadMe file to appear in a browser window. If XP's AutoPlay is not active, then click ***Start > My Computer***, right-click on the removable storage device that holds *TheSkyX* media and then click ***Open***. Next, double-click the file named ***AutoPlay*** on *TheSkyX* media to proceed.
3. Click the ***Install*** button to begin the installation process (Figure 3).
4. Follow the on-screen instructions to complete the installation.

Or, you can double-click *setup.exe* on the distribution media to start the installation process.

Starting TheSkyX on Windows

Windows 8

To start *TheSkyX* on Windows 8, click its icon on the ***Start*** window. (Click the Windows accelerator key to show the Start window).

Windows 7 and Earlier

To run *TheSkyX* on earlier Windows operating systems, click ***Start > All Programs > Software Bisque > TheSkyX [Edition Name] > TheSkyX [Edition Name]***.

TheSkyX Default Installation Folder

TheSkyX Professional Edition and *TheSkyX Serious Astronomer Edition* are installed, by default, into different locations, depending on the operating system.

Mac

By default, *TheSkyX* is installed to the computer's Applications folder on Mac OS X. From Finder, choose the ***Applications*** command from the ***Go*** menu to view the applications that are installed on your computer (⇧⌘A).

Windows

The three most commonly used Windows operating systems are Windows 7, Windows Vista and Windows XP. *TheSkyX's* default installation location varies slightly between 32- and 64-bit Editions of Windows.

Windows 8, Windows 7 and Windows Vista 32-bit Application Support Files Folder Example

The default folder for TheSkyX Professional Edition's application support files on Windows 7 and Windows Vista 32-bit Editions is:

C:\Program Files\Software Bisque\TheSkyX Professional Edition

The default folder for TheSkyX Serious Astronomer Edition's application support files on Windows 7 and Windows Vista is:

C:\Program Files\Software Bisque\TheSkyX Serious Astronomer Edition

For 32-bit Editions of Windows, you can determine the computer's *Program Files* folder from a Command Prompt by typing the bold letters below:

C:\echo %PROGRAMFILES% <Enter Key>

The default folder is: `C:\Program Files`

Windows 8, Windows 7 and Windows Vista 64-bit Application Support Files Folder Example

The default folder for TheSkyX Professional Edition's application support files on Windows 7 and Windows Vista 64-bit Editions is:

C:\Program Files (x86)\Software Bisque\TheSkyX Professional Edition

The default folder for *TheSkyX Serious Astronomer Edition*'s application support files on Windows 8, Windows 7 and Windows Vista is:

C:\Program Files (x86)\Software Bisque\TheSkyX Serious Astronomer Edition

Note that under 64-bit Editions of Windows, 32-bit applications are installed to the *Program Files (x86)* folder instead of the *Program Files* folder.

On 64-bit Editions of Windows, you can determine the computer's *Program Files* folder for 32-bit applications from a Command Prompt by typing the bold letters below:

C:\echo %PROGRAMFILES(x86)% <Enter Key>

The default folder is: `C:\Program Files (x86)`

Removing TheSkyX

If you wish to remove or uninstall *TheSkyX* from your computer please follow the procedure outlined below.

Macintosh

1. From Finder, click ***Go > Applications*** to open the ***Applications*** folder.
2. Drop *TheSkyX Professional Edition* or *TheSkyX Serious Astronomer Edition* application to the trash. Note that you must empty the trash before re-installing. The files you create with *TheSkyX* are saved to the *Application Support* folder. See "Application Support Files" on page 24 for details.

Windows

1. Log on as an administrator.
2. Click Start > Control Panel > Uninstall a Program (or double-click the Add/Remove Programs from XP).
3. Select ***TheSkyX Professional Edition*** or ***TheSkyX Serious Astronomer Edition*** from the list of installed programs, and click the ***Uninstall*** button (or click the ***Remove*** button under Windows XP).

Name and Serial Number Registration

The first time *TheSkyX* is launched, you'll be prompted to enter your name and serial number.

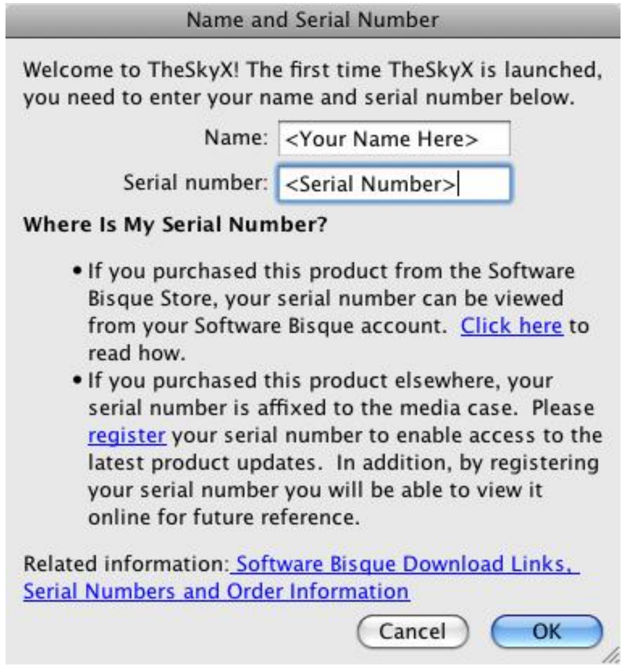


Figure 4: The Serial Number dialog.

If you purchased *TheSkyX* from the Software Bisque store, your serial number has already been registered, and is included as part of your web order information. To access your registered serial number from your Software Bisque account, sign in to www.bisque.com, then click your ***Sign In*** name on the upper right side of the page. On your account profile page, click the ***Subscriptions*** link on the left side of the page (below your account's avatar).

If you did not purchase the product directly from Software Bisque, your serial number is located on the outside of the media case. We urge you to register your software at www.bisque.com/register. After you register your serial number, you will be able to download the full product installer and latest update.

We also recommend that you keep a copy of your serial number for your permanent records. Your registered serial number serves as one form of proof of purchase for future updates, and you'll need it if you ever have to reinstall *TheSkyX*.

Small Computer Screens

When *TheSkyX* is opened on a Netbook computer or a laptop with a small screen, it automatically configures settings to maximize screen real estate.

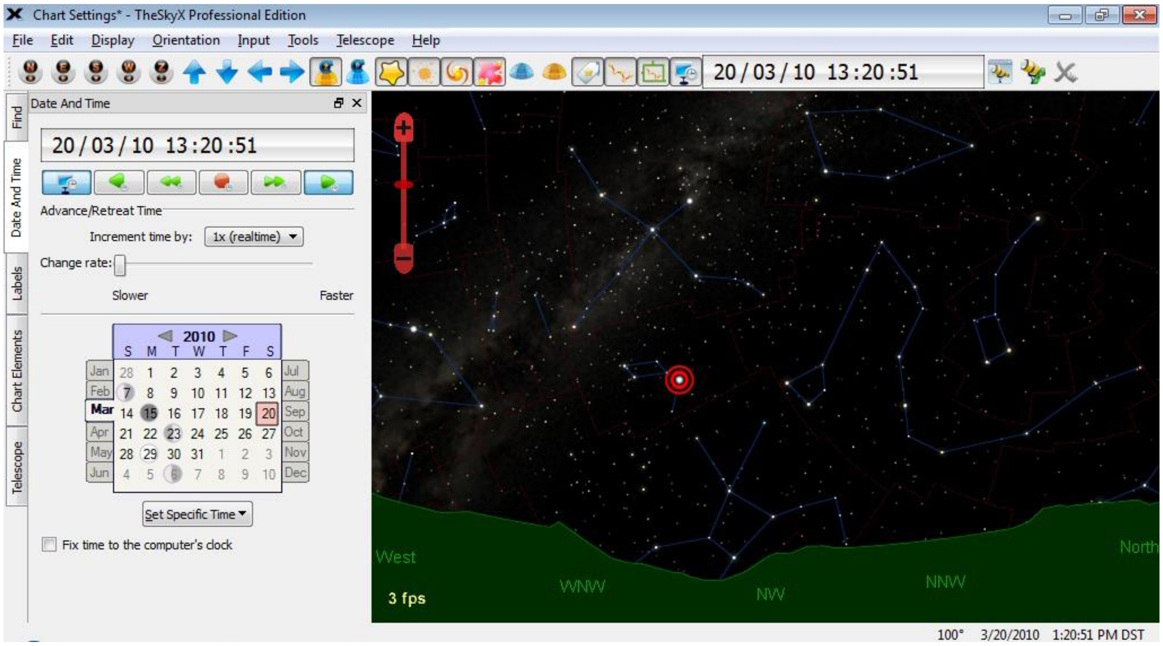


Figure 5: TheSkyX's window optimized for a 1024 x 600 Netbook computer.

The following reminder message is displayed.

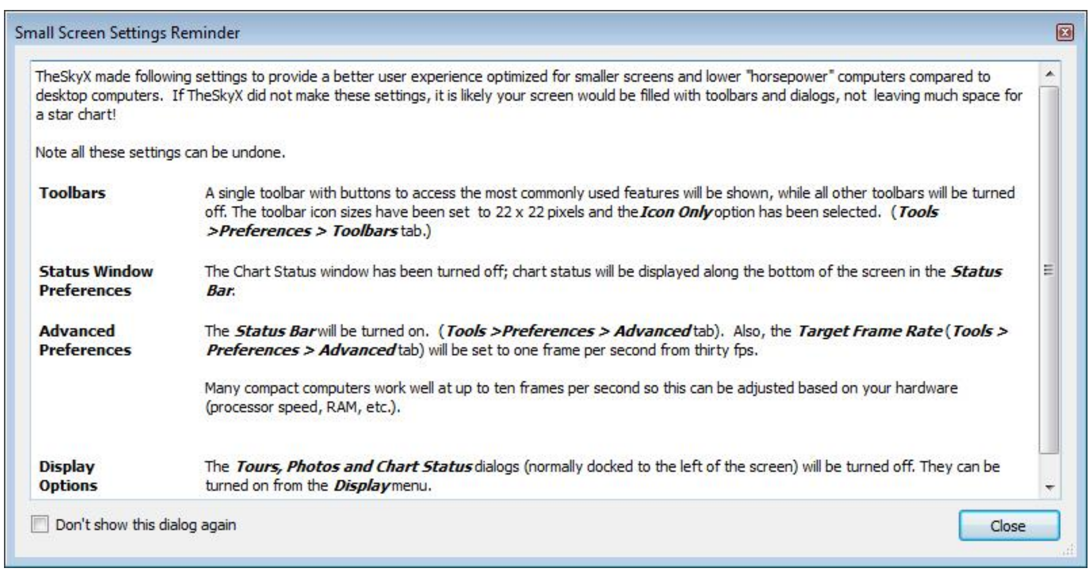


Figure 6: The Small Screen Settings Reminder window.

Turn on the ***Don't Show this Dialog Again*** checkbox to prevent this window from appearing in the future.

Follow the instructions on the ***Small Screen Settings Reminder*** window to restore TheSkyX's settings for higher resolution displays.

Minimizing CPU Usage

TheSkyX computes and displays the positions of astronomical objects (stars, satellites, comets, and so on) in "real time." You may wish to minimize the resulting computational load on the CPU when using an older model computer with a slower processor, or when running a battery powered laptop.

Use the Sleep command to temporarily suspend *TheSkyX's* computations and use zero percent of the CPU.

Application Support Files

When *TheSkyX* is launched for the first time, a *user account-specific* folder, called *TheSkyX's Application Support Files Folder*, is created to save and restore settings. Settings include:

- The serial number(s) you entered for *TheSkyX* and optional Add Ons
- Location, date and time settings
- Sky Chart preferences
- Positions of windows and dialogs
- Tool bar positions and configuration
- Field of view indicator databases
- Custom field of view indicators
- Custom panoramic horizon photos and custom drawn horizons
- Configuration of the telescope and other equipment
- Tour files
- *TPoint Add On* settings, pointing samples and models
- Any other *TheSkyX-related* files that you create and save in this folder or its sub folders

Each time *TheSkyX* is started, the settings from the previous session are automatically restored.

The Application Support Files Folder is named either *TheSkyX Professional Edition* or *TheSkyX Serious Astronomer Edition*, depending on the Edition that was installed. The exact location of this folder depends on the operating system, as described below.

Mac Application Support Files Folder

TheSkyX's application support files are located in the *Library/Application Support/Software Bisque* folder in your account's home directory.

Notes:

- Mac OS X version 10.7 (Lion) does not reveal the Library folder by default. To open this folder, from ***Finder***, press and hold the ***Option*** key, then choose the ***Library*** command in the ***Go*** menu (toggling the ***Option*** key shows and hides the ***Library*** command).

- *TheSkyX's* support files and folders will remain in your home folder until they are sent to the trash. If you ever remove *TheSkyX* from your Mac (page 21), you will want to remove these files and folders, too.

Windows Application Support Files Folder

TheSkyX's application support files and folders are located in the *Software Bisque* folder of the *Documents* (Windows 8, Windows 7 and Windows Vista) or the *My Documents* folder (Windows XP).

Windows 8, Windows 7 and Windows Vista

To navigate to the ***Documents*** folder on Windows 7 or Windows Vista, click the ***Start*** graphic and then click the ***Documents*** command in the Start menu.

Windows Explorer opens the Documents folder. Double-click the folder named ***Software Bisque***, then either ***TheSkyX Professional Edition*** or ***TheSkyX Serious Astronomer Edition*** folder to view *TheSkyX's* application support files and folders.

Windows XP

To navigate to the ***My Documents*** folder on Windows XP, click the ***Start*** graphic and then click the ***My Documents*** command in the Start menu.

Windows Explorer opens the My Documents folder. Double-click the folder named ***Software Bisque***, then either ***TheSkyX Professional Edition*** or ***TheSkyX Serious Astronomer Edition*** folder to view *TheSkyX's* application support files and folders.

The application support files and folders will remain in your *Documents* folder until you delete them. *TheSkyX's* uninstaller (page 21) *will not delete files or folders from your Documents folder*.

Restoring Default Settings

TheSkyX has a broad-ranging set of features with literally hundreds of options. If you are ever overwhelmed and wish to restore *every* setting and *every* option to the "factory defaults," do the following:

1. Exit TheSkyX.
2. Rename *TheSkyX's* Application Support Files folder. Renaming this folder, rather than deleting it, creates a backup of existing settings files, just in case you want to restore a particular setting from a particular file later. See "Application Support Files Directory Structure and Files" on page 26 for a list of, and explanation for, each folder and file, and how it is used by *TheSkyX*.
3. Launch *TheSkyX*. You'll need to enter your serial number, just like the first time *TheSkyX* was launched.

Note that restoring the default settings is essentially the same as uninstalling *TheSkyX,* deleting the Application Support Files folder and then reinstalling. Remember, there's almost never a compelling reason to uninstall *TheSkyX*, unless you want to permanently remove it from the computer.

Backing Up or Copying Settings

To backup all your *TheSkyX* settings, copy entire application support files folder, including files and sub-folders to your backup drive. You can also "replicate" *TheSkyX's* settings on multiple accounts or on another computer by copying the application support files folder and all the sub-folders to the appropriate folder on the second machine. (See "Mac Application Support Files Folder" on page 24 or Windows Application Support Files Folder on page 25 for details about the location of these files and folders).

Application Support Files Directory Structure and Files

The table below describes each file and folder in *TheSkyX's* application support files folder

Folder Name	**Files**	**Description**
TheSkyX Professional Edition or *TheSkyX Serious Astronomer Edition*		This root folder stores all the files and folders for *TheSkyX's* settings.
	AppSettings.ini	This text file stores *TheSkyX's* application wide settings, including the product's serial number.
	ImagingSystem.ini	This text file stores the configuration settings related to telescopes, cameras, focusers, filter wheels, and domes.
	LastDocument.ini	This text file stores the name and location of the last Chart Settings file that was opened.
	Locations.txt	This text file stores the database of locations that are displayed in the ***List of Locations*** tab of the ***Location*** window (page 33).

Folder Name	**Files**	**Description**
	LogFileOpen.txt	This text file is a log of every file that TheSkyX opens or accesses when it is run. It can be a useful diagnostic tool for troubleshooting.
	LogVerifyFileResources.txt	This text file is a log of *TheSkyX*-related resources that are opened. It can be a useful diagnostic tool for "debugging" purposes.
	OutputSplash.txt	This text file logs critical initialization points that can help diagnose startup problems.
	SDBState.inf	This binary file saves stores which Sky Database is presently turned on.
	TheSkyXInstallPath.txt	This text file stores the location or full path of TheSkyX on the computer. It is used by *TheSkyX's* Daily Build installer.
	WindowPositions.ini	This text file stores the size, position and orientation of *TheSkyX's* main window, toolbar windows and dialogs.
Asteroids		This folder is the default location for saving asteroid orbital element text files that are downloaded from the web.
Astrometry		This folder is the default location for saving photo-specific files related to astrometric solutions.
AutoCalibration		This folder is the default location for saving files related automated pointing calibration runs.
Comets		This folder is the default location for

Folder Name	Files	Description
		saving comet orbital element text files that are downloaded from the web.
Database Queries		This folder is the default location for saving supplied and custom database query files. These files end with the extension *.dbq*.
Documents		This folder is the default location for saving Chart Settings. These files end with the extension *.skyx*.
Exported Data		This folder is the default location for saving exported Sky Charts.
Field of View Indicators		This folder stores files related to Field of View Indicators.
	Detector geometry.txt	This text file contains the database of cameras (or "detectors") that is displayed in the ***Detectors*** branch of the ***Equipment Database*** tree list on the ***Equipment*** tab of the ***Field of View Indicators*** window (page 93).
	Eyepieces.txt	This text file contains the database of eyepieces that is displayed in the ***Eyepieces*** branch of the ***Equipment Database*** tree list on the ***Equipment*** tab of the ***Field of View Indicators*** window (page 93).
	My equipment.txt	This text file contains a list of the equipment added to the ***My Equipment*** list on the ***Field of View Indicators*** window (page 93).
	Telescopes.txt	This text file contains the database of telescopes that is displayed in the ***Telescopes*** branch of the ***Equipment Database*** tree list on the ***Equipment***

Folder Name	Files	Description
		tab of the ***Field of View Indicators*** window (page 93).
Horizons		This folder stores custom panoramic horizon photographs and related files.
Movies		This folder is the default location to save movies generated in the Create Tour window.
Observer Log		This folder holds XML-based observing logs generated by the ***Add or Edit Observation*** button (page 65).
Observing Lists		This folder stores custom observing lists that are generated from the Manage Observing List command.
Orchestrate		This folder stores Orchestrate-related files.
Pocket Edition Files		This folder stores TheSky Pocket Edition-related files (this feature is not currently supported).
Satellites		This folder is the default location for saving satellite data (TLEs) downloaded from the web (page 155).
SDBs		This folder is the default location for custom Sky Databases.
Source Extraction		This folder holds the Source Extraction configuration files.
Star Chart GIFs		This folder is the default location for saving exported Sky Charts in GIF format.

Folder Name	Files	Description
SVG		This folder is the default location for saving scalable vector graphics (*.svg*) files that can be applied to Chart Elements.
Tours		This folder is the default location for saving custom tours that are generated by the ***Create Tour*** command (page 70).
TPoint		This folder is the default location for saving TPoint data. These files end with the extension *.tptx*. Click the ***TPoint Add On User Guide*** command from the ***Help*** menu for details about using TPoint improve the telescope's pointing.

About This Documentation

We'll discuss customizing *TheSkyX* for your geographic location in a moment…

The purpose of the User Guide is to familiarize you with the basic organization and structure of our program, and to introduce those of you who are new to the subject of astronomy to some of its most important terms and concepts. We also hope the Guide will stimulate you to become more interested in astronomy and space science, and excited to start learning about the extraordinary universe we live in.

We urge you join the Software Bisque support community at www.bisque.com/support. If you have questions, our support staff and other knowledgeable astronomers will try to help.

Having a Look Around

The star chart display is the heart and soul of *TheSkyX*. We call it the *Sky Chart*, to distinguish it from the real thing. To the left of the Sky Chart you'll find a series of stacked windows with vertical tabs to access the most commonly used commands and options. You can show or hide stacked windows from the ***Display*** menu.

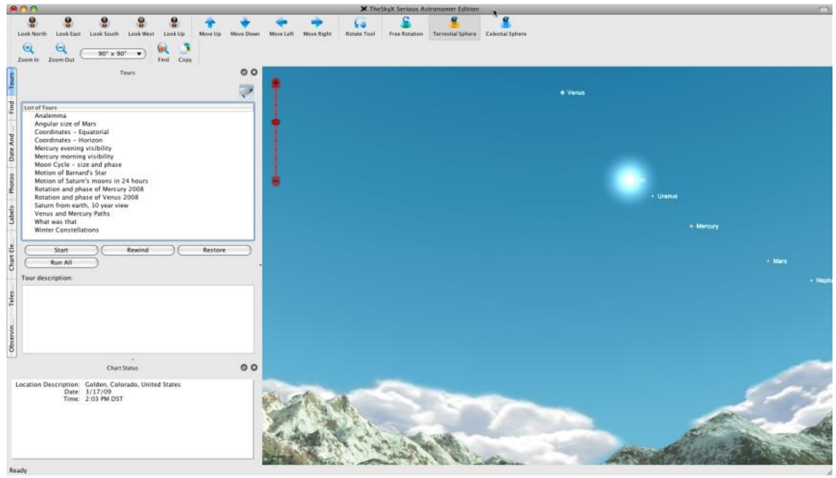


Figure 7: *TheSkyX’s* default screen showing the Sky Chart in Daylight mode, with stacked tool windows on the left and toolbars on the top.

Figure 8: The toolbars (click and drag the checkered “gripper” on the left side of each toolbar to move it).

When *TheSkyX* is first launched, it attempts to automatically set your location using the web; the date and time are read from your computer’s clock.

You’ll also notice that if you are using *TheSkyX* during daytime, the sky it displays is blue (just like the actual sky). In a moment we’ll describe how to change that to a night view even during the day.

To help you get started and more easily identify commands, the toolbar buttons are configured with large icons and text description.

The software authors understand that showing both a graphic and text consumes valuable real estate on notebooks, smaller computer screens, or when operating *TheSkyX* from a remote computer. To reduce the size of the toolbar buttons, click the ***Preferences*** command from the Tools menu (***TheSkyX*** menu on the Mac), then click the Toolbars icon. In the ***Appearance*** pop-up, select ***Icon Only***; in the ***Size*** pop-up, select ***Small*** and then click ***Close***. See “*Customizing Toolbars*” on page 164 for more information.

Right now, let’s make sure that the program is set to display the Sky Chart from your location.

Entering Your Location

Home is where you hang your hat, and also where most of you probably view the sky. The first time *TheSkyX* is launched, your computer’s IP address is used to place your location on Earth, typically within a few miles, which is close enough for most astronomy work.

If you know the precise longitude of your location, you can enter it, or choose the name of the city you live in, or the one closest to you, from the list in the ***Location*** window.

1. Highlight the ***Input*** item in the main menu.
2. Select the first command, ***Location***.

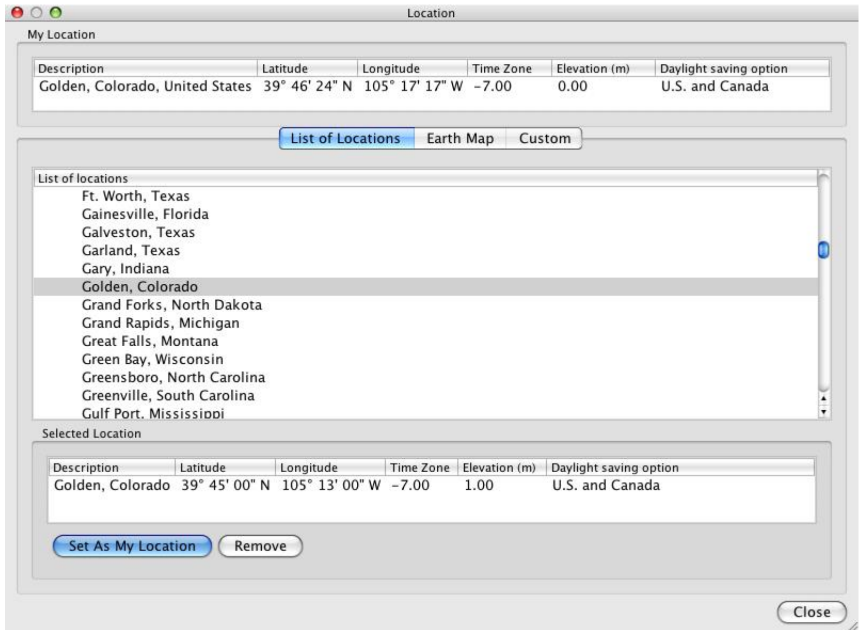


Figure 9: Location window, List of Locations tab.

A window appears displaying options for setting your location. From the ***List of Locations*** tab, if you live in the U.S., *double-click* on United States. A list of the major cities within your country appears. You can choose your city, or the one closest to where you live, by double-clicking on it.

The Location on Earth used by TheSkyX (My Location)

The ***My Location*** table shows your location on Earth as defined by its longitude, latitude, time zone, elevation and Daylight Saving Option.

Location Description (Description)

The location ***Description*** is for reference purposes only. Double-click the description to change it.

Time Zone Offset (Time Zone)

The time zone of a location on Earth is the difference between Universal Time (UT) and local time, in hours. For most locations, this equals your longitude divided by 15 degrees. Regional variations can cause the time zone to differ by plus or minus one hour.

Daylight Saving Option (DSO)

TheSkyX can be configured to automatically “spring forward” when Daylight Saving Time begins, then “fall back” when it ends. Select the DSO for your region.

See “Appendix C: Daylight Saving Time” on page 533 to see the starting and ending dates for each option.

Location Database (List of Locations)

TheSkyX includes a large database of pre-defined locations that can be used to get you “close enough” to your home location.

When a location is highlighted in the list, the ***Selected Location*** table shows the details for this location.

Select a location from the list, then click the ***Set As My Location*** button, or double-click on the location name to use it as your location.

Click the ***Remove*** button to remove the selected location.

Your location settings are saved when you click the ***Close*** button, and will be used the next time *TheSkyX* is started.

Custom Location

Alternatively, you can enter your latitude and longitude or U.S. zip code from the Custom tab.

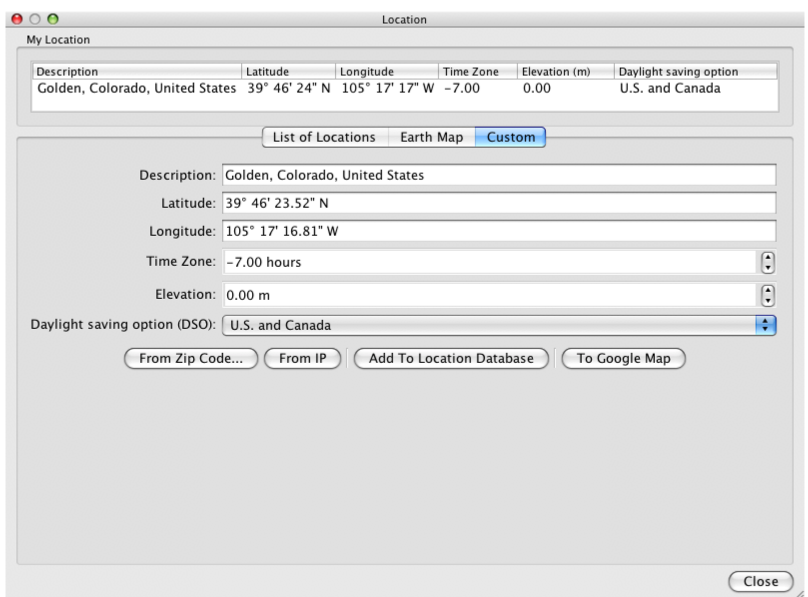


Figure 10: The Custom location tab (Input > Location).

Location from Zip Code (From Zip Code button)

Residents of the U.S. can enter a zip code to retrieve their location information.

Location from Computer's Internet Protocol (From IP button)

If your computer is connected to the Internet, you can obtain reasonably accurate location data using your computer's IP address.

Adding Custom Locations to TheSkyX's Location List (Add to Location Database button)

After manually entering your location details, click this button to permanently save them in *TheSkyX's* Locations List.

Using Google™ Maps (To Google Map button)

Compare your coordinates to a Google map to make sure they're accurate. Or, use the Google map to refine your location. Clicking the ***To Google Map*** button launches a browser and shows this location on a Google Map.

To refine the coordinates, adjust the map accordingly, right-click (⌘+left-click on the Mac) on the map, or click the Satellite button to show the satellite photo of your observatory, for example, then click the Directions To command to show the precise latitude and longitude, in decimal format, of this point in the Driving Directions.

Highlight the latitude (the first coordinate that is shown), then select the Copy command from the Edit menu. From *TheSkyX*, right-click (⌘+left-click on the Mac) and select the Paste command. Repeat this procedure for longitude.

When you're done, click the ***To Google Map*** button again to make sure the values you entered are correct. The coordinates of pointer on the map that appears should match your observing site.

Always double-check to make sure your location is correct before proceeding!

Errors entering your longitude, latitude and time zone will result in charts that do not match what you see in the nighttime (or daytime) sky.

A good way to verify all's well is to click the ***To Google Map*** button. It will should show you a map that is near your observing site.

Earth Map

Yet another way to find home is to use the ***Location*** window's ***Earth Map*** tab.

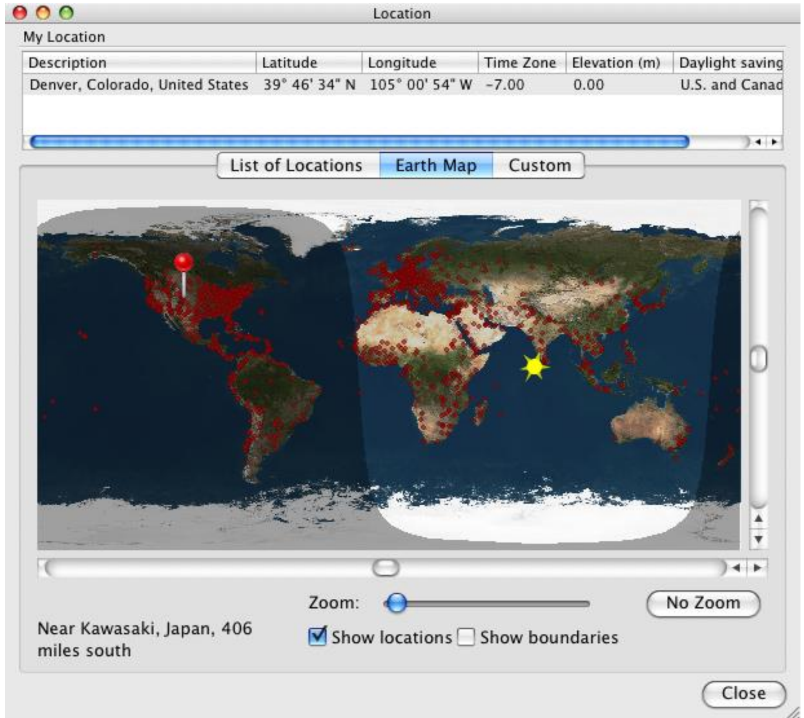


Figure 11: The Earth Map tab (Input > Location window).

The default view shows a map of the entire Earth with a red stick pin at the current location. Use the ***Zoom*** slider to change the magnification, and the scroll bars, or left drag on the map, to center the desired region. Turn on the ***Show Locations*** checkbox to overlay *TheSkyX's* ***List of Locations*** on the map, indicated by a small red dot. The location descriptions will also appear at higher magnifications. The ***Show Boundaries*** option shows you the approximate country and U.S. state boundaries. Double-click on the map to choose the location beneath the mouse cursor.

The Basics

What follows is an introductory section, which describes the basic functions of *TheSkyX*, and will help you to quickly get started exploring the marvels of the sky. Included in this section are instructions for zoom, scroll, and pan controls, as well as display options, returning to home position, and moving/adjusting the toolbars and "dockable" windows.

Zoom Control

There are a number of ways to zoom in and out in the Sky Chart. You can use the ***zoom in/zoom out*** buttons on the toolbar, the ***zoom box***, or by using ***Orientation*** menu controls.

Zoom Buttons

To zoom in on objects in the Sky Chart, simply click the ***zoom in*** button in the toolbar. This will reduce your field of view, and increase the angular size of the scene (called the *field of view* or *field width*).

To zoom out, simply click the toolbar's ***zoom out*** button. This will increase the Sky Chart's field of view, giving you a wider field of view.

Zoom Menu Controls

Alternatively, you can zoom in or out using menu commands. Under the ***Orientation*** menu, you will find controls to zoom in and out.

Sky Chart Zoom Tool

On the left side of the Sky Chart window, you will find a red ***zoom tool***. This tool makes it easy to zoom in and out with a simple click and drag. Just click the zoom tool's slider bar, and by dragging it up or down, you will zoom either in (up) or out (down). Or, click the ***+/–*** symbols to zoom out or in.

To show or hide the zoom tool, click the ***Zoom Tool*** command from the ***Tools*** menu.

Figure 12: The Zoom Tool on the Sky Chart.

Zooming with Scroll Wheel Mouse

If you are using a mouse with a scroll wheel feature, you can zoom in or out by simply rolling the wheel forward for zoom in, and backward for zooming out. This feature is great for quick, convenient zooming.

Zoom Box

Using the zoom box is another easy way to zoom in on objects in *TheSkyX*. Choose a portion of the Sky Chart into which you would like to zoom. Hold down the ***SHIFT key*** (the cursor changes to the pointing finger) while clicking in one corner of the chosen portion, and drag the mouse to the opposite corner. Release the mouse button, and the box's caption says, "***Click inside to zoom, outside to cancel***."

Notice that the box's diagonal dimensions appear above it in degrees, minutes and seconds of arc. Click anywhere inside the box to ***zoom in***, filling the Sky Chart's field of view with the dimensions of the ***zoom box***.

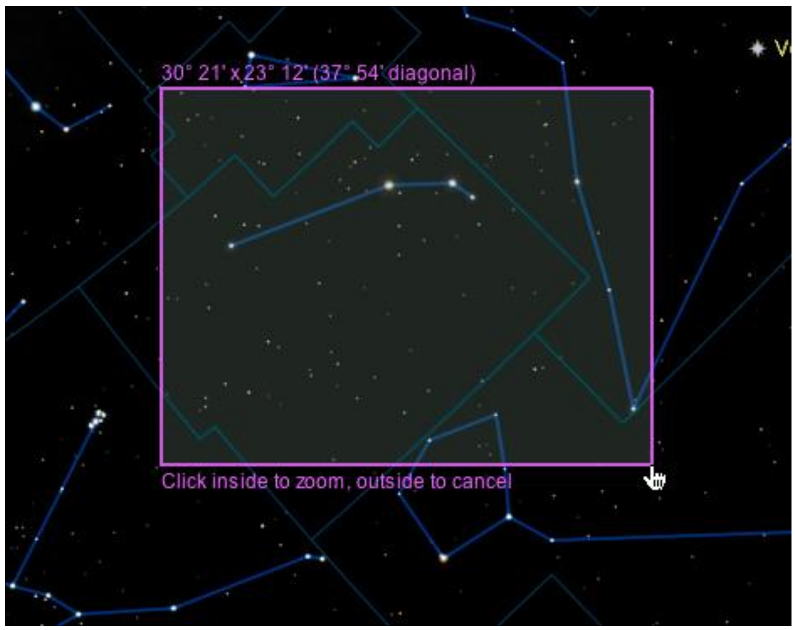


Figure 13: A zoom box on the Sky Chart (SHIFT+drag).

Returning to Naked-Eye View

Regardless of how you zoom, you can always return to the naked-eye field of view by either zooming out manually, or by selecting ***Orientation > Zoom To > Naked Eye 100°***.

Scrolling and Panning Control

Scrolling or panning the Sky Chart's "camera" will allow you to look at the universe in any desired direction, giving you that perfect view.

Toolbar Controls

The toolbar features four easy to use buttons for camera scrolling and panning. By locating and clicking any of the ***four blue arrow buttons*** (***Move Up***, ***Move Down***, ***Move Left***, ***Move Right***), you can move to camera to look up, down, left, or right. Also, to look specifically in the four cardinal directions or at the zenith (straight up), locate and click the "***look***" buttons (***Look***

North, for example). Clicking any of these buttons will orient the Sky Chart in the corresponding direction.

Figure 14: The cardinal direction and move up, down, left and right buttons.

Clicking and Dragging

Alternatively, you can adjust the field of view by ***left-clicking*** your mouse anywhere in the Sky Chart and dragging the view.

Chart Navigation

The navigate command lets you explore the digital sky through a celestial sphere map (showing the constellations and their boundaries), by entering specific coordinates, or by selecting a specific position angle.

Using the Navigate Command

To access the Navigate command, select ***Orientation > Navigate***. Three tabs at the top of the window indicate the navigator choices: ***Celestial Sphere***, ***Sky Chart Center***, and ***Rotation***.

Celestial Sphere

This tool lets you select a region of the sky from a model of the Celestial Sphere, in Mercator projection, and with celestial north at the top. The brightest stars (in correct colors) and the constellation borders appear in this map.

If the chart looks too small at first, simply click and drag the window's lower right corner to resize it. After you close the window or quit the application, *TheSkyX* will remember the window size and position each time you open it.

As you mouse over the map, notice that both the equatorial and altitude-azimuth coordinates of your pointer's current position appear at the bottom of the window. The constellation associated with your pointer's position also appears.

Click on any location to center it on the Sky Chart.

By default, *TheSkyX* attempts to pin the local horizon near the bottom of the screen. If the "clicked on" position happens to be below the horizon, the Sky Chart moves to the closest visible point. Turn on the ***Allow Sky Chart to be Scrolled Below the Horizon*** option on the Horizon tab on the ***Display > Horizon & Atmosphere Options*** window to allow regions below the local horizon to be accessible.

To see more of the map, click and drag at any point to scroll. Because it represents a sphere, the map is a continuous loop.

You can remove the horizon picture altogether by deselecting the ***Show Horizon*** checkbox. Click ***Close*** to return to the Sky Chart. You will notice that you can now scroll below the horizon either manually or with the ***Celestial Sphere*** navigator.

When finished with the Navigate window, click ***Close*** to return to the Sky Chart.

Sky Chart Center

Select the ***Sky Chart Center*** tab to enter specific coordinates in either equatorial (RA/Dec) or horizon coordinate (Az/Alt) systems.

To enter coordinates, click on the desired field and directly enter the values into it. For convenience, you can simply enter three numbers separated by spaces. For example, enter ***10, 30, 29*** into the ***RA*** field to specify right ascension of 10h 30m 29s.

Because equatorial coordinate systems are based upon the orientation of Earth's axis, their accuracy diminishes over time due to, among other factors, precession. For that reason, many publications reference equatorial coordinates at a specific point in time known as an *equinox*. If you are using RA/Dec coordinates, it is important to choose the correct equinox (either ***2000.0*** or ***1950.0***). The 1950.0 equinox setting can be useful, as many older publications list equatorial coordinates according to the 1950.0 equinox.

Click ***Center on RA/Dec*** (for equatorial coordinates) or ***Center on Az/Alt*** (for horizon coordinates) to center the Sky Chart on the selected coordinates.

Click the ***Get Sky Chart Center Coordinates*** button to display the current coordinates of the Sky Chart's center in the above coordinate fields.

For your reference, example input for each of the coordinate systems appears near the bottom of the window.

Click ***Close*** to return to the Sky Chart.

See "Slewing to a Specific Coordinate" on page 299 for details about slewing a telescope using the Navigate commands.

Rotation

The Sky Chart can be rotated to position angle you wish. This parameter is called a *position angle*, and it helps to match the Sky Chart to the real sky and to any paper charts you may use while observing or planning an observation session.

Click the ***Rotation*** tab to view and adjust the Sky Chart's position angle. You will immediately see a graduated circle with a ***brown indicator*** showing the Sky Chart's current position angle. Click and drag this indicator to adjust the position angle to whatever you wish in real-time.

Near the bottom of the window, you will see the Sky Chart's current position angle. You can also enter a specific position angle into the field at the bottom of the window (to hundredths of a degree of accuracy). Use the up and down arrows here for an easy way to adjust the position angle in whole-degree increments. For example, if you enter 42.78°, clicking the up arrow once will increase the value to 43.78°.

Once you have entered a position angle, click ***Set*** to update the Sky Chart.

Click ***Close*** to return to the Sky Chart.

Note: The horizon disappears when you adjust the position angle. Changing the position angle is equivalent to changing the direction of "down" in relation to the horizon, so the horizon as a reference becomes irrelevant. ***TheSkyX*** removes it to avoid confusion.

Mirror Image

Refractors and catadioptric telescopes used with star diagonals produce mirror images of the sky because they have an odd number of image reflections. Selecting ***Display > Show Mirror Image*** flips the Sky Chart to "reflect" the view through a refractor or catadioptric telescope with star diagonal.

Right Clicking the Sky Chart

Commonly used commands can be accessed by right-clicking the mouse on the Sky Chart.

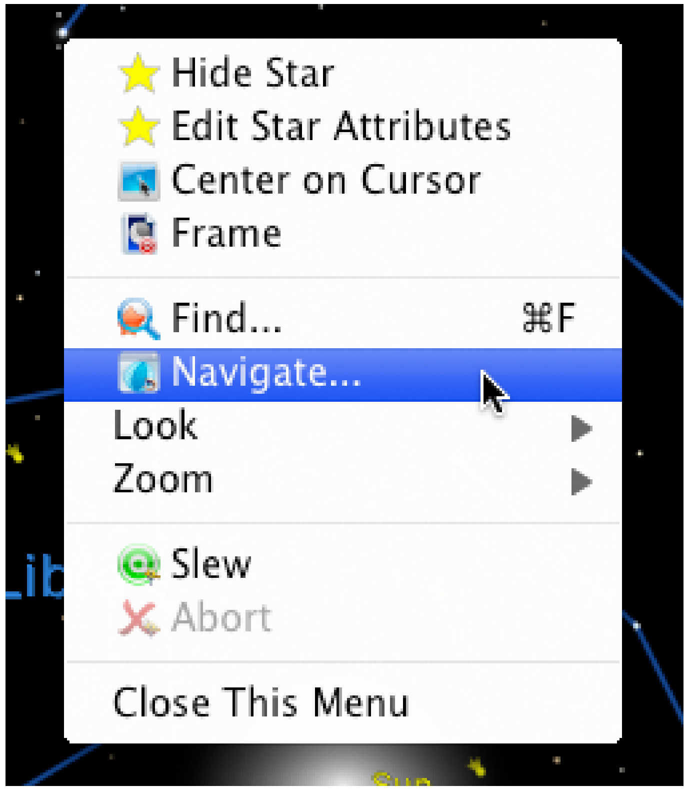


Figure 15: Right-click on the Sky Chart to access the pop-up menu above.

Hide <Object Type>

Right-clicking the Sky Chart when the mouse cursor is placed on a star or other object shows a pop-up menu where the first command is to ***Hide <Object Type Here>***; clicking this command turns off objects of this type. In Figure 15, for example, the mouse cursor was placed over a star, so the command reads ***Hide Star***.

Lock On <Solar System Object>

Right-clicking on a solar system object shows the ***Lock On*** command. Click this command to pin the object to the center of the Sky Chart.

Edit <Object Type>

Choosing the second command in the right-click pop-up menu shows the Edit Preferences window that allows the attributes for this element to be changed. See “Editing Chart Element Attributes” on page 192 for more information.

Center on Cursor

Click this command to center the Sky Chart on the right-click mouse position.

Frame

Click this command to center the object on the Sky Chart and adjust the chart’s field of view to approximately match the object’s angular size.

Find

Click this command to show the ***Find*** window (page 55).

Navigate

Click this command to command to show the ***Navigate*** window (page 38).

Look Pop-Up Menu

The commands in the ***Look*** pop-up menu orient the Sky Chart to look north, south, east, west or directly overhead (page 118).

Zoom Pop-Up Menu

The commands in the ***Zoom*** pop-up menu can be used to change the Sky Chart's field of view to any one of several preset values (page 36).

Slew

Click this command to slew the telescope to the celestial coordinates of the right-click mouse position on the Sky Chart (page 299).

Abort

Click this command to halt the telescope's motion during a slew.

Close This Menu

Click this command to hide the Sky Chart's right-click pop-up menu.

Display Chart Elements

In addition to the huge database of celestial objects in *TheSkyX*, a number of other useful elements, such as coordinate system lines, constellation boundaries, and other reference lines, are all available to you. Each can be toggled on or off with ease.

Chart Element Buttons

On the toolbar, you will find a number of buttons assigned to control chart elements (Constellation Figures, the Ecliptic, etc.). To toggle a given chart element on or off, simply click the appropriate button. For instance, if you want to turn on the constellation figures, locate and click the ***Show Constellation Figures*** button on the toolbar: the constellation figures appear in the Sky Chart. Also, note that the button is now a darker gray than the rest of the toolbar. This change indicates that the constellation figures are turned on. To hide them, click the button again. The button color will lighten and the constellation figures will fade from view. There are several other chart element buttons on the toolbar. Try them all to get a feel for how they work.

Chart Elements Window

A complete list of chart elements is available by selecting ***Chart Elements*** from the ***sidebar*** of the ***stacked tool windows***, which is located on the left side of the screen when you first open *TheSkyX*.

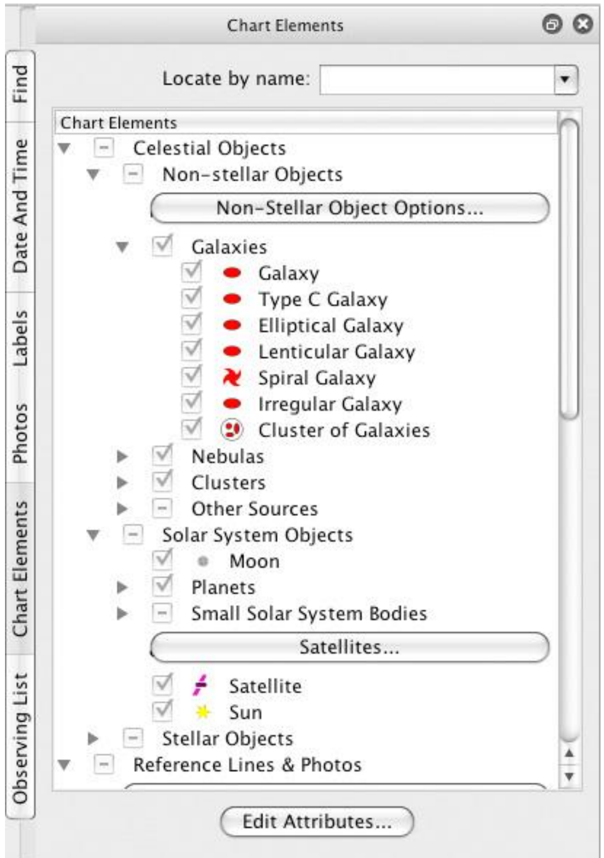


Figure 16: The Chart Elements window (Display menu).

If ***Chart Elements*** does not appear in your stacked tool window, or if you removed it, you can always access it again by selecting ***Chart Elements*** from the ***Display*** menu.

Locating a Chart Element by Name (Locate by Name)

If you know the name of the Chart Element you're after, there's a quick way to find it in the list. For example, suppose you want to turn on the line that represents the galactic equator. Typing the letter "g" into the ***Locate by Name*** text input shows a list of all of the elements that begin with this letter in the pop-up menu. Selecting ***Galactic Equator*** expands the Reference Lines and Photos node to reveal this option. Press the TAB key to place the "focus" on this checkbox.

From here, you can turn the checkbox on or off, or, click the ***Edit Attributes*** button to configure this element's upper and lower magnitude limits, angular size limits and other display properties, such as the font size, line styles, fill colors and symbol. See "Customizing Chart Elements" on page 192 for more information.

Customizable Interface

One of the great features of *TheSkyX* is its customizable interface. All toolbars and "dockable" windows are movable and adjustable, giving you great flexibility in using *TheSkyX* to best suit your needs.

Positioning Toolbars

When you first open *TheSkyX*, you will notice rows of toolbars on the top of the screen, a stacked tool window on the left, and the Sky Chart on the right.

When looking at the toolbars, notice that at the far left of each, you will see a textured area (or "gripper bar").

Figure 17: The textured region on the left side of toolbar windows can be used to position the toolbar.

Clicking and dragging on this area will allow you to move that toolbar to almost any new desired location on the screen. As you drag the toolbar, you will notice that portions of the screen move to allow you to drop the toolbar into position. If you drop a toolbar in one of these positions, it will "snap" into place. (You may also drop the toolbar over the Sky Chart in any location, without snapping.) Feel free to experiment with this feature to get a feel for how the toolbars can be moved, as you can always move the toolbar back to its default position later. Be sure to look over each toolbar, and you will see that they are divided into sections, each of which can be moved. Note that the textured section denotes the beginning of a new toolbar section.

Moving Dockable Windows

To the lower left of the screen, you will find a set of tool windows that are stacked together. A ***sidebar*** allows you to choose which window you want to see. All of the windows stacked together on the left side of the screen can be moved and/or made into a new stack. Notice that when you select a stacked window on the sidebar, its name also appears at the top of the window along with a ***window resize button*** and a ***close window button***. By clicking the ***window resize button***, you release that particular window from the stack. Now you are free to move the window to any location that you like by clicking and dragging it. Alternately, you can dock the window on the left or right side of the window by dragging it and releasing it in any area that readjusts as the window is drug over. For instance, try clicking ***Labels*** in the stacked tool window. Now click the ***window resize button*** in the top right of that window. The window will now undock from the stack. Click and drag the window to the far right side of the screen. You will notice that the Sky Chart will move slightly to the left, and a dark gray area will appear, indicating that you may "dock" this window here. Release the mouse button, and you have docked the window. If you would like to move another window, simply repeat the previous steps.

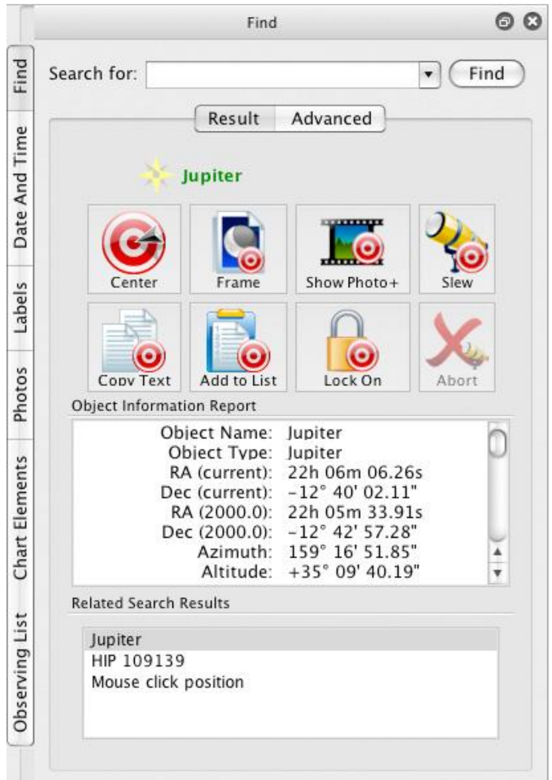


Figure 18: The stacked tool windows, including Tours, Find, Date and Time, Photos, Labels and Telescope and Observing List.

Stacking and "Dockable" Windows

Windows can be stacked by dropping a window on top of docked windows. When the docked window turns a dark gray, drop the window you are moving to stack them.

Closing and Reopening a Docked Window

If you wish to remove a window from view completely, simply select it from the stacked tool window sidebar, and click the ***close window*** button.

If you want to view a window again, simply select it from the ***Display*** menu.

The following windows can be stacked on the left or right side of the main window, or, by dragging the window's title (caption), positioned anywhere on your computer's monitor.

- Chart Elements
- Chart Status
- Date and Time
- Find

- Labels
- Observing List
- Photos
- Telescope
- Tours
- Telescope-specific command windows

Full Screen

The Sky Chart can fill your entire screen. To enter Full Screen Mode, choose the ***Full Screen command*** from the ***Display*** menu.

Press the Escape (ESC) key on the computer's keyboard to exit Full Screen Mode.

Heading Home

The universe is a big place, and when you are ready to go home, it is nice to know that *TheSkyX* can get you there in only two clicks (that's one click faster than it takes with a pair of famous red shoes). When you are ready to return to your default space and time, simply click ***Look South***, followed by ***Computer Clock***, both in the toolbar. This action will adjust the Sky Chart's view to the south, and at the current time designated by your computer's internal clock. Welcome back!

Restoring Default Sky Chart Settings

Or, select the ***New*** command from the ***File*** menu whenever you want to restore *TheSkyX's* chart settings to their default values.

This will show the daytime sky (***Display > Show Daylight***), set the date and time to the computer's clock and (turn on the ***Computer Clock*** button on the ***Date and Time*** window, ***Input*** menu), shows the default objects labels, object types, reference lines, object magnitude and size limits; just like when *TheSkyX* was first launched.

Saving & Retrieving Your Sky Chart

Your Sky Chart settings can be saved and opened at any time by creating special *TheSkyX* files with the extension ***.skyx***.

Saving Your Sky Chart

You can save your current Sky Chart, along with all of its settings, at any time by selecting the ***Save*** command from the ***File*** menu. This saves the Sky Chart (as a .skyx settings file), which is a handy way to save data you wish to quickly recall later, such as when you journey to your favorite hilltop.

Choosing the ***Save As*** command from the ***File*** menu allows you to save another .skyx file without overwriting the current one.

Opening An Existing File

To open an existing Sky Chart, select the ***Open*** command from the ***File*** menu. You will then be able to search your hard disk for existing .skyx files.

Help Options

As you continue to use *TheSkyX* and read through this User Guide, keep in mind that we have included the complete User Guides for both *TheSkyX* and the *TPoint Add On*, as well as an XML-based help guide and all are accessible from *TheSkyX*'s ***Help*** menu. Even the most seasoned observer sometimes needs a little help, and with all the features packed into *TheSkyX*, it is handy to always have a reference guide at your fingertips.

Help Search

You can easily search through *TheSkyX's* many commands by entering search terms into the Help menu's search field. For more detailed help, continue reading for more help options.

TheSkyX Help - Assistant

TheSkyX includes a powerful, html-based help guide called *Assistant*, which is designed to help you to get the most out of *TheSkyX*, no matter how you plan to use it. Whether you use *TheSkyX* to plan for meteor showers, or you want to use the most advanced telescope controls, *TheSkyX Assistant* is there for you, regardless of your user experience.

TheSkyX User Guide

This user guide is available, in its entirety, at any time from the Help menu. Simply select ***Help > TheSkyX User Guide*** to access it.

TPoint Add On User Guide

TPoint is an advanced telescope pointing analysis system, which allows you to analyze the errors inherent in your particular telescope system to drastically improve its pointing performance. TheSkyX offers an optional *TPoint Add On* that integrates telescope modeling, polar alignment assistance and automated pointing calibration (*Professional Edition only*). Both *TheSkyX Serious Astronomer Edition* and *TheSkyX Professional Edition* come with a trial version of the *TPoint Add On*, which can be activated the first time you use the add on, after which time, you will have to purchase a license separately. *TPoint* can be accessed from the ***Tools*** menu.

Like all aspects of an imaging system, there is a significant learning curve with *TPoint*. Fortunately, *TheSkyX* makes using *TPoint* smooth, and you should be able to complete a mapping run on the first night and start analyzing your system right away. There is a comprehensive user guide for *TPoint* available by selecting ***Help > TPoint Add On User Guide***.

Finding and Identifying Celestial Objects

TheSkyX's astronomical databases can be quickly searched to locate any one of millions of available objects, either by clicking on the object on the Sky Chart (called "identifying") or through the ***Find*** command from the ***Edit*** menu.

Identifying Objects

The Sky Chart is linked to *TheSkyX*'s astronomical databases. Click the left mouse button on any celestial object to identify it, and display the ***Object Information Report*** on the ***Find*** window (the ***Find*** window will be displayed automatically if it is hidden). The ***Object Information Report*** provides a wealth of information about the object.

You can also search for objects by name or catalog number using with the ***Find*** command on the ***Edit*** menu (see "Finding Objects" on page 55 for more information).

A red bull's eye appears on the Sky Chart at the mouse click position (Figure 20) and identifies this object as the *target object*, or *target*. Tool bar buttons that act on, or apply to, the target include a red or green target graphic.

Object Information Report Contents

- the object's common name and/or its catalog designation
- the graphical symbol used to represent this object on the Sky Chart
- cross references to other catalogs (in the Name 2–Name 10 fields)
- the object's type (planet, variable star, irregular galaxy, and so on)
- the constellation in which the object lies
- the object's magnitude
- a star's Bayer (Greek-letter) brightness designation
- the plain English Dreyer description for the object
- the object's distance from Earth, in light years and AU (where available)
- catalog-specific information (such as min/max magnitude of variable stars, spectral class, parallax, proper motion, position error, distance from the Solar System)
- the object's topocentric equatorial (RA-Dec) coordinates, for both the date specified in the ***Date and Time*** dialog (page 110) and Equinox 2000.0
- the object's current horizon (Az-Alt) coordinates
- the object's rise time, transit time and set time for the site location and the object's angular dimensions
- the angular separation from the last object identified

- the object's position angle (the angle between the line connecting the object and the last-identified object, and the line connecting the last identified object and the North or South Celestial Pole)
- Other catalog and object-specific information

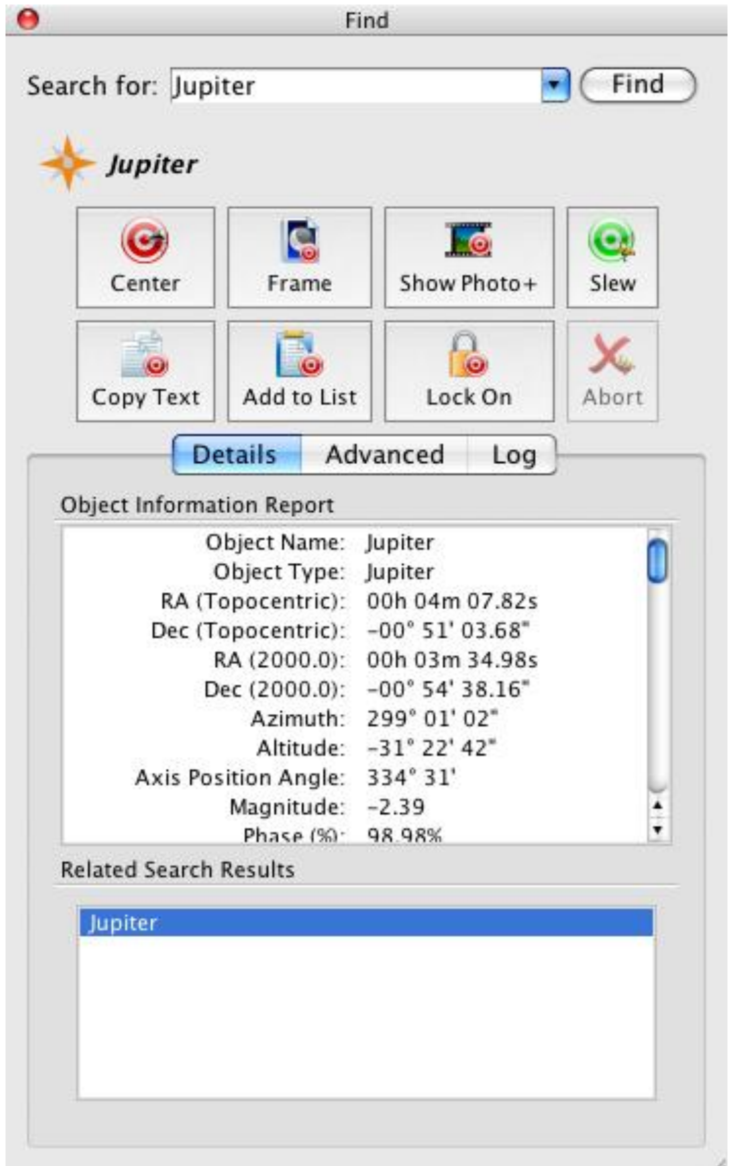


Figure 19: The Object Information Report on the Find window (Edit menu).

The *target* is highlighted with a red bull's eye on the Sky Chart (Figure 20). Press the *ESCAPE* key to hide the bull's eye.

Figure 20: The Sky Chart displays a bull's eye centered on the current target.

The object you clicked on (or located using the ***Find*** command), and up to ten "nearby" objects (or objects with names that closely match this object), are listed in the ***Related Search Results*** box. This eliminates any need to click exactly on the object, and makes it easy to study groups of objects without having to click on each one. If you click in an area without any nearby objects, the ***Mouse Click Position*** is the only entry.

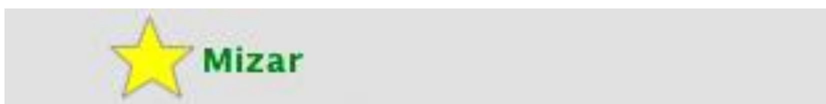


Figure 21: The text color indicates the object's visibility (green means the object is currently above horizon; black text means it is below horizon).

The object's symbol (a yellow star in Figure 19) is displayed next to the object's name. When the object's name is displayed with green-colored text, the object is presently above the horizon. Black-colored text means the object is currently below the horizon.

Identifying Galaxies, Nebulas, and Open Clusters

At wide fields of view, galaxies, nebulas and open clusters are displayed as their standard symbols. At higher magnifications, the symbols are replaced with circles or ellipses that represent the shape and dimensions of the object. Within these extended objects, there is no marked point on which to click. If the object is displayed as a circle, you can click anywhere within the circle. For objects displayed as ellipses, click within the circular region defined by the ellipse's minor axis, as shown in the drawing below.

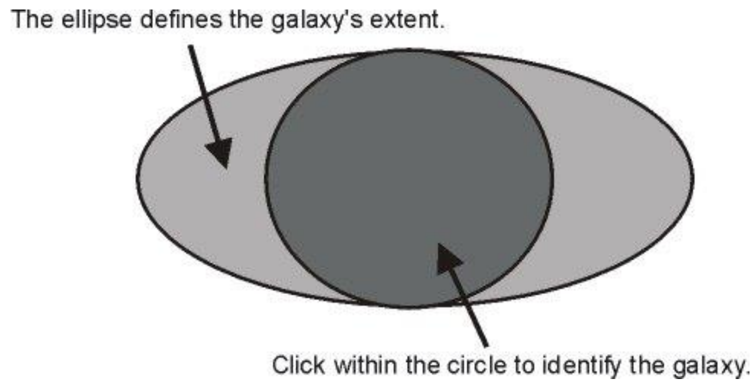


Figure 22: Click inside the shaded circle to identify this extended object (galaxy).

The Andromeda galaxy (M31) is one example of an extended object. You need to click on a point towards the center of M31 – without too many nearby stars – to identify it. Click on the central region of stars to identify them.

Figure 23: Object-specific buttons on the Find window.

Centering Objects on the Sky Chart (Center button)

The ***Center*** button repositions the Sky Chart with the identified object at the center.

Framing Objects (Frame button)

The ***Frame*** button repositions the Sky Chart with the identified object at the center and adjusts the field of view to show extended objects.

The default field of view for point sources (or cataloged objects that do not have size information) is 10 arcminutes. To use a different framed field width, change the Default ***Frame Size when Object Size is Unknown*** value on the Non-stellar Object Options dialog from the Display menu.

Show Photographs, HR Diagrams and Notes (Show Photo+ button)

If the identified object has a photograph (not all objects have photographs), the ***Show Photo+*** button shows it in the ***Photo Viewer*** window (Figure 24).

Figure 24: Photo Viewer window showing IC 434.

If the identified object is a star that has spectral class information, a Hertzsprung-Russell (HR) diagram is displayed instead. The yellow crosshairs show star's color relative to other stars.

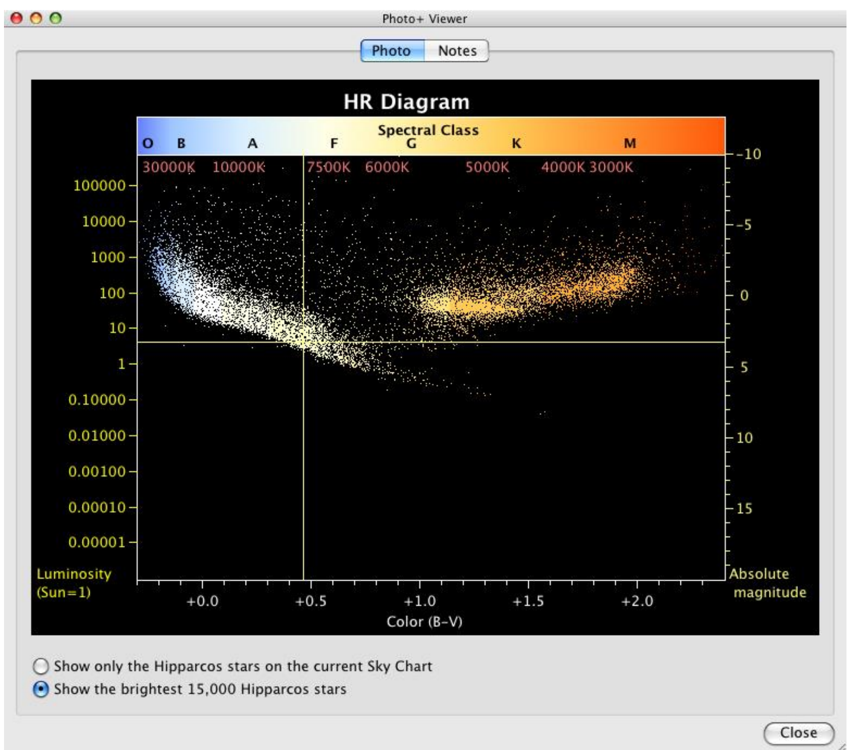


Figure 25: HR Diagram for a Hipparco-Tycho star 68686.

Show only the Hipparcos Stars on the Current Sky Chart

Choose this option to graph only the Hipparcos stars that are on the current Sky Chart.

Show the Brightest 15,000 Hipparcos Stars

Choose this option to show the brightest stars from the Hipparcos catalog on the current Sky Chart.

Observing and Other Notes about Objects (Notes tab)

TheSkyX includes interesting and educational notes on the constellations, many Messier, IC and NGC objects as well as hundreds of stars.

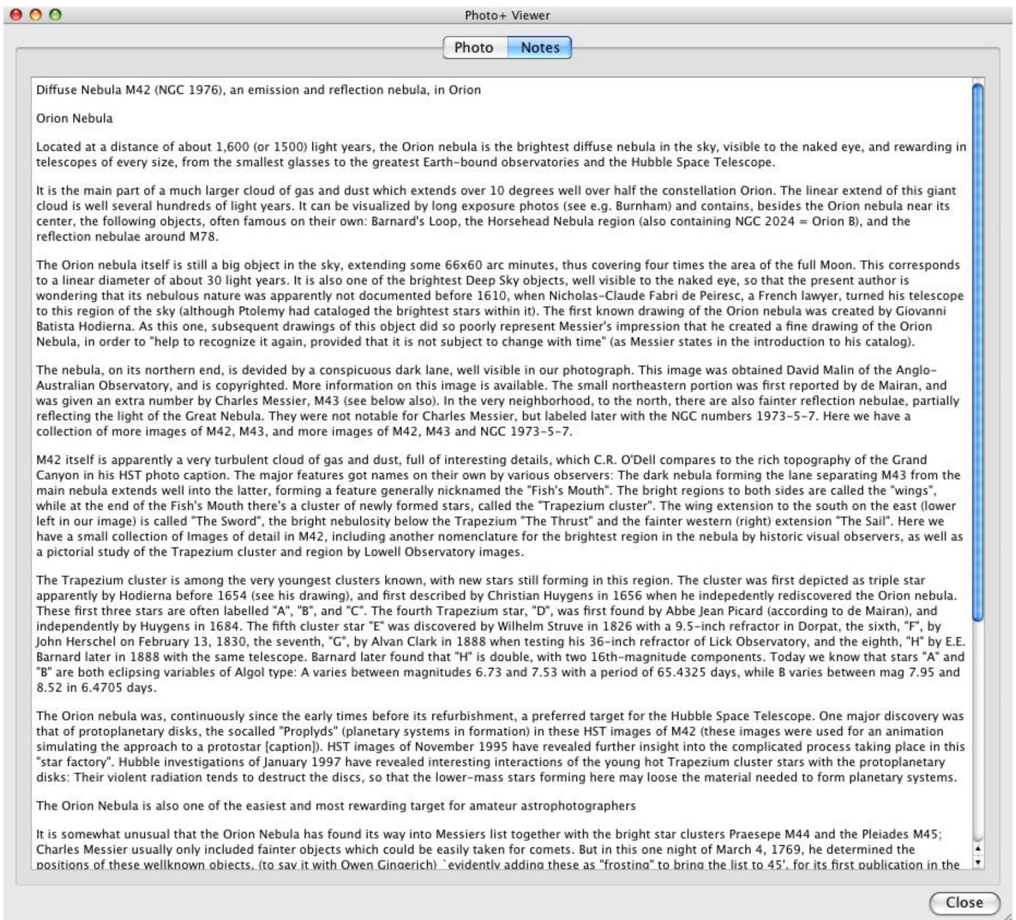


Figure 26: Notes for M42, the Great Nebula in Orion.

- Constellation notes based on the book Star Tales by Ian Ridpath
- Star notes from Jim Kaler (professor emeritus of astronomy, University of Illinois)
- Visual observing notes of selected objects by Steve Gottlieb
- Visual observing notes of selected objects by Tomm Lorenzin

These notes are copyrighted and distributed with permission.

Slew the Telescope (Slew button)

When a telescope connection is established, click the ***Slew*** button to command the telescope to slew to this object.

Aborting Telescope Slews (Abort button)

If you change your mind after clicking the ***Slew To*** button, click the ***Abort*** button to terminate the slew. This button is available only while the telescope is slewing.

Copy Object Information Report to Clipboard (Copy Text button)

To copy *all* the information in the Object Information Report to the Clipboard, click the ***Copy*** button. Or, right-click (⌘+click on the Mac) on the report and click the ***Copy Text*** command in the pop-up menu.

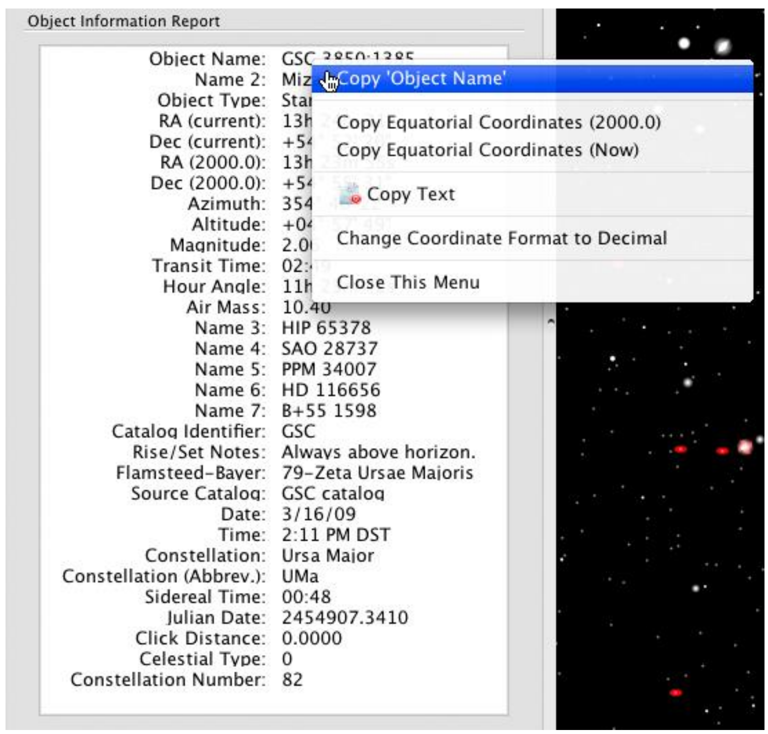


Figure 27: Right-clicking (⌘+click on the Mac) over the Object Information Report to show a context pop-up menu.

To copy the contents of a single field, move the mouse cursor over it, right-click the mouse (⌘+click on the Mac) and then click the ***Copy '<Field Name>'***, where '<Field Name>' is the name of the information field beneath the mouse cursor.

Other pop-up menu commands allow copying just the equatorial coordinates (J2000.0 or current), or toggling the number formatting between sexagesimal and decimal format.

Adding Objects to an Observing List (Add to List button)

TheSkyX can create an *observing list* of the objects. To add this object to the Observing List, click the ***Add to List*** button. See *"Observing Lists"* on page 230.

Locking on a Solar System Object (Lock On button)

If the target object is a planet, moon or other solar system object, click the ***Lock On*** button to pin this object to the center of the Sky Chart.

As a reminder, the text ***Locked on <Solar System Object>*** appears in the lower right corner of the Sky Chart. Left-click and drag the screen to break the lock.

Objects outside the solar system cannot be locked on.

Finding Objects

You don't have to locate an object in the Sky Chart to get information about it. The ***Find*** command in the ***Edit*** menu can locate *every* object in *TheSkyX'*s databases.

You can also access it by pressing ⌘F, or by clicking the Find button in the Edit toolbar. Selecting the Find command displays the Find window, which provides several ways to locate any object.

Finding by Name

One way to find an object is to enter its *name* (Aldebaran, Bear Paw) in the ***Search For*** text input. You can enter the names of comets, minor planets, and auxiliary objects that appear in any active Sky Database.

For example, to find the Orion Nebula, type `Orion Nebula`
and click the ***Find*** button. The Object Information report shows details about the Orion Nebula. If the Orion Nebula is within the current field of view, it's marked with a bull's eye.

You can also search for a star by manually entering its Bayer (Greek-letter) magnitude designation, followed by the constellation's three-letter abbreviation. For example, to find the third-brightest star in Orion, type `Gamma Ori`. Clicking the ***Find*** button locates that star, Bellatrix.

Great Nebula in Orion
Gamma Ori

If you are not sure of the correct spelling…

Star names are Greek, Arabic, or Latin. You don't have to know the correct spelling. The Find command shows you matching names.

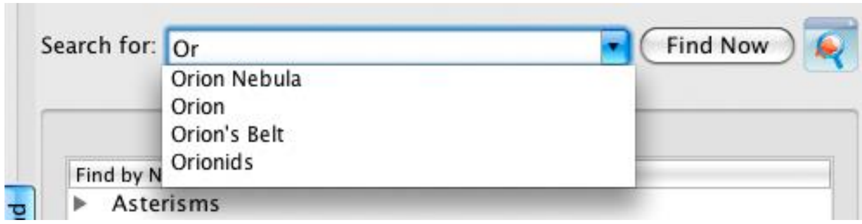


Figure 28: A list of matching names appears as you type.

For example, if you enter 'Or" the Search For text input shows objects that start with these letters.

The Milky Way and the Magellanic Clouds

The Milky Way (our galaxy) is displayed as a photograph or draw as a polygon that can cover a significant portion of the Sky Chart. Keeping track of its boundaries in all cases would consume too many resources. It was therefore decided not to identify the Milky Way when you click inside it. At narrow fields of view, the Milky Way's boundaries are not usually visible and the polygon forms a solid background color. This is potentially confusing ("Is that the Milky Way or a nebula?"), so the Milky Way is not displayed at fields of view below 20°.

The Magellanic Clouds (the two smaller galaxies "attending" our galaxy) are large, complex objects. The Small Magellanic Cloud is shown as a filled ellipse and is easy to spot in the Sky Chart – it's located at a right ascension of about 1h, not far from the south celestial pole. Type the text 'Small Magellanic Cloud' in the ***Search For*** text input and then click the ***Find*** button to locate it.

By default, the Large Magellanic Cloud is not shown as a specific object. To display the region in which it's located, search for Large Magellanic Cloud. To have *TheSkyX* draw a polygon that represents this region, select the Large Magellanic Cloud Sky Database in the ***Database Manager*** window from the ***Input*** menu.

Entering Catalog Numbers with the Mouse

Because it can be difficult to type keyboard keys in the dark, *TheSkyX* includes a method for entering catalog numbers with the mouse.

On the ***Advanced Find*** tab, click the numbers (and the decimal point) on the right to enter numerical keys. Clicking Space enters a space. Clicking ***Back*** deletes the last (rightmost) character in the edit box, regardless of the current location of the text cursor.

Advanced Searches

Finding by Object Type

Objects are categorized by type in the ***Find by Name or Catalog Number*** list on the ***Advanced*** tab of the ***Find*** window.

A simple way to find any object is to first determine its type (is the object a star, galaxy, cluster or other?). Next, determine what catalog you want to search and then select the name of the object from the catalog list. The table below lists each category in the Find tree list.

Object Type	Catalog/Cross Reference	Description
Asterisms		Lists the names of many common asterisms.
Constellations		Lists the names of the 88 constellations.
Non-stellar Objects		Lists databases of non-stellar objects.
	Caldwell	Caldwell Catalog objects.
	Common Names	Names of common non-stellar objects.
	Herschel	Herschel 400 catalog.
	IC	Index Catalog.
	Lorenzin	Tomm Lorenzin Catalog.
	Messier	Messier Catalog.
	NGC	New General Catalogue.
	PGC	Principal Catalog of Galaxies.
	PGC cross reference	Cross references to the Principal Catalog of Galaxies.
	PLN	Planetary Nebulae.
	SAC*	Saguaro Astronomy Club Deep Space Object catalog.
Sky Databases (SDBs)	Optional (non-core) databases	These optional Sky Databases (SDBs) can be turned on from the ***Database Manager*** command in the ***Input*** menu (page).
Solar System		Objects within our solar system.
	Meteor Shower Radiants	Locations of meteor showers.
	Moon	Earth’s Moon.

Object Type	Catalog/Cross Reference	Description
	Planets (alphabetical)	Earth Jupiter Mars Mercury Neptune Saturn Uranus Venus
	Satellites	Man-made satellites that have been imported from the Satellites window on the Input menu.
	Small Solar System Bodies	Objects that are classified as Small Solar System Bodies by the IAU.
		Asteroids (Large Database): Names of asteroids that have been imported from the Large Database tab on the Small Solar System Bodies windows (Input menu).
		Asteroids (Small Database): Names of asteroids that have been imported from the Small Database tab on the Small Solar System Bodies windows (Input menu).
		Comets: Names of comets selected in the Comet tab on the Small Solar System Objects dialog (Input menu).
	Dwarf Planets	Pluto
	Sun	The Sun.
Stellar Objects		Lists databases of stars.
	Bayer	Bayer catalog designations.
	Common name	Common star names.
	DM	Bonner Durchmusterung number.
	Flamsteed	Flamsteed designations.
	GCVS	General Catalog of Variable Stars.

Object Type	Catalog/Cross Reference	Description
	GSC	Guide Star Catalog.
	HD	Henry Draper Number.
	NSV	Catalog of Variable Stars.
	SAO	Smithsonian Astrophysical Observatory.
	Struve	Struve Catalog stars.
	WDS	Washington Double Star catalog.

SAC Cross References

The Saguaro Astronomy Club Database contains cross references to the astronomical catalogs in the table below.

Catalog Name	SAC Cross Reference
Third Cambridge Catalog of Radio Wave Sources	3C
George Abell (planetary nebulae and galaxy clusters)	Abell
Aitken Double Star catalog	ADS
Arp-Madore (globular clusters)	AM
(open clusters)	Antalova
Apriamasvili (planetary nebulae)	Ap
Halton Arp (interacting galaxies)	Arp
Barkhatova (open clusters)	Bark
Barnard (dark nebulae)	B
(open clusters)	Basel
Bonner Durchmusterung (stars)	BD
Berkeley (open clusters)	Berk
Bernes (dark nebulae)	Be
Biurakan (open clusters)	Biur
(open clusters)	Blanco

Catalog Name	SAC Cross Reference
(open clusters)	Bochum
Cederblad (bright nebulae)	Ced
Catalog of Galaxies and Clusters of Galaxies	CGCG
Collinder (open clusters)	Cr
(open clusters)	Czernik
David Dunlap Observatory (dwarf galaxies)	DDO
Dolidze (open clusters)	Do
Dolidze-Dzimselejsvili (open clusters)	DoDz
Dunlap (Southern objects of all types)	Dun
European Southern Observatory (Southern objects)	ESO
Feinstein (open clusters)	Fein
(open clusters)	Frolov
(bright nebulae)	Gum
William Herschel (globular clusters)	H
(open clusters)	Haffner
(open clusters)	Harvard
Havermeyer and Moffat (open clusters)	Hav-Moffat
Henize (planetary nebulae)	He
(open clusters)	Hogg
Holmberg (galaxies)	Ho
Haute Provence (globular clusters)	HP

Catalog Name	SAC Cross Reference
Humason (planetary nebulae)	Hu
1st and 2nd Index Catalogs to the NGC (All types of objects except dark nebulae)	IC
Iskudarian (open clusters)	Isk
Jonckheere (planetary nebulae)	J
Kohoutek (planetary nebulae)	K
Father Lucian Kemble (asterisms)	Kemble
(open clusters)	King
Krasnogorskaja (planetary nebulae)	Kr
Lacaille (globular clusters)	Lac
(open clusters))	Loden
Lynds (bright nebula))	LBN
Lynds (dark nebulae)	LDN
Northern Proper Motion, 1st part, Galaxies	NPM1G
(open clusters)	Lynga
Messier (all types of objects except dark nebula)	M
Morphological Catalog of Galaxies	MCG
Merrill (planetary nebulae)	Me
Markarian (open clusters and galaxies)	Mrk
Melotte (open clusters)	Mel
Minkowski (planetary nebulae)	M1 thru M4

Catalog Name	SAC Cross Reference
New galaxies in the Revised Shapley-Ames Catalog	New
New General Catalogue of Nebulae & Clusters of Stars. (All types of objects except dark nebulae)	NGC
Palomar (globular clusters)	Pal
Peimbert and Costero (planetary nebulae)	PC
(open clusters)	Pismis
Perek & Kohoutek (planetary nebulae)	PK
Rodgers, Campbell, & Whiteoak (bright nebulae)	RCW
(open clusters)	Roslund
Ruprecht (open clusters)	Ru
Sandqvist (dark nebulae)	Sa
(open clusters)	Sher
Sharpless (bright nebulae)	Sh
Sandqvist & Lindroos (dark nebulae)	SL
Shapley & Lindsay (clusters in LMC)	SL
Stephenson (open clusters)	Steph
(open clusters)	Stock
Terzan (globular clusters)	Ter
(open clusters)	Tombaugh
Tonantzintla (globular clusters)	Ton
Trumpler (open clusters)	Tr
Catalog of selected Non-UGC galaxies	UA

Catalog Name	SAC Cross Reference
Uppsala General Catalog (galaxies)	UGC
United Kingdom Schmidt (globular clusters)	UKS
(open clusters)	Upgren
Vorontsov-Velyaminov (interacting galaxies)	VV
van den Bergh (open clusters, bright nebulae)	vdB
van den Bergh & Herbst (bright nebulae)	vdBH
van den Bergh-Hagen (open clusters)	vdB-Ha
Vyssotsky (planetary nebulae)	Vy
(open clusters)	Waterloo
Double Star (Messier 40)	Winnecke
Zwicky (galaxies)	ZWG

To locate objects in the SAC, in the ***Search For*** text input on the ***Find*** window, enter ***SAC <Cross Reference> <Catalog Number>*** and then click the ***Find*** button. For example, entering the text ***SAC Cr 33*** locates this open cluster in the Collinder catalog.

Finding by Catalog Designation

Another way to find an object is to enter its *catalog designation*. Leading zeroes are not required; the search routine automatically adds them. Typing *just* the catalog abbreviation (with no number) lists the first 10 items in the catalog.

The Tycho catalog's designers indexed it with the corresponding GSC numbers. We have therefore not included it as a searchable catalog.

Searching Other Catalogs

Other catalog designations can be used to find objects. The table below lists the available catalogs and their prefixes, along with the number of galaxies in the catalog (Count) and an example of the correct format.

See Catalog Cross References in Appendix A: Databases and Cross References on page 514 for a list of these catalogs.

More Find Examples

The following tables show a variety of useful search queries for the ***Locate By Name*** text box.

Star Name	**Type of Query**
Polaris	Common star name
SAO 308	Smithsonian Astrophysical Observatory star
GSC 4628:237	Guide Star Catalog number
HIP 11767	Hipparcos identifier
PPM 431	Positions and Proper Motions (PPM) number
HD 8890	Henry Draper number
B+88 8	Bonner Durchmusterung catalog
C-34 12784	Cordoba Durchmusterung catalog
P-42 7856	Cape Durchmusterung catalog

Flamsteed/Bayer (use constellation abbreviation)	**Result**
ALPHA UMI	(Alpha Ursae Minoris)
25 PSI 1 ORI	25 Psi 1 Orionis

Non-stellar Objects	**Result**
Great Nebula in Andromeda	Common non-stellar object name
M31	M31 Messier Object
NGC 224	NGC 224 in the New General Catalog
IC 434	IC 434 in the Index Catalog
PGC 18508	Principal Galaxies Catalog
GCVS GK ORI	General Catalog of Variable Stars
NSV	New Suspected Variable Catalog
PLN 194+2.1	Planetary Nebula

Solar System Objects	**Result**
Saturn	Finds Saturn
Wild 4	Finds the comet named "Wild 4"
Ceres	Finds small database asteroid named "1 Ceres"
MPL 835 OLIVIA	"MPL" prefix finds that asteroid (or *minor planet*) named "835 Olivia" from the large asteroid database.

Uranometria Star Charts	Result

URA 36	Centers on Uranometria star chart number 36
URA 36+	Centers on Uranometria star chart number 36 and sets Uranometria-like chart attributes.

Satellites/Spacecraft	Result
SAT COSMOS 100	Searches for the satellite named "Cosmos 100"

Miscellaneous Objects	Result
Zenith	Moves to 90 degrees altitude
AAVSO A	Sets field width to AAVSO type A (accepts a-g)
12.3, 13.4	Moves to the equatorial coordinates right ascension 12.3 and declination 13.4
Z2.5	Zooms to 2.5 degree field of view
Z2.5m	Zooms to 2.5 minute field of view
Z200s	Zooms to 200 arcsecond field of view
SCALE 2.5	Adjusts the sky chart so that the scale is 2.5 arcseconds/pixel

Logging Observations

Click the ***Log*** tab on the ***Find*** window to view the observing log and notes for this object.

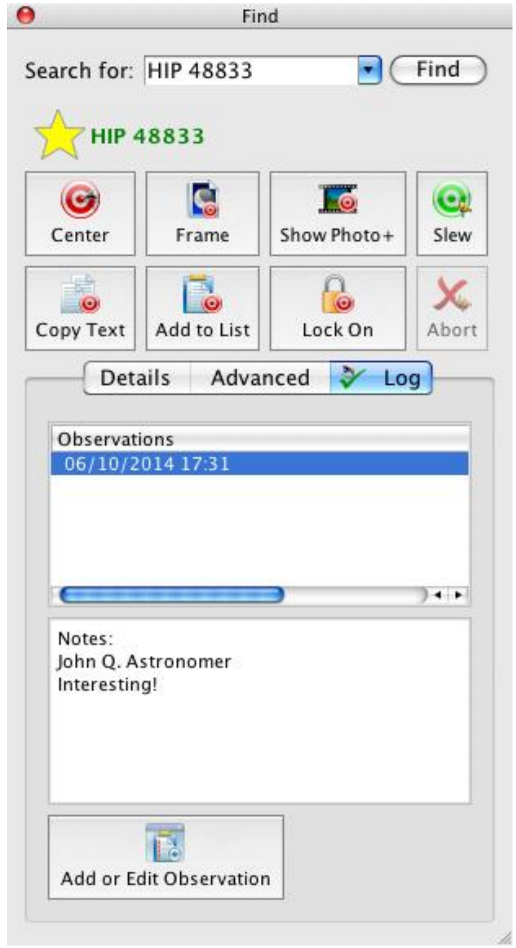


Figure 29: The Log tab on the Find window showing an observation notes for a star.

Click the ***Add or Edit Observations*** button to show the ***Observer Log*** window that allows you to add notes, a seeing scale, rating and other information for the current object, and view a table of your observations.

Note: The object observed graphic (above) appears on the ***Log*** tab for objects that have a recorded observation.

Figure 30: Observer Log window.

Observations are stored in XML format in the ***Observer Log*** folder located in the Application Support folder (page 24). See "*Add Observing Notes (Add to Observer Log)*" on page 236 for more information about Observer Logs.

Labeling Objects

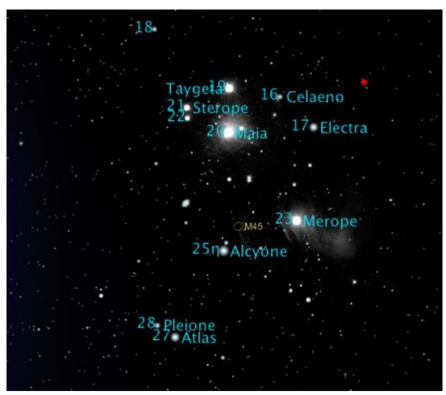


Figure 31: Common star, Bayer and Flamsteed designation labels near the Pleiades Nebula (M45).

The first time *TheSkyX* runs, the common names for the planets are shown. To show the names of other objects, select the ***Labels*** command from the ***Display*** menu to turn on the ***Labels*** window or click the ***Labels*** tab to make it visible.

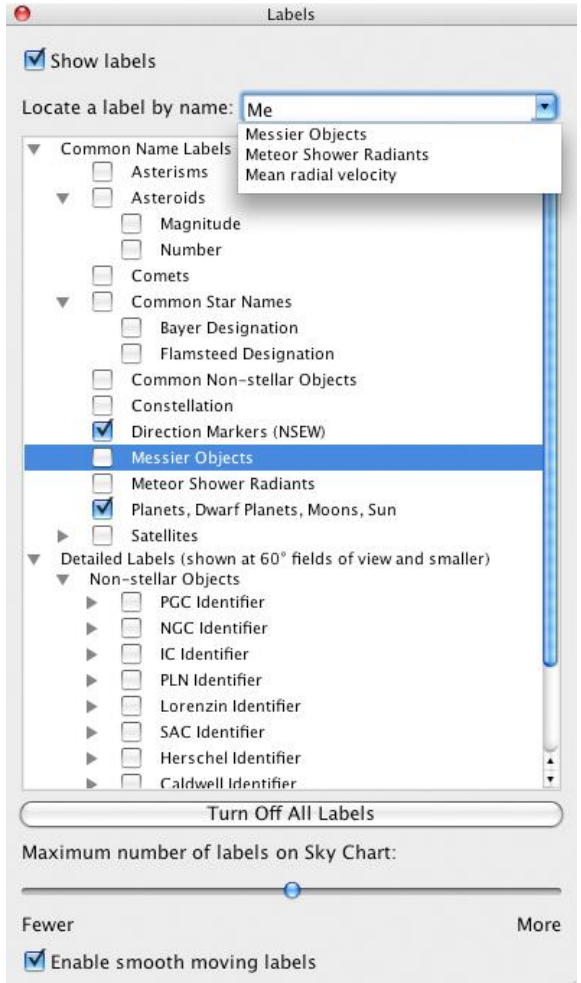


Figure 32: The Labels window (Display > Labels command).

The Labels window allows you to show or hide the names of the following common objects.

- Asterisms
- Asteroids (Name, Magnitude and Number)
- Comets
- Common Star Names
- Bayer Designation
- Flamsteed Designation
- Common Non-stellar Object Names
- Constellations
- Cardinal Directions
- Messier Objects
- Meteor Shower Radiants
- Planets, Dwarf Planets, Moons and the Sun
- Spacecraft or Artificial Satellites (Name, Range and Latitude/Longitude Position)
- Detailed and customizable catalog specific labels

Turn on the checkbox next to the desired common label to show it. Turn off the checkbox to hide the label.

The astronomical catalogs used by *TheSkyX* also contain catalog-specific information that might be useful to show on the sky chart. ***Detailed Labels*** can also be shown for star and non-stellar catalogs and custom Sky Databases (SDBs).

For example, if you're working with double stars, you can show a detailed label that contains the magnitude and angular separation between star systems in Washington Catalog of Double stars by expanding ***WDS*** in ***Stellar Objects*** section under ***Detailed Labels***.

Or, if you're researching galaxies in the New General Catalogue (NGC), you might want to show a detailed label that includes blue magnitude and equatorial coordinates (***Detailed Labels > Non-stellar Objects > NGC Identifier*** group).

Detailed labels are shown on the Sky Chart at 60° fields of view and smaller.

Showing Labels (Show Labels)

This checkbox shows or hides the check marked labels.

Finding a Specific Label (Locate a Label by Name)

Use this text input to quickly locate (and turn on or off) a particular common name or detailed label in the labels tree. For example, to turn on Messier labels, type "m"; the labels that begin with this letter appear in the pop-up menu. Select ***Messier Objects*** to expand the labels list and show the ***Messier Objects*** checkbox. Pressing the TAB key highlights the checkbox

Turning Labels Off (Turn Off All Labels)

Press this button to turn off the ***Show Labels*** checkbox and turn off every checkbox in the labels list.

Label Density (Maximum Number of Labels on Sky Chart)

Adjust this slider to change the number of labels that will appear on the Sky Chart at one time.

Anti-aliased Labels (Enable Smooth Moving Labels)

The font used to display labels can be "anti-aliased" that the motion of the label (as the chart is updated, or, particularly during time skip animations or viewing tours) is smooth. When this option is turned off, you might notice a slight "jerky motion" of fonts during animations.

Tours

Before we investigate the various menu and "button" commands arranged across the top of the screen, let's explore some of the tours that have been created to demonstrate some common yet fascinating things you can see in the sky.

Notice the series of tabs running vertically on the right side of the main. Select the tab labeled ***Tours***. If this window is not visible, click the ***Tours*** command from the ***Display*** menu to show it. A list of available tours is displayed:

- Analemma
- Angular size of Mars
- Coordinates – Equatorial
- Coordinates – Horizon
- Mercury evening visibility
- Mercury morning visibility
- Moon cycle – size and phase
- Motion of Barnard's Star
- 24-Hour Motion of Saturn's Moons
- Rotation and Phase of Mercury 2008
- Rotation and Phase of Venus 2008
- Saturn from Earth Over 10 Years
- Venus and Mercury Paths
- What Was That? (Iridium Flare Example)
- Winter Constellations

Go ahead and take one of the tours. Highlight one that sounds interesting, then click the ***Start*** button. Or, click the ***Run All*** button to watch them consecutively.

Creating Tours

PROFESSIONAL

TheSkyX Professional Edition provides a powerful interface that can be used create *tours* that simulate astronomical events, highlight interesting objects, or demonstrate astronomical concepts.

A tour is based on a timeline that can be as long or as short as you want. Any number of *waypoints* can added to the timeline at which you can "show something" (for example, turn on the constellation lines) or "do something" (for example, perform a 100-year time skip simulation) by executing a *macro command*. One, or any number macro commands can be executed at each waypoint, providing a virtually unlimited set of tools to create educational demonstrations. Tours can be saved later in QuickTime movie format.

To get started, let's look at one of the supplied tours.

1. Highlight the ***Winter Constellations*** tour on the ***Tours*** window. Click the ***Tours*** command from the ***Display*** menu to show this window if necessary. This displays the ***Tour Information*** tab.

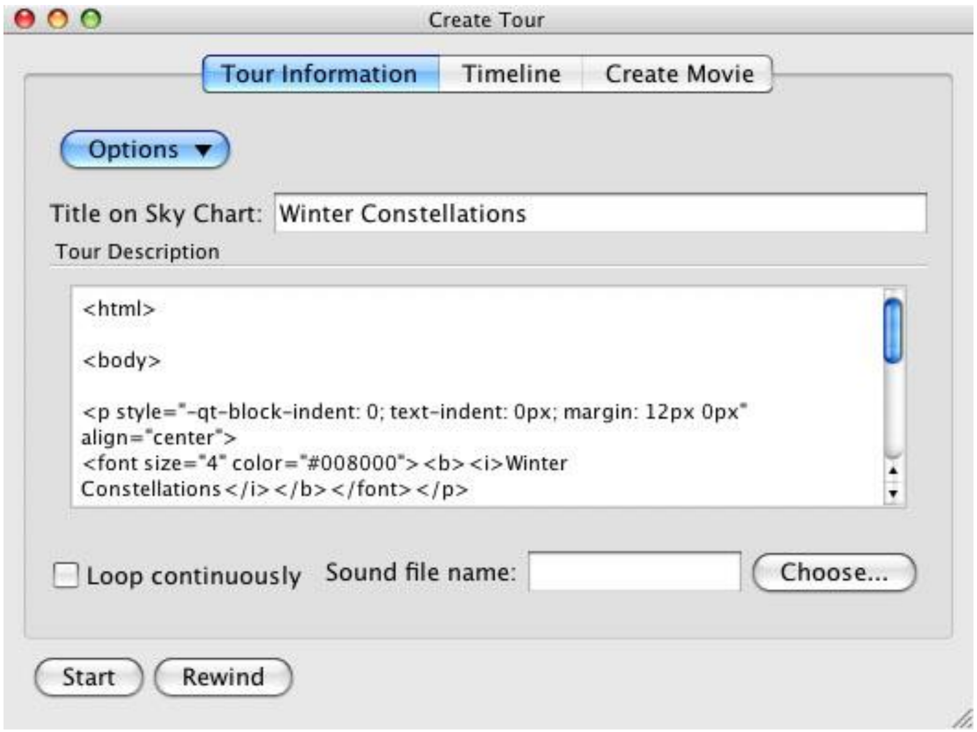


Figure 33: Tour Information tab on the Create Tour dialog.

2. Enter the title of the tour in the ***Title on Sky Chart*** text input. This text will appear at the top of the Sky Chart while the tour is running.
3. Enter a ***Tour Description*** as plain text or HTML. This description appears on the ***Tours*** window when the tour name is highlighted.
4. To play a sound at the beginning of the tour, click the ***Choose*** button and select the file. Turn on the ***Loop Continuously*** checkbox to play the tour repeatedly.

Options Pop-up Menu

New Tour

Select this command to reset the tour parameters to default settings.

Open Tour

Select this command to choose a tour file name to open.

Save Tour/Save Tour As

Saves the current tour to the Tours folder in the “Application Support Files” folder (page 24). Save As lets you use enter a different name for the tour file.

Copy Tour

Copies the tour to the Clipboard as text.

Paste Tour

Pastes a tour-formatted text file from the Clipboard.

The next step is to define the timing of the tour on the ***Timeline*** tab.

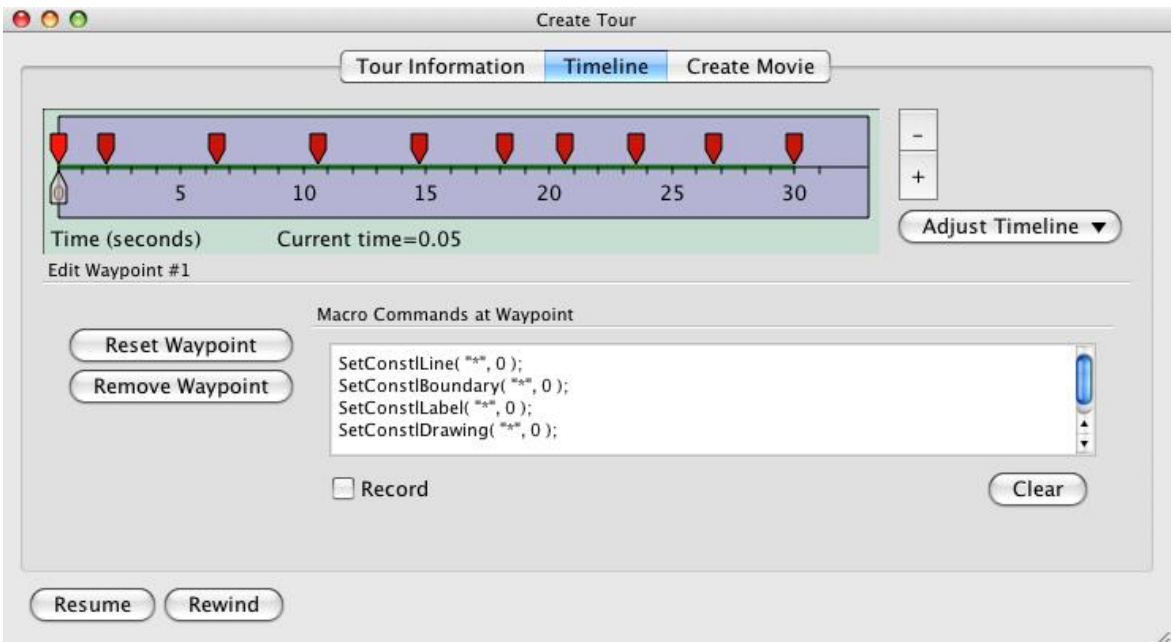


Figure 34: The Timeline tab.

The green line on the timeline graphic shows the length of the tour, in seconds. A red arrow on the top of the timeline represents the position of a waypoint. Dragging the gray, upward pointing *tour time pointer* (positioned at 0 seconds in Figure 34) lets you advance to a specific time in the tour.

The *Winter Constellations* tour is 30 seconds long. Click the **+** button to expand the timeline, or the **–** button to shorten it. This tour also includes ten different waypoints (indicated by a red pointer on the top of the timeline). Each waypoint represents a point of transition in the tour.

Defining a new waypoint is easy, just drag the tour time pointer to the desired time and then click the ***Add Waypoint*** button. When the tour time pointer is positioned beneath a waypoint, the button text ***Reset Waypoint*** appears instead.

5. Drag the tour time pointer to 0 seconds or click the ***Rewind*** button to go to the beginning of the tour. The ***Macro Commands at Waypoint*** text input now shows the four macros that will be run when the tour begins:

Macro	**Explanation**
SetConstlLine("*", 0);	Show or hide constellation lines. Argument 1 is either constellation's abbreviation in quotation marks ("Ori"), or an asterisk in quotes "*" to indicate all constellation lines. Argument 2 defines how to show the constellation lines. A 1 means to turn on the constellation(s), a 0 turns them off.
SetConstlBoundary("*", 0);	Show or hide constellation boundary lines. Argument 1 is either constellation's abbreviation in quotation marks ("Ori"), or an asterisk in quotes "*" to indicate all constellation boundary lines. Argument 2 defines how to show the constellation lines. A 1 means to turn on the constellation boundary lines on, a 0 turns them off.
SetConstlLabel("*", 0);	Show or hide constellation labels. Argument 1 is either constellation's abbreviation in quotation marks ("Ori"), or an asterisk in quotes "*" to indicate all constellation lines. Argument 2 defines how to show the constellation labels. A 1 means to turn on the constellation label(s) on, a 0 turns them off.
SetConstlDrawing("*", 0);	Show or hide constellation drawings. Argument 1 is either constellation's abbreviation in quotation marks ("Ori"), or an asterisk in quotes "*" to indicate all constellation lines. Argument 2 defines how to show the constellation labels. A 1 means to turn on the constellation drawing(s) on, a 0 turns them off.

Macro	Explanation

See “Appendix D: Macro Commands” on page 537 for a complete list of available macro commands.

6. Drag the time pointer under each red arrow to reveal the macro commands for that waypoint.
7. Click the ***Rewind*** button, then the ***Start*** button to watch the entire tour.

Adjust Timeline Pop-up Menu

Use the commands in the ***Adjust Timeline*** pop-up menu to add or remove time from the tour.

- ***Scale Time to Pointer*** adjusts the length of the tour based on the current position of the time slider.
- ***Remove Before Pointer*** resets the start of the tour to the current position of the time slider and removes all waypoints before this position.
- ***Remove After Pointer*** resets the end of the tour to the current position of the time slider and removes all waypoints after this position.
- ***Mirror*** creates a mirror image of the timeline and waypoints.

Clear Button

Click this button to remove all text from the ***Macro Commands at Waypoint*** text input.

Record

When the ***Record*** checkbox is turned on, the macro commands necessary to perform an action are displayed as you perform them. For example, clicking ***Display > Horizon & Atmosphere Options*** and turning off the ***Show Horizon*** checkbox shows:

SetVisible(“Horizon”, 0);

Note that you can access any of *TheSkyX’s* celestial object types in macro arguments by name. For example, instead of “Horizon” as argument 1, you can turn the *meridian line* on or off by using the text *“Meridian”* as the first argument instead. See “Customizing Chart Elements” on page 192 and the Chart Elements window for the complete list of permitted object type names.

New Tour

Click this button to start a new tour.

Start/Pause/Resume

The text on this button changes depending on current position of the tour time pointer. When the pointer is at 0 seconds and the tour is not playing, click ***Start*** to begin playing the tour. When the tour is playing, click ***Pause*** to stop it. Click ***Resume*** to play the tour from the current position of the tour time pointer.

Rewind

Resets the tour time pointer to the beginning of the tour.

Create Movies

Once your tour is complete, you can create a QuickTime™ movie from the ***Create Movie*** tab. Windows users will have to install QuickTime (available free from Apple's web site) to use this feature.

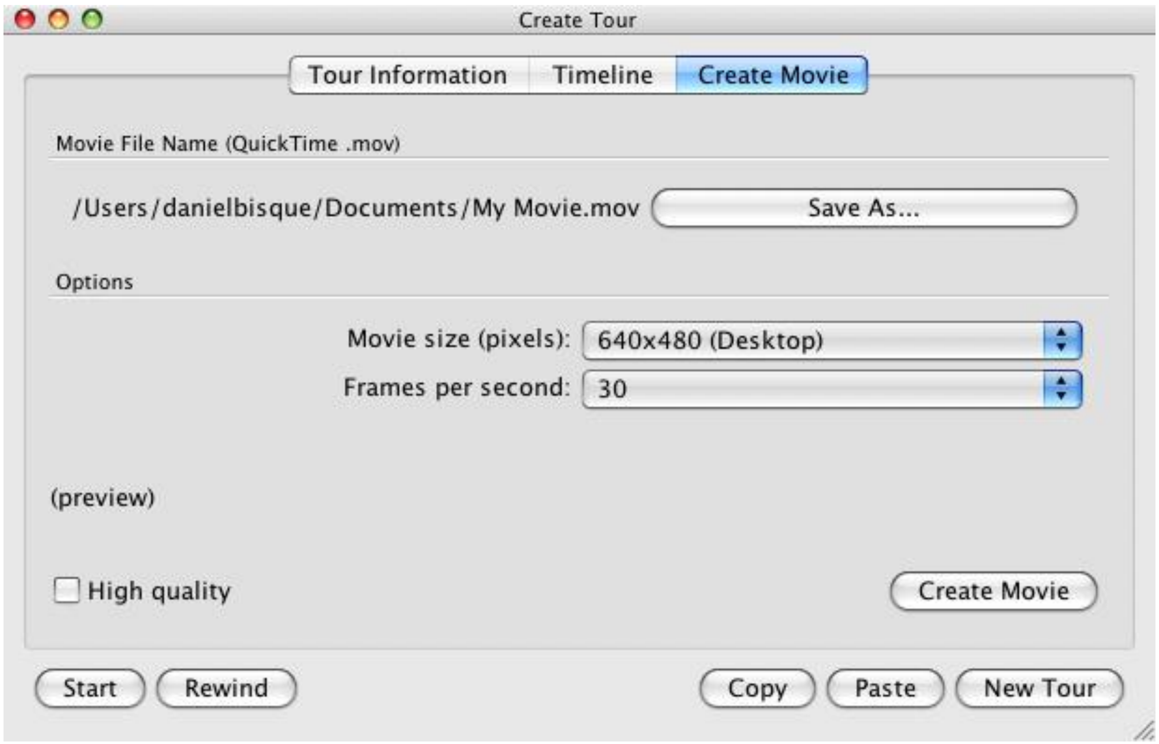


Figure 35: Create Movie tab.

Movie File Name

Displays the file name of the movie that will be created. Click the ***Save As*** button to specify a different file name.

Save As Button

Click this button to enter the name of the movie.

Options

The resolution and frame rate of the movie is configurable to your audience.

Movie Size (Pixels)

Select the resolution of movie from the ***Movie Size*** list.

- 320x240 (iPod Classic)
- 640x480 (Desktop)

- ***480x272 (PSP)*** Sony PlayStation Portable™ format
- 480x320 (iPhone/iPod Touch)
- 800x600

Frames per Second

Select the number of frames, or frequency to capture the Sky Chart when creating the movie. The higher the frames per second, the better the quality at the expense of a larger movie file.

High Quality

Turn this radio button on to configure high quality QuickTime movie settings.

Create Movie

Click this button to create the movie. The length of time it takes create the movie depends on the length of the tour, the resolution and frame rate settings, as well as the speed of your computer.

Photos of the Deep Sky

Since the middle of the 19th century astronomers have been taking pictures of the sky. In recent years, digital imaging sensors have replaced film to capture even more remarkable views of the Moon and planets, as well as star clusters, nebulas, and galaxies. Relatively modest amateur telescopes, equipped with digital cameras, can capture images that rival the best photographs taken by professional observatories just a couple of decades ago.

TheSkyX has a veritable art gallery's worth of fantastic space images you can look at any time. Browsing these images will give you a taste of the extraordinarily diverse number of objects that populate the night sky.

Viewing Astronomical Photos

In the stacked windows, you'll see a tab called ***Photos***. Select it. (Select the ***Photos*** command from the ***Display*** menu to show this window if necessary.)

In the dialog that opens, you'll see two items, ***Photo Groups***, and ***NGC/IC Digitized Sky Survey Photos***. NGC/IC stands for New General Catalogue/Index Catalog. These are two of the most popular catalogs astronomers use to keep track of the huge number of celestial objects they've been studying over the centuries.

As you scroll through the list of objects, a small picture of each will be displayed below the list. Click the ***Show in Photo Viewer*** option to view them in a separate window.

Placing Photos

PROFESSIONAL

TheSkyX Professional Edition's ***Place Photo*** command lets you create and manage individual or groups of photographs and provides tools to precisely position each photograph on the Sky Chart. In short, there's everything you need to show off your "in-place" photos.

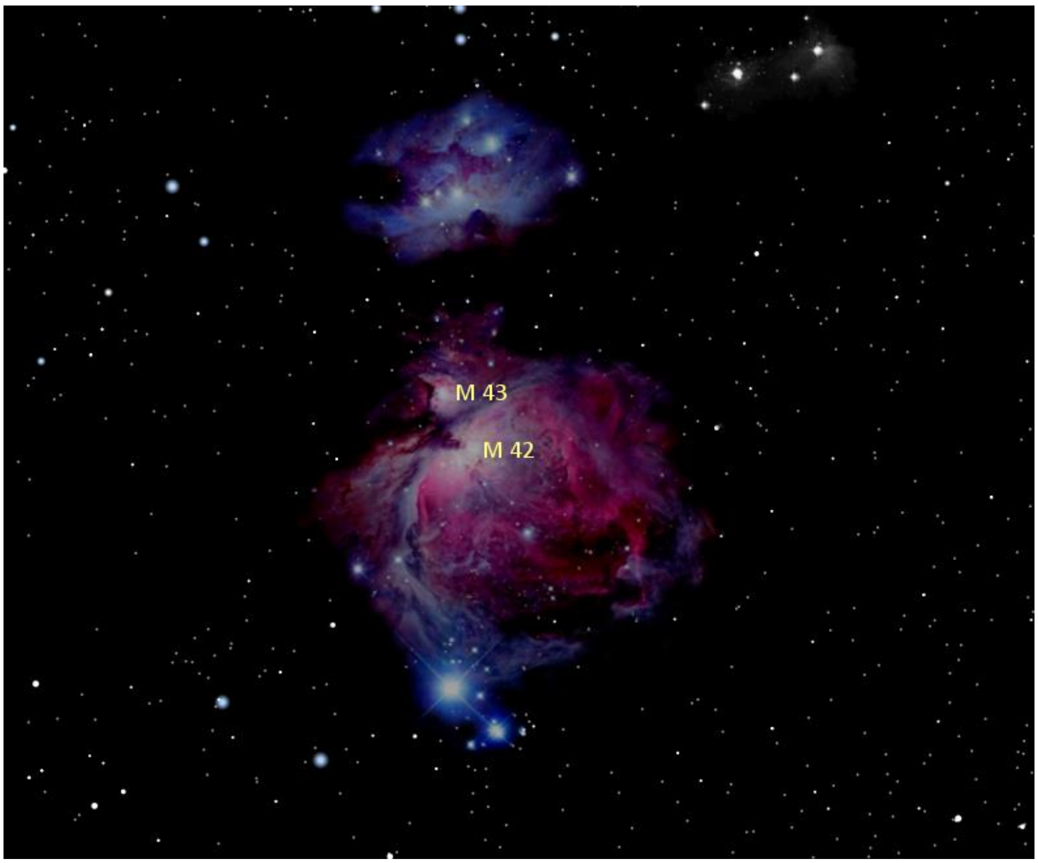


Figure 36: Sky Chart showing in-place photo of the Great Nebula in Orion (M42).

The Bevis constellation drawings are one example of one Photo Overlay Group that is included with *TheSkyX*. The ***Deep Sky Overlays*** is another.

Creating a Photo Group

To create a photo group from your collection, start by copying all the photos to a single folder on your computer. Note that *TheSkyX* can show *GIF*, *JPG*, *TIFF* and *PNG* file formats. The *PNG* format works well since it can have a transparency layer and is compressed.

We'll use the ***Messier Overlay*** photos as a "collection" to demonstrate how to create a photo group. On the Mac, *TheSkyX's* resources are stored inside the *application bundle*, so these photos are not readily accessible or visible from Finder. If you are familiar with accessing files in an application bundle, you'll find the files in this example in the *Resources/Common/Photos/SDBs/Messier Overlays* folder. If you'd like to follow along, you can make a copy of these files in a folder on your desktop. On Windows, these files are located, by default, in the following folder:

C:\Program Files\Software Bisque\TheSkyX <Edition Name Here>\ Resources/Common/Photos/SDBs/Messier Overlays

Where *<Edition Name Here>* is either *TheSkyX Serious Astronomer Edition* or *TheSkyX Professional Edition*.

1. To avoid confusion, first turn off the existing Messier Overlays Photo Group by clicking the ***Database Manager*** command from the ***Input*** menu, and turning off the checkbox next to ***Messier Overlays*** in the ***Photo Databases*** node under ***Sky Databases***, then click ***Close***.
2. Select the ***Place Photo*** command from the ***Input*** menu to show the ***Place Photo*** window.

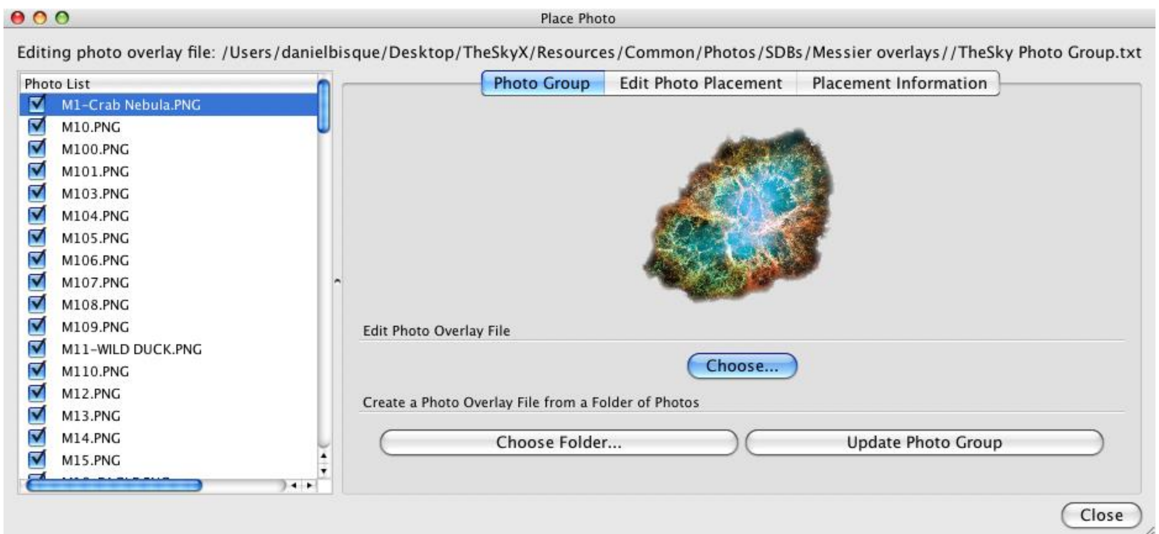


Figure 37: Photo Group tab on the Place Photo window (Input menu).

3. On the ***Photo Group*** tab, click the ***Choose Folder*** button and navigate to the folder that holds your collection of photos then click the ***Choose*** button.
4. Your photos appear in the ***Photo List***. The name of the photo group text file, which stores the photo group information, is listed in the ***Editing Photo Overlay File*** text input box.
5. To overlay and place a single photo in the list on the Sky Chart, highlight its name. A preview of the photo appears on the Photo Group tab.
6. Click the ***Place Photo*** tab. The selected photo is centered on the Sky Chart. From here, you need to adjust the Sky Chart's center coordinates, field width and rotation to align the photo.

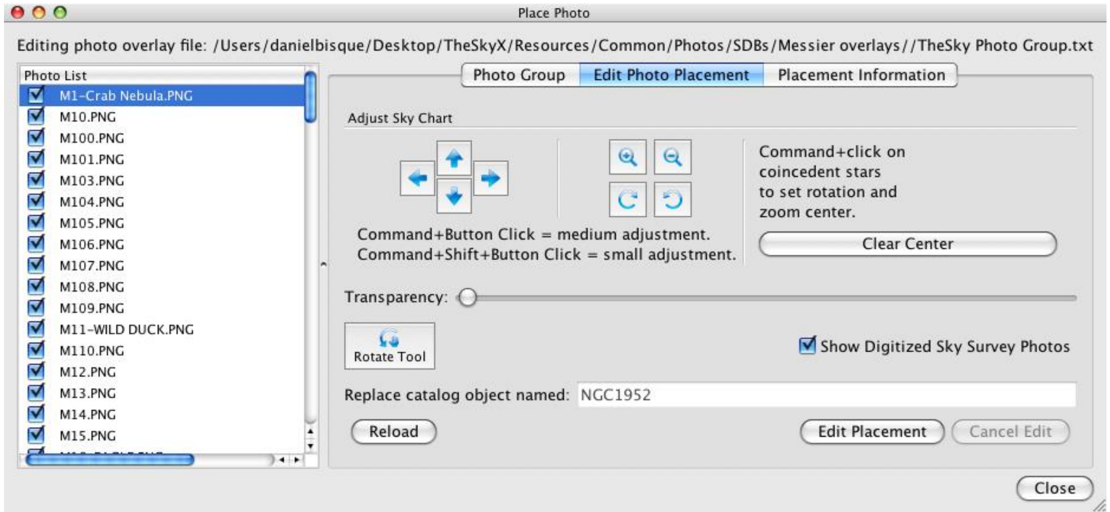


Figure 38: Edit Place Placement tab on the Place Photo window.

7. The ***Edit Photo Placement*** tab has tools to move left, right, up, down, zoom in, out and rotate the Sky Chart so that the photo can be aligned with the Sky Chart. Click the ***Edit Photo Placement*** button to begin this process. The ***Show Digitized Sky Survey Photos*** checkbox allows you to show these photos as another frame of reference to help align your photo. Once you are satisfied with the position of the photo, click the ***Save Placement Changes*** button to save it. Click the ***Cancel Edit*** button to abort the process and not save changes.
8. Repeat steps 5-7 for each photo in the ***Photo List***.

Placement Information

Click on the ***Placement Information*** tab to show the equinox 2000.0 ***RA/Dec*** coordinates of the photo, as well as the photo's ***Scale***, in arcseconds/pixel and ***Position Angle***, in degrees.

Managing Photo Databases

Click the ***Database Manager*** command on the ***Input*** menu to show the ***Database Manger*** window. Next, expand the ***Photo Databases*** branch of the ***Sky Databases*** node in the ***Databases*** tree to show the available photo overlays.

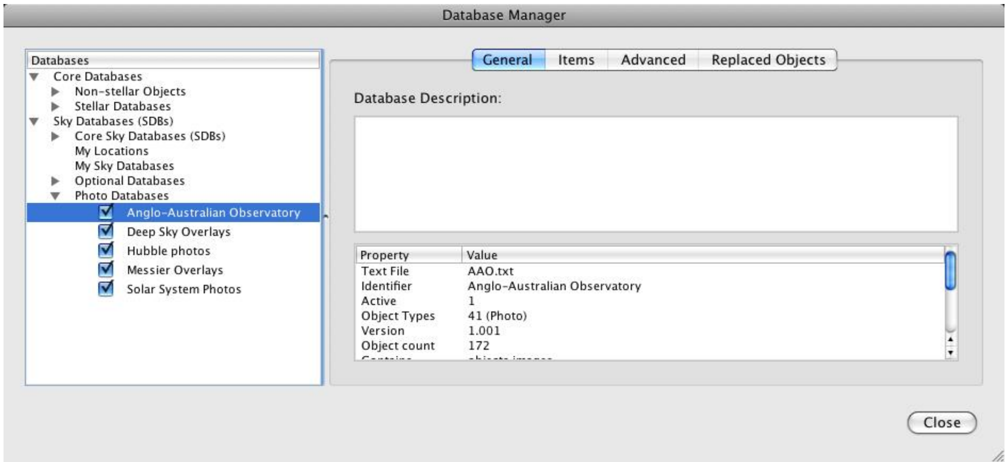


Figure 39: Photo Databases in the Database Manager's Databases list.

Viewing Photos from the Digitized Sky Survey

PROFESSIONAL

TheSkyX Professional Edition can overlay photos from the Digitized Sky Survey (DSS) on the Sky Chart (see Figure 126) or retrieve the equivalent FITS image for any position on the celestial sphere and for any field of view up to 2° x 2°. This "all-sky photographic reference" can be extremely useful when searching for new objects such as supernovas or asteroids.

Overlaying Digitized Sky Survey Photos on the Sky Chart

1. Adjust the Sky Chart to the desired position and field of view. For example, frame the spiral galaxy M81 by selecting the ***Find*** command from the ***Edit*** menu, entering ***M81*** in the ***Search For*** text input, and then clicking the ***Frame*** button. You should now see the color photo of M81 on the Sky Chart.
2. For convenience, select the ***Celestial Sphere*** command from the ***Orientation*** menu. This command fixes the equatorial center of the Sky Chart to the center of the window with the north celestial pole "up" on the screen.
3. Select the ***Digitized Sky Survey*** command from the ***Tools*** menu.

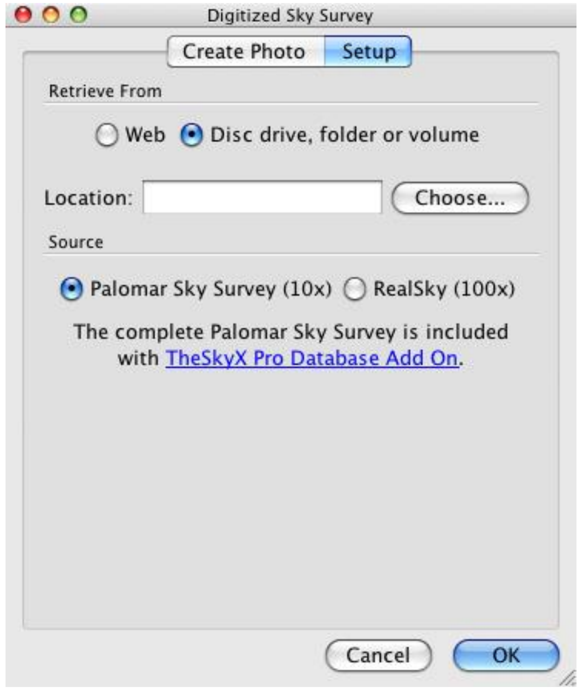


Figure 40: Setup tab of the Digitized Sky Survey window.

4. From the ***Setup*** tab, select the ***Web*** option (internet connection required). If you own the *TheSkyX Pro Database Add On* (page 520), select the ***Disc Drive, Folder or Volume*** option, click the ***Choose*** button to specify the location of the Digitized Sky Survey data, then select the ***Palomar Sky Survey (10x)*** option.
5. Click the ***Create Photo*** tab.
6. Click the ***Fill Sky Chart*** button. The photo is retrieved from the selected source.
7. Click the ***Show Photo in Front of Chart Elements*** option to show the photo on top of everything else on the Sky Chart.

Creating a FITS File of a Digitized Sky Survey Photo

1. Follow steps 1-5 above.
2. Click the ***Create*** button. The FITS file is retrieved from the selected source and displayed in the FITS Viewer window.

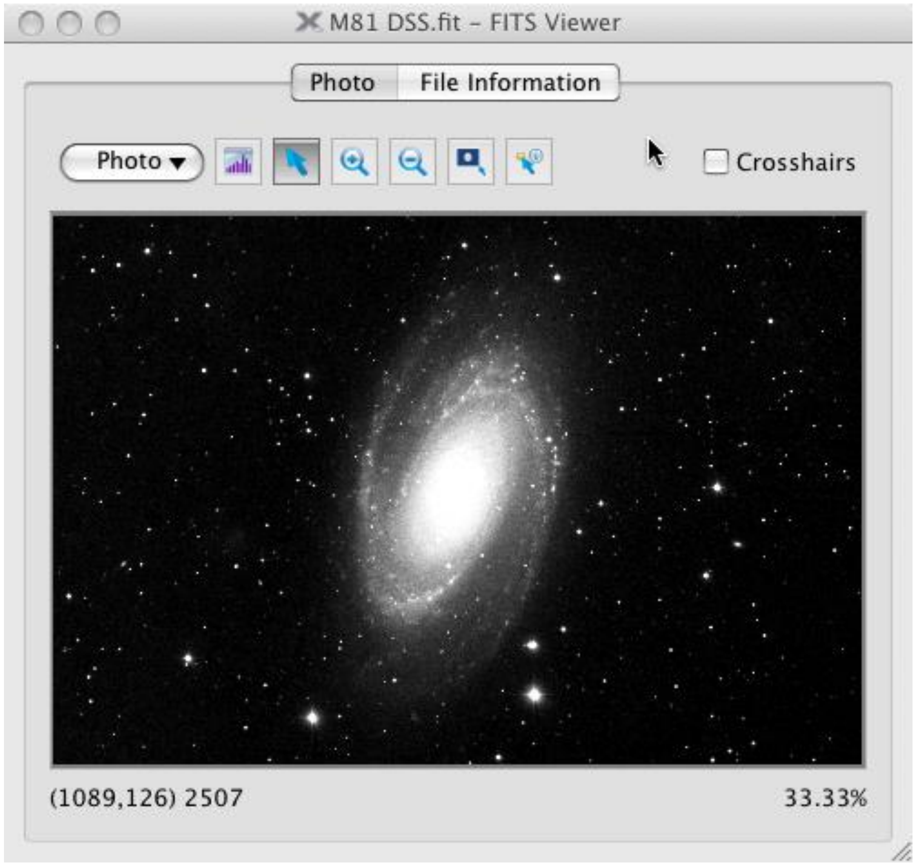


Figure 41: M81 in the FITS Viewer window.

Viewing FITS Photos

PROFESSIONAL

TheSkyX Professional Edition uses the High Energy Astrophysics Science Archive Research Center's (HEASARC) *CFITSIO* software library to manage FITS files. It is the "standard" library that handles the all complexities of different FITS file formats so that your FITS (provided it adheres to the FITS standard) will be opened and displayed correctly.

Opening a FITS

1. Click the ***Open FITS*** command from the ***Tools*** menu.
2. Navigate to the location of the FITS file, select it and then click ***Open***.
3. The FITS photo is now displayed on the ***FITS Viewer*** window.

FITS Viewer Window

The ***FITS Viewer*** window contains basic image manipulation commands and shows a table with the FITS header information.

Photo Pop-Up Menu

The following commands are available from the ***Photo*** pop-up menu.

Open

Opens a FITS and displays it on the ***FITS Viewer*** window. Note that the FITS file must use the extension FIT or FTS to be recognized as a FITS on the Mac.

Save

Saves the FITS file using its current file name.

Save As

Saves the FITS file using the file name you specify.

Print

Prints the FITS file to the default printer.

File Information

This command shows the ***File Information*** tab with the FITS header information. Search the web for the *Flexible Image Transport System specification* for details about FITS headers and keywords.

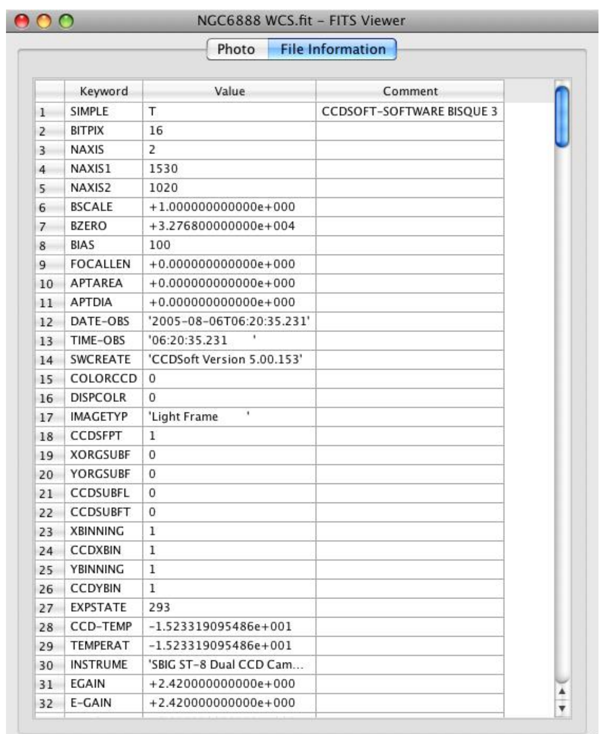


Figure 42: The FITS Header Information tab on the FITS Viewer window.

Zoom In/Zoom Out

These commands can be used to change the scale of the displayed photo by zooming in or out.

Actual Pixels

This command shows the photo without any scaling..

Clear

Click this command to close the FITS image.

To Image Link

Select this command to copy the displayed photo to the ***Image Link*** window. See "Image Link and Automated Astrometry" on page 243 for details.

Close

Click this command to close the ***FITS Viewer*** window.

Fits Viewer Toolbar

The toolbar buttons located at the top of the ***FITS Viewer*** window give access to commonly used commands to manipulate photos.

Histogram Control Button

Click this button to show the histogram control at the bottom of the ***FITS Viewer*** window. The histogram control is used to adjust the photo's contrast.

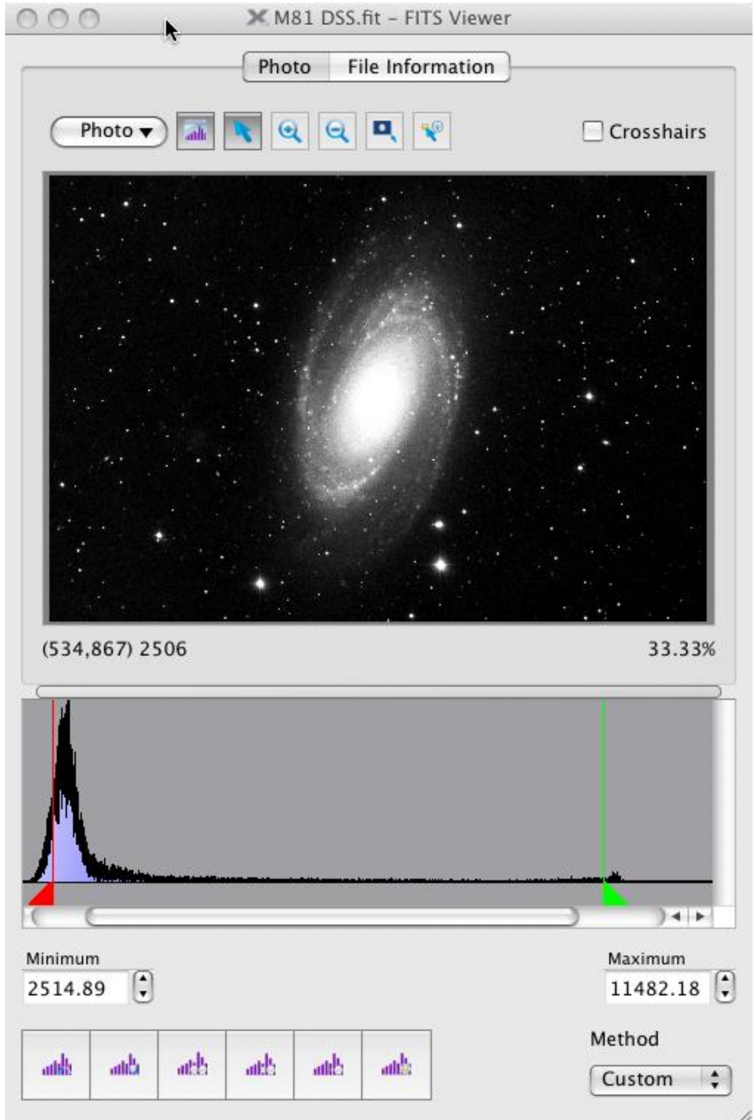


Figure 43: The histogram control is displayed by clicking the Histogram button.

The Histogram Control

The histogram control allows the photo's contrast to be adjusted both graphically and manually, by entering numbers that represent minimum (black point) and maximum (white point) points to scale the photo's data.

The upper portion of the histogram control shows a red triangle with a red vertical line, and green triangle with a green vertical line. Red represents the position on the histogram below which all data are displayed using the color black. Green represents the position on the histogram above which all data is displayed using the color white. Values between the minimum and maximum positions are scaled using different shades of gray.

- Click and drag the red triangle to adjust the black point.
- Click and drag the green triangle to adjust the white point.

- Placing the mouse cursor on the histogram window and use the mouse scroll wheel to zoom in on the histogram graph at that position.
- Swap the position of the red and green triangle to show the photo's negative.

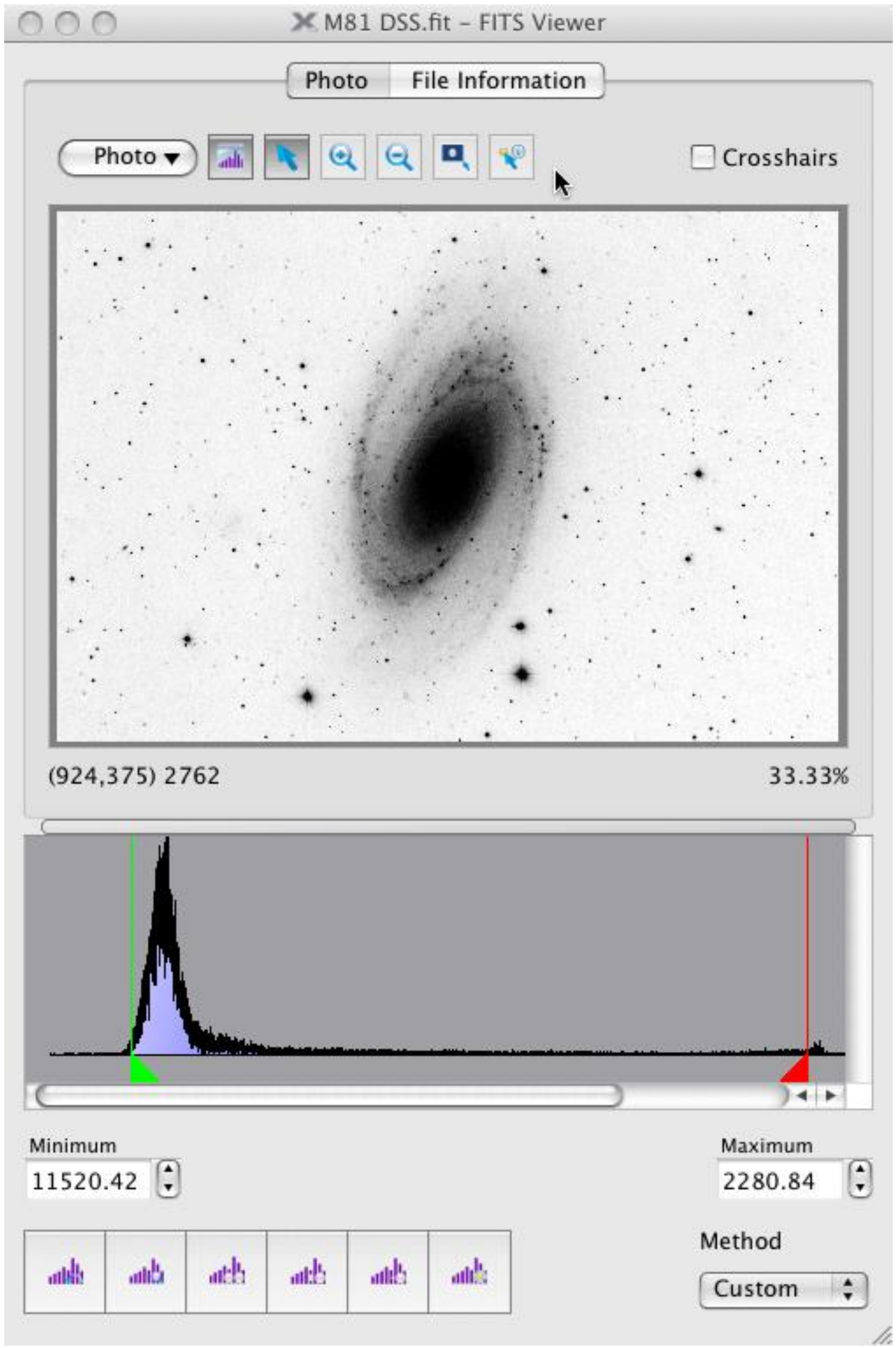


Figure 44: Green and red triangles are inverted to show the photo black on white (as a negative).

Minimum

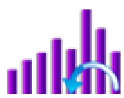
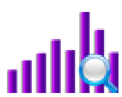
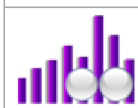
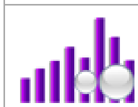
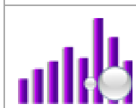
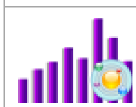
Enter the value below which the photo's data is scaled to the color black.

Maximum

Enter the value above which the photo's data is scaled to the color white.

Histogram Control Toolbar

The six toolbar buttons on the Histogram window are described in the table below.

Button	Description
	Click this button to reset the histogram's minimum and maximum values to zero and the maximum data value for this photo, respectively. For example, the maximum value of a 16-bit FITS photo would be 65,535.
	Click this button to scale the histogram so that minimum and maximum contrast values approximately match the photo's data.
	Click this button to scale the histogram for low contrast.
	Click this button to scale the histogram for medium contrast.
	Click this button to scale the histogram for high contrast.
	Click this button to scale the histogram to best show photos of planets.

*Method**

The ***Method*** pop-up menu on the lower left corner of the *Histogram Control* provides several different algorithms that can be used to set the photo's contrast.

SBIG

Use SBIG's algorithm to scale the photo.

Bjorn

This is a proprietary algorithm (named after the author) that can be very effective in setting appropriate contrast values for a variety of photos.

The Bjorn method's ***Background*** settings include:

- None
- Weak
- Medium
- Strong
- Very Strong

The "stronger" the background setting, the higher the black point on the histogram. A ***Very Strong*** background shows the least faint detail in the photo.

The Bjorn method ***Highlights*** options include:

- None
- Weak
- Medium
- Strong
- Very Strong
- Adaptive (for general purpose use)
- Planetary (best for planets)

The lower the highlight setting, the higher the white point value and the more "data" that is included when scaling the histogram. Lower highlights can reveal details in the brightest portions of the photo.

Linear

This method scales the data in the histogram linearly.

Custom

Use this option with the ***Minimum*** and ***Maximum*** inputs to scale the photo.

*If the contrast algorithm used to scale a photo's histogram results in an all-white or all-black photo, try using a different contrast method.

Arrow Button

When the ***Arrow*** button is clicked, the X and Y position of the mouse cursor, and the brightness value of this picture element (pixel) is displayed in the lower left of the photo window.

Clicking and dragging changes the position of the zoomed photo.

Zoom In Button

Click this button to zoom in and magnify the photo.

Zoom Out Button

Click this button to zoom out, making the photo appear smaller in the window.

Subframe Button

Click this button to enable the subframe tool can be used to draw a rectangular region, or subframe on the photo.

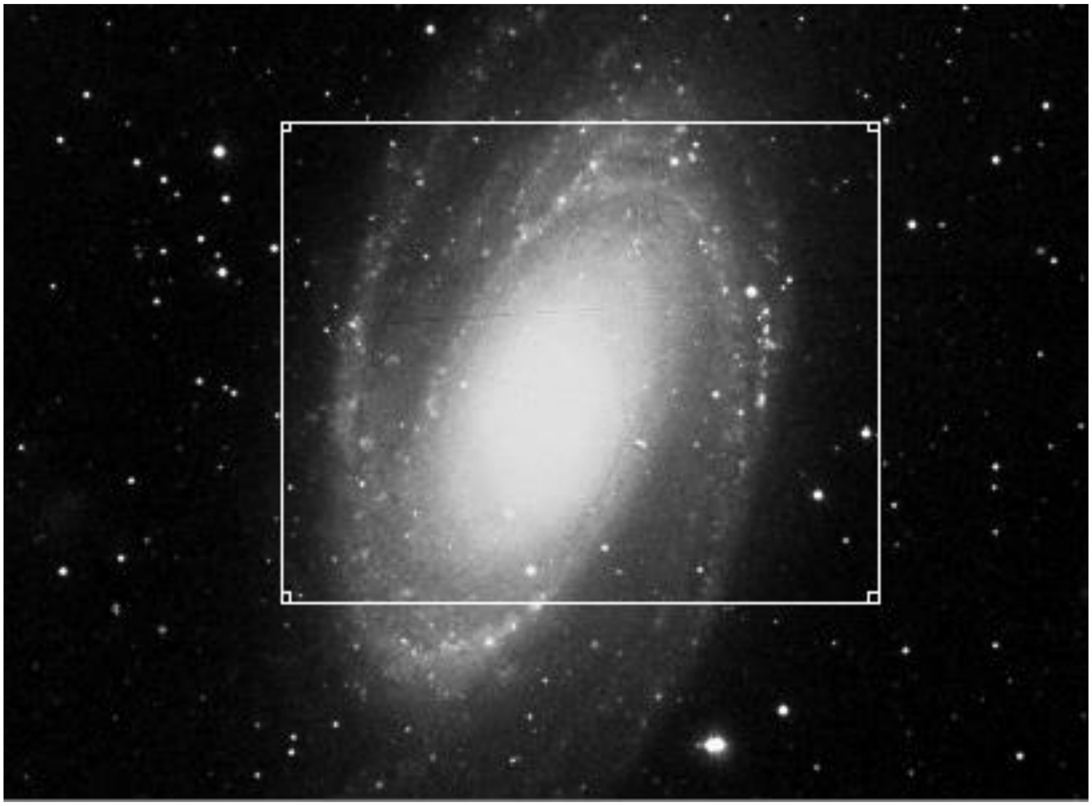


Figure 45: A subframe drawn on the photo of M81.

The control is presently only used to define the region around a guide star during autoguiding (page 375).

Text Tool

Click this button to enable the text tool that can be used to add text to a photo. Click on the photo to place the text input box, then enter the desired text. The text box can be clicked and positioned anywhere on the photo.

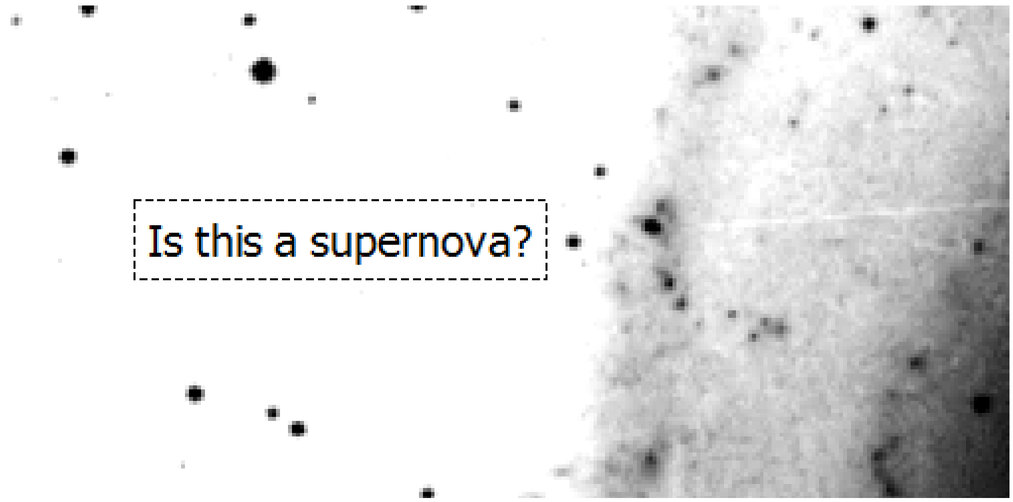


Figure 46: Custom text can be added to photos.

Cursor Information

Click this button to display the pixel position and right ascension and declination coordinates of the pixel directly under the mouse cursor, based on the photo's World Coordinate System (WCS) information. If the photo does not contain WCS, only the pixel position is shown.

The equatorial coordinates of a centroid around the region under the mouse cursor is also displayed. Notice the slight difference between the ***Cursor*** coordinates and the ***Centroid Under Cursor*** in Figure 47.

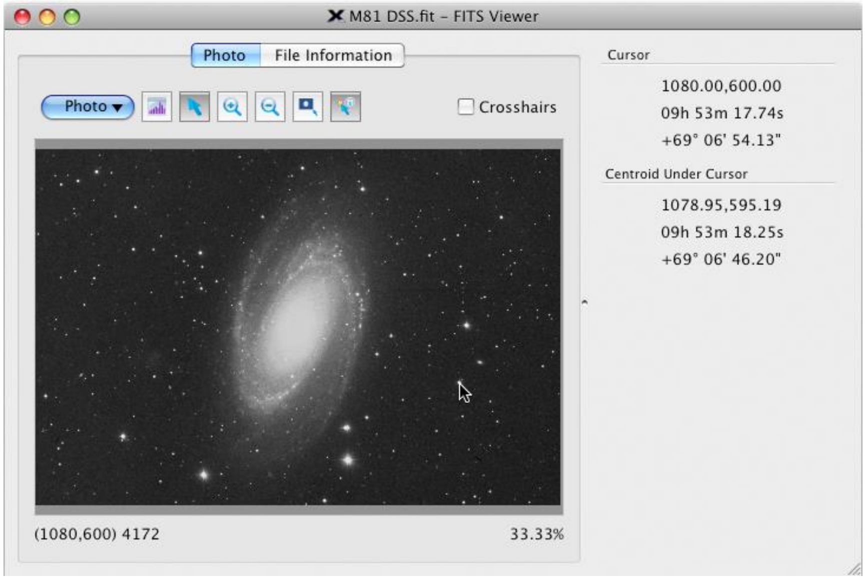


Figure 47: The Cursor Information button shows WCS coordinates for the cursor position.

Crosshairs

Turn on this checkbox to overlay a graphical crosshair on the photo.

Your Sky Tonight

This section is intended to help you explore the night sky from your location on any date, at any time. You'll be able to answer the question: "When I head outside tonight at, say, 9 p.m., what am I going to be able to see?" You'll also learn how to plan ahead for special events, like meteor showers and lunar eclipses.

For a given location, what you can see in the sky on any given night depends on the date and time. The stars that are visible at 9 p.m. on a December night are very different from the ones you would see at 9 p.m. in June, for example. And the Moon and planets follow their own unique celestial paths – their positions, and their brightness, vary from month to month and year to year.

Observing Lists

TheSkyX includes a command that will display a select list of objects that will be visible in your night sky on the current date. You can set the parameters of this list to choose the kinds of objects you're most interested in seeing.

To generate a What's Up Observing List:

1. Go to the ***Tools*** menu.
2. Select the Manage Observing List command.

3. Click the ***What's Up Setup*** tab.
4. Select the ***Viewing Time*** for the list.
5. Select the ***Optical Aid*** that you will be using.
6. Click the ***What's Up?*** button.
7. Click the ***Close*** button.

Clicking the ***What's Up?*** button creates and shows the list of objects that are visible from your location in tonight's sky on the Observing List window. When you highlight an item, observing notes are displayed.

Some of these objects, and the data displayed with them, may be unfamiliar to you. We'll be describing most of the information in the ***What's Up?*** command in more detail on page 230.

Field of View Indicators

A Field of View Indicator (FOVI) is a chart element that represents the field of view that is rendered by an eyepiece, CCD sensor, camera body and optical tube, or a Telrad™ finder, binoculars or other optical system.

As you zoom in or out in the Sky Chart, the FOVIs shrink or grow in proportion to the field of view. The utility to this feature is endless, particularly helpful during observing sessions and with telescope control. Easy, quick identification of celestial objects can be made when you view the Sky Chart as if you were looking through the eyepiece, so there is no guesswork required.

Choosing Your Telescopes, Eyepieces and Cameras

Select the ***Field of View Indicators*** command from the ***Display*** menu to open the ***Field of View Indicators*** window.

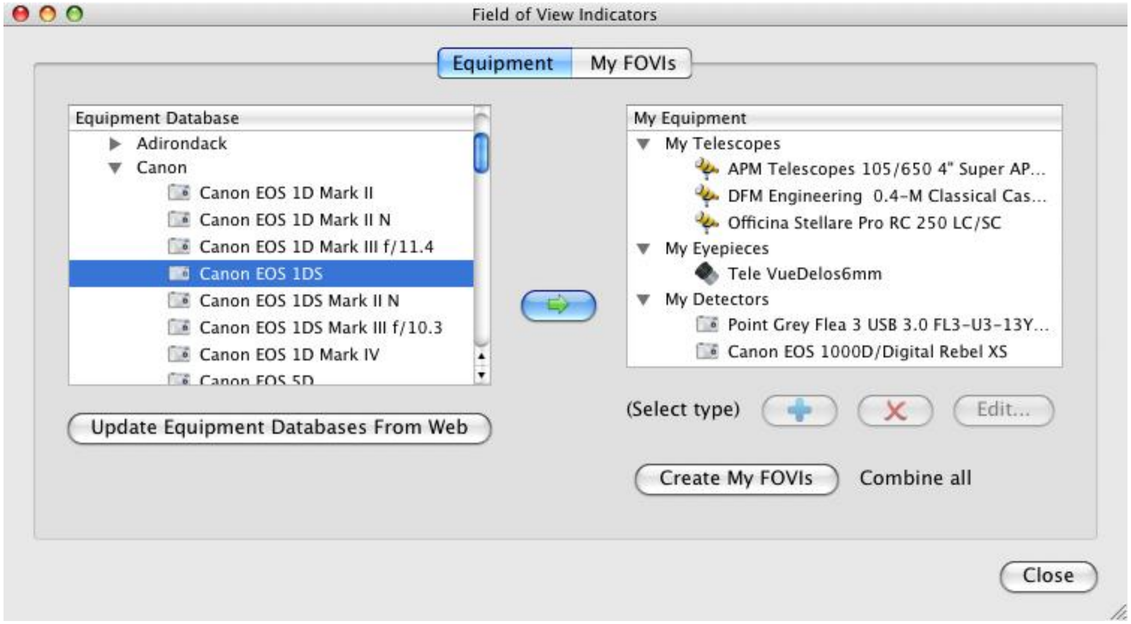


Figure 48: Field of View Indicators dialog.

To the left, you will see the equipment database list, including selections for ***Telescopes***, ***Eyepieces***, and ***Detectors***. To select a telescope, expand the ***Telescopes*** portion of the tree. You will see a large selection of telescope makers. Expanding a telescope maker's menu will produce a list of telescope models by that manufacturer. Choose your telescope from the list. Once you have selected your telescope, click the ***green arrow*** button found in the middle of the window. You will then see the telescope listed on the ***My Equipment*** list to the right of the window.

Now, choose your eyepiece and/or detector from the appropriate menu from the left side ***Equipment Database***.

Update Equipment Databases from Web Button

If your model camera, eyepiece, lens or telescope is not listed, click this button to download the most recent equipment databases available from the Software Bisque web site, then check the appropriate ***Equipment Database*** to see if your hardware has been added since you installed your software.

If your equipment still does not appear, post a question on the Software Bisque community forums with the exact make and model of your equipment, and we'll update the web-based databases.

Once you have chosen your telescope, eyepieces, and detectors, click the ***Create my FOVIs*** button. You will then be taken to the ***My FOVIs*** tab, where each FOVI will appear in a list with a checkbox to turn each FOVI on or off.

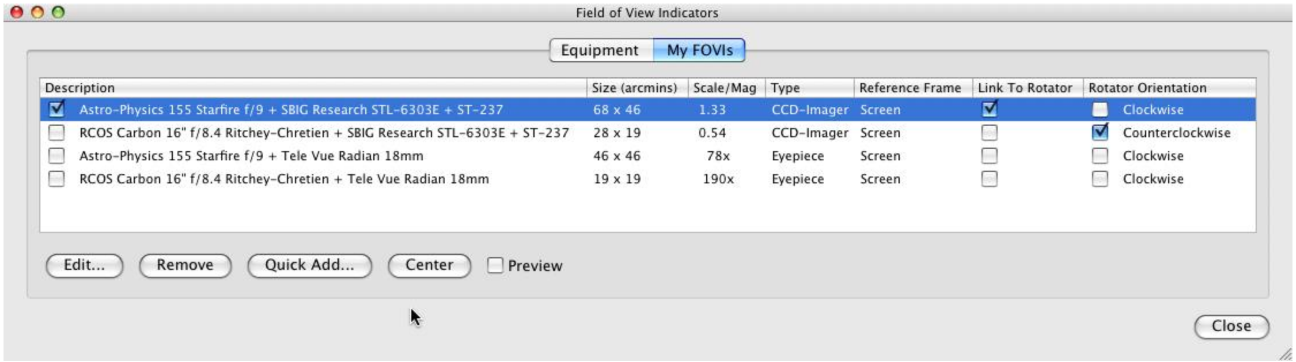


Figure 49: My FOVIs tab.

Selecting a FOVI and clicking the ***Edit*** button will show the ***Add/Edit Equipment*** dialog where you can edit each element and aspect of the telescope and eyepiece or detector combination (page 97).

Clicking the ***Quick Add*** button also opens the ***Add/Edit Equipment*** dialog, in which you can add a FOVI with characteristics of your choosing. Just input the desired ***Shape***, ***Reference Frame***, and ***Width and Height*** in arcminutes, and you've added a brand new FOVI of custom dimension.

Clicking ***Remove*** will remove a FOVI from the list. Clicking ***Center*** will center the FOVI on the screen.

Checking the ***Preview*** checkbox will reveal a preview of each selected FOVI in the Sky Chart. When the ***Preview*** checkbox is turned on, the currently selected FOVI is centered on the Sky Chart. This lets you quickly determine which optical system is best for your needs.

Note that if you turn on both the ***Preview*** checkbox *and* the checkbox next to a FOVI, two identical FOVIs will appear on the Sky Chart (the "preview" FOVI and the actual FOVI). To avoid confusion, make sure to turn off the ***Preview*** checkbox before closing this window.

Remember that FOVIs represent the view through your telescope, and will not appear on the Sky Chart if the chart's field of view is set to 100° (naked eye) and wider. To see the indicators, you must zoom to a smaller field of view.

The ***My FOVI*** tab shows the following information for each field of view indicator.

Description

The FOVI description is the combination of the telescope and the eyepiece or detector description. To change a description, highlight the FOVI in the list and click the ***Edit*** button.

Size

The size column shows the angular dimensions of the FOVI, in arcminutes.

Scale/Magnification

For telescope and camera FOVIs, the scale or image scale, in arcseconds per pixel is displayed. The optical system's magnification is displayed when the FOVI consists of a telescope and eyepiece.

Type

The ***Type*** column shows either ***Eyepiece*** for eyepiece plus telescope combinations, or ***CCD*** for a camera plus telescope FOVI.

Reference Frame

This column shows the frame of reference to use when displaying the FOVI. See "FOVI Frame of Reference (Reference Frame List)" on page 99 for details about reference frame options.

Link to Rotator

This column shows a checkbox that can be turned on to link a field of view indicator to the rotator hardware. When turned on, rotating the field of view indicator (page 99) also moves the rotator hardware to the same position angle.

Rotator Orientation

This column shows a checkbox that can be used to change the rotator hardware's relative direction of rotation. To determine the direction of rotation, move the physical rotator to zero degrees, turn on ***Link To Rotator*** for the FOVI, then rotate the FOVI (page 99) 10 degrees. If the checkbox is turned off (which means the default direction of rotation is ***Clockwise***) but the rotator hardware shows a rotation angle of –10 degrees (or, 350 degrees), then turn on the checkbox so that the rotator orientation is ***Counterclockwise***.

Showing Telrad Finders

Telrad™ finder FOVIs are shown at all fields of view (but may not be completely visible at small fields) and can be added to the Sky Chart using the ***My Chart Elements*** command on the ***Input*** menu.

To add one or more Telrad Finder FOVIs to the Sky Chart:

1. Click Input > My Chart Elements.
2. On the ***Manage*** tab, click the ***Add Telrad*** button.
3. Under ***Command+Click*** (Mac) or ***Ctrl+Click*** (Windows), select ***Cursor Position*** in the ***Snap To*** pop-up menu.
4. Position the mouse cursor over the Sky Chart, press and hold the ⌘ key on the Mac or the CTRL key on Windows, then click the left mouse button. A new Telrad finder is drawn at the current cursor position.

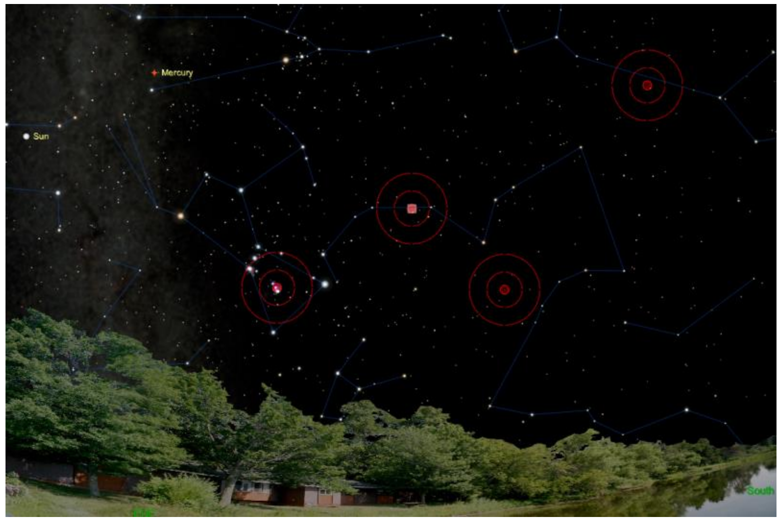


Figure 50: Sky Chart showing multiple Telrad finders.

To position a Telrad finder at a specific coordinate:

1. From the ***Manage*** tab on the ***My Chart Elements*** window, highlight the Telrad you want to move in the ***My Chart Element*** list by clicking on it or click on the center of the Telrad Finder on the Sky Chart. A selected Telrad finder appears as ***My Chart Element #*** in the ***Object Information Report*** on the ***Find*** window.
2. Click the ***Edit*** button (or double-click on the element) to show the ***Add/Edit Chart Element*** window.
3. To enter equatorial coordinates, click the ***Equatorial*** radio button then enter the right ascension (***RA)*** in hours, minutes and seconds and declination (***Dec)*** in degrees, minutes and seconds.

To enter horizon coordinates, click the ***Horizon*** radio button then enter the azimuth (***Azm)*** in hours, minutes and seconds and altitude (***Alt)*** in degrees, minutes and seconds.

To Drag and Move a Telrad Finder:

1. From the ***Manage*** tab on the My Chart Elements window, select the Telrad you want to move in the ***My Chart Element*** list, or click on the center of the Telrad Finder on the Sky Chart. A selected Telrad finder appears as ***My Chart Element #*** in the ***Object Information Report*** on the ***Find*** window.
2. Click and drag the small red rectangle in the center of the Telrad finder to move it.
3. Release the mouse when the Telrad is positioned where you want it.

Adding or Editing Field of View Indicator Properties

Clicking the ***Edit*** button or the ***Quick Add*** button on the ***My FOVIs*** tab (***Field of View Indicators*** dialog) shows the ***Add/Edit Equipment*** dialog. This window lets you define up to twenty different FOVI elements.

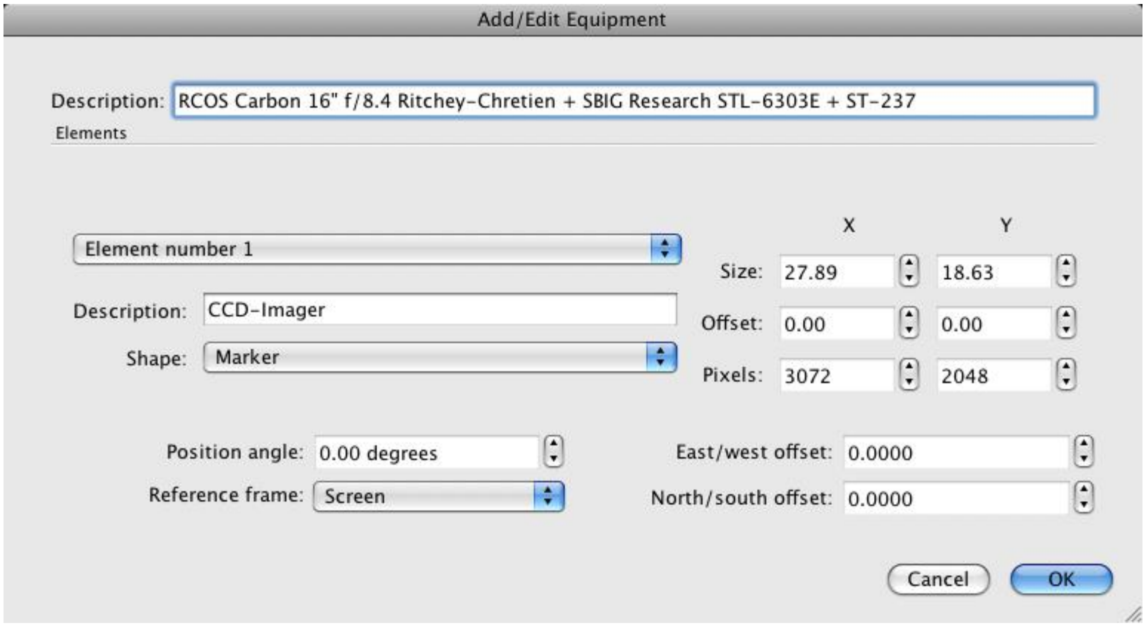


Figure 51: The Add/Edit Equipment dialog (clicking the Edit button).

Field of View Indicator Description (Description)

Enter a description for your detector, such as *Super CCD with 10 Detectors*.

Element Number List

Up to twenty separate FOVI elements can be defined for each FOVI. For example, if your camera has a built-in autoguider, then the FOVI will have two different elements, one for the imaging detector and one for the autoguider.

Element Description (Description)

Enter a text description for the element, such as “ST-237 guider mounted to my guide scope”.

Shape

Specify the shape of the element. An element can be:

- Circular (or elliptical)
- Rectangular
- Marker (a small cross offset from the main FOVI)

Position Angle

Enter the position angle, measured *clockwise** from North, of the FOVI element. The FOVI’s position angle can also be modified by clicking and dragging on the FOVI graphic that appears on the Sky Chart.

Conventionally, position angle is measured* ***counterclockwise* *from North, not* ***clockwise****. Unfortunately, TheSky historically used the opposite convention for FOVIs, and changing the* *convention would adversely affect all third-party scripting applications that use FOVIs. So, we've opted to maintain the unconventional FOVI position angle.*

To rotate a FOVI on the Sky Chart

1. Click on a FOVI line to highlight the FOVI. The FOVI is highlighted when two small red "dragging squares appear on the FOVI"; one square appears at the center of the FOVI, and the second on the outer edge of the FOVI. The FOVI's current position angle is also displayed.
2. Click and drag the mouse on the outer square to adjust the FOVI's position angle.

Hint: When accurate FOVI position angles are required, the FOVI's position angle can be adjusted to one-tenth of one degree by clicking and dragging the mouse cursor away from the center of the FOVI. When the cursor is positioned further from the center of the FOVI, small changes in the mouse position results in small changes to the FOVI's position angle.

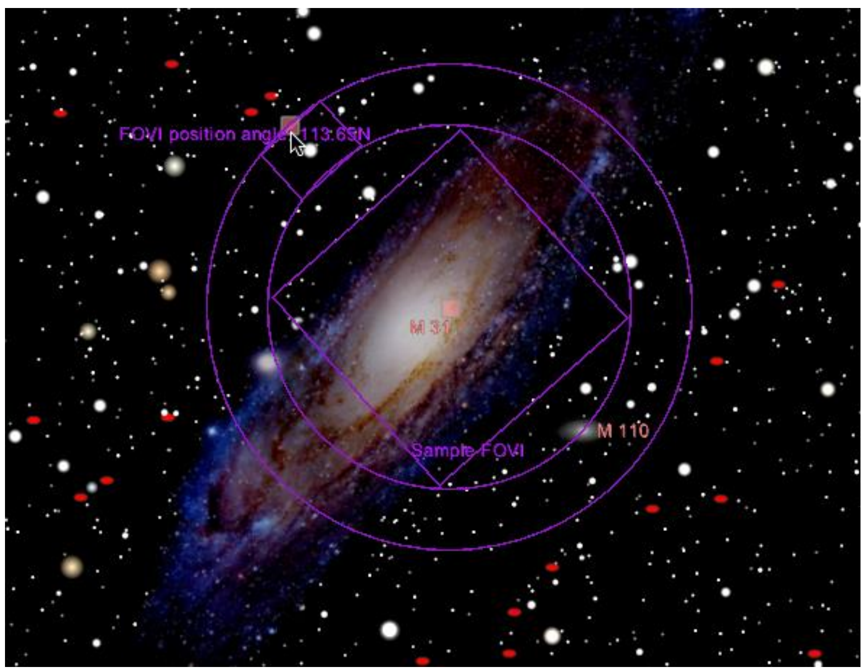


Figure 52: Click and drag on the small red square to change the FOVI's position angle.

FOVI Frame of Reference (Reference Frame List)

Select the frame of reference for the detector or detector/telescope combination.

- **Sky Chart**: The FOVI is pinned to the center of the Sky Chart.
- **Equatorial**: The FOVI is displayed specific equatorial coordinate.
- **Telescope Crosshairs**: When connected to a telescope, and the field of view 35º and smaller, the FOVI is displayed with the telescope crosshairs symbol in the center of the FOVI. At wider fields of view, only the telescope cross hair appears (two concentric yellow circles).

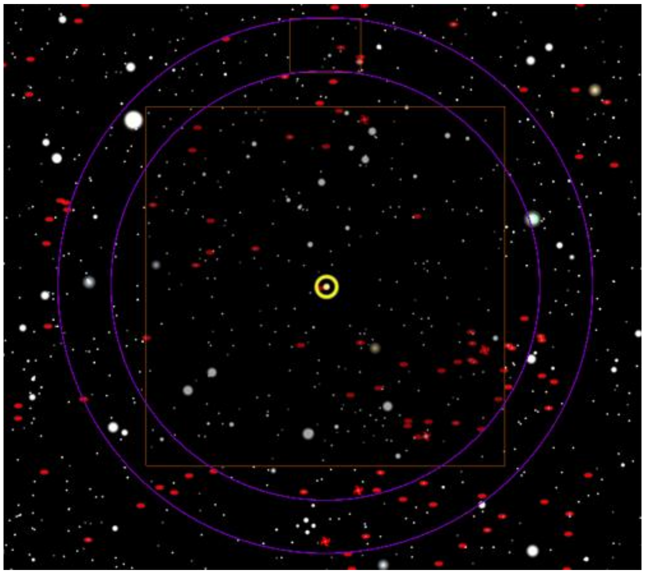


Figure 53: Sky Chart showing a Telescope Crosshairs FOVI at 35º and smaller fields of view.

- **Telescope Mask**: Use this option to simulate the view through a telescope. Regions outside the FOVI are “masked” and therefore not visible.

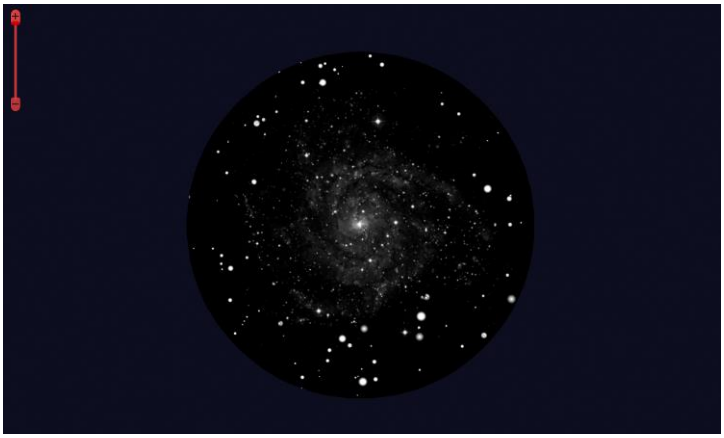


Figure 54: Sky Chart showing a telescope mask FOVI.

Size, X/Y

Enter the physical size of the camera’s detector, in mm.

Offset, X/Y

Enter the offset of the element from the Element Number 1, in mm.

Pixels, X/Y

For CCD cameras, enter the number of pixels in each axis. This value is used to compute the scale of images acquired with the camera, in arcseconds/pixel.

East/West offset

Specify the number of arcminutes to shift the center of the FOVI to the East or West. A number greater than zero shifts the FOVI West, a negative number shifts it East.

North/South Offset

Specify the number of arcminutes to shift the center of the FOVI to the North or South. A number greater than zero shifts the FOVI South, a negative number shifts it North.

Clicking the ***Quick Add*** button shows slightly different options.

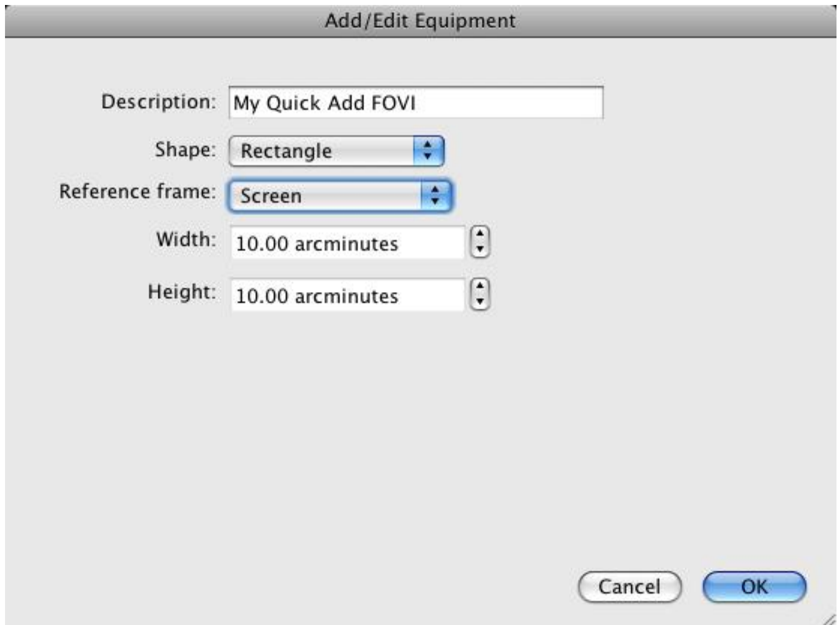


Figure 55: The Add/Edit Equipment dialog (clicking the Quick Add button).

Enter the FOVI's ***Description***, ***Shape*** and ***Reference Frame*** (described above) and the ***Width*** and ***Height,*** in arcminutes.

FOVIs and the Sky Chart

FOVIs that are displayed on the Sky Chart are configurable *and* customizable. They can be:

- Clicked and dragged to any part of the screen
- Copied and "pinned" to a specific equatorial (RA/Dec) coordinate
- Rotated to any angle
- Used as the telescope cross hairs
- Used to create a telescope mask

How to Position a FOVI on the Sky Chart

Select the FOVI on the Sky Chart by clicking on it, or click on the center marker (if the FOVI has a visible center marker). Two small reddish squares, and the position angle, appear when the

FOVI is selected. The center square can be dragged to move the FOVI; drag the outer square to change the position angle.

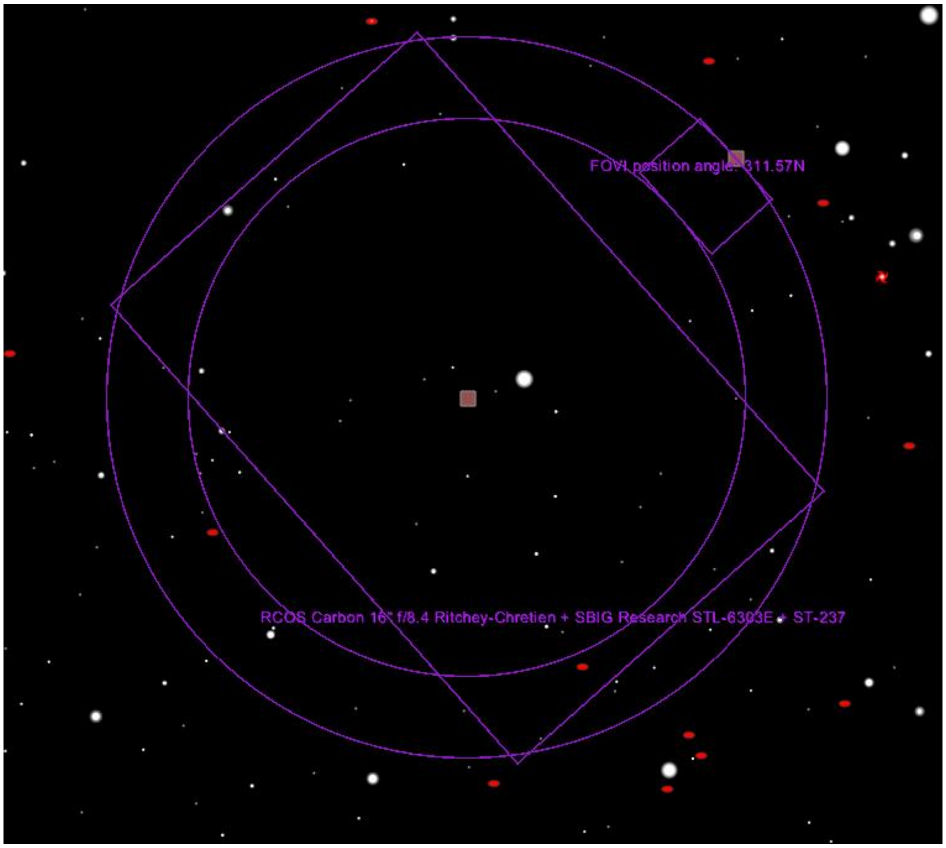


Figure 56: Clicking on a FOVI shows the position angle, and rectangles to position and orient it.

How to Use a FOVI as the Telescope Cross Hair

1. Click the Field of View Indicators command from the Display menu.
2. Click on the My FOVIs tab.
3. Highlight the FOVI that you want use as the telescope cross hair.
4. Click the ***Edit*** button.
5. On the Add/Edit Equipment dialog, select Telescope from the ***Reference Frame*** list.
6. Click ***OK***.

When the Sky Chart's field of view is small enough to resolve the FOVI, and the telescope is connected, the telescope's cross hair will include the FOVI, too.

Object Paths

Sometimes the best way to say something is with a picture. This is certainly true with a complex concept like planetary motion. Tracing out motion paths of solar system objects is the perfect way to demonstrate their motion and to plan for upcoming observation sessions. *TheSkyX* allows you to do so with ease and flexibility.

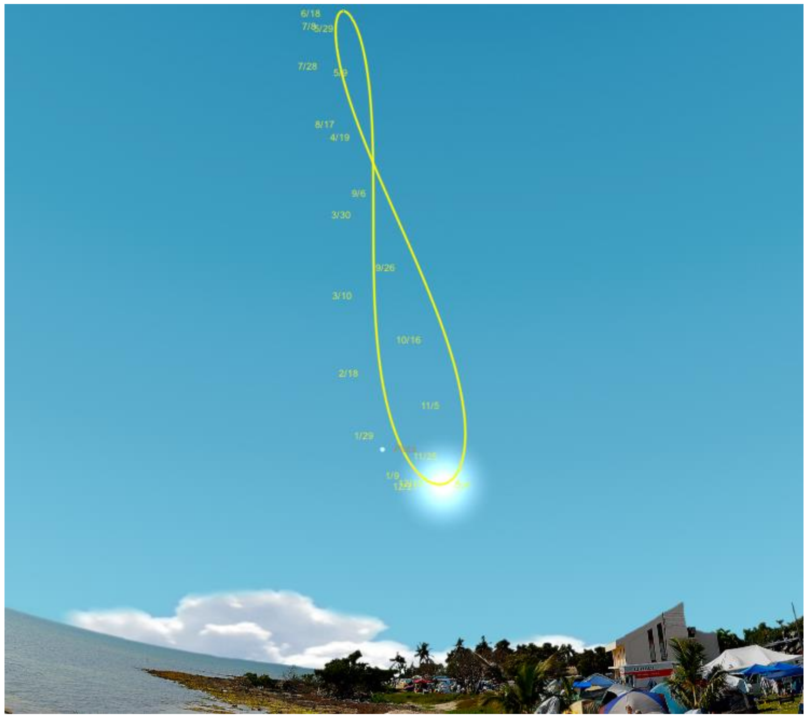


Figure 57: An object path showing the Sun's analemma.

Generating an Object Path

Selecting the ***Object Paths*** command from the Tools menu will bring up the ***Object Paths*** dialog. In it, you will see a list of solar system objects, along with various drop-down menus and buttons that control the various object path functions. On the left, you will see a list of solar system objects: the eight classical planets, plus Pluto, the Sun, Moon, comets, and asteroids. On the right, you will see information pertaining to the path that *TheSkyX* is currently set to create, including the number of items selected, the chosen time increment, the count of time increments, and the path style.

To get our feet wet, let's try out the object path tool on an observer's favorite, the planet Mars.

Note: This process works the same way with any object. If Mars is not in your sky right now, you can always choose another object, or adjust your Sky Chart to the next time Mars is visible.

1. Choose ***Object Paths*** from the ***Tools*** menu.
2. From the Select Solar System Object list, select Mars.
3. Looking over to the right side of the window, you will now see that ***Items Selected*** now says ***1***.
4. By default, *TheSkyX* sets the time increment to ***1 day***, which is changeable by using the pop-up menu. Let's leave it at 1 day for now.
5. The ***Count*** is set at ***30*** by default, which means that the system will calculate a path for 30 of the chosen time increments. In this case it is 30 days.

6. The ***Path Style*** may be changed from a connected line to a dotted line, each with various point styles. Experimenting with this feature will allow you to best decide which option is right for you.
7. Then, click the ***Create Path*** button, and a new path appears in the Sky Chart, revealing the path taken by Mars starting with the current system time and ending in the next 30 days.

In this example, the generated path shows the position of Mars in the sky each day at the same time. So, if the clock is set at 12:00 a.m. when you generate the path, it will show the position of Mars each day at 12:00 a.m.

Clicking the ***Show*** button in the ***Object Paths window*** will zoom in and center the path in the Sky Chart.

What if you would like to see the path that an object takes through the sky during a single day? *TheSkyX* makes that easy, as well. Using Mars as our example again, following these easy steps will lead you to success.

1. Select ***Object Paths*** from the Tools menu.
2. Choose Mars from the Select Solar System Objects list.
3. Ensuring that the ***Create Paths*** button is highlighted on the right, change the time increment to ***1 hour***.
4. Change the frequency to ***24*** by either typing it into the field or by using the field's arrow buttons.
5. Select the path style that is best for you.
6. Click ***Create Path***.

You will now see a path on the Sky Chart reflecting Mars' motion through the sky over the next 24 hours.

Remember, clicking the ***Show*** button in the ***Object Paths window*** will zoom in and center the path in the Sky Chart.

Once you get the hang of the example path, try out several different paths, changing the variables to achieve different effects.

Updating Object Paths

Should you wish to update object paths based upon new time and date settings, simply click the ***Update All*** button.

Clearing Object Path Data

If you would like to clear paths from the Sky Chart, click ***Clear All Paths***.

Create Paths Options

TheSkyX allows you to create object paths with a great amount of flexibility. The following is a detailed explanation of each option under the ***Create Paths*** menu.

Items selected

This area denotes how many objects are selected for which paths will be drawn. You may select as many objects as you wish from the list on the left.

Time increment

Here, you can select the desired increment of time for the object path. This input behaves similarly to ***Date and Time Control*** (page 111), where virtually any time increment can be specified using a <number>+<keyword> sequence. The time keywords include:

- ***year*** = 365.2425 days
- ***week*** = 7 days
- ***day*** = 1 Earth day
- ***hour*** = 1 hour of time
- ***minute*** = 60 seconds of time
- ***second*** = 1 second of time

Each keyword must be preceded by a number as shown in the examples below. Plural or singular keywords are acceptable.

5 hours 3 minutes 25.2 second
15 days
6 year
7 weeks

Count

Using this function lets you choose how many time increments you want to include in the object path. Selecting ***1 hour*** as the time increment and ***24*** as the count generates a path that is 24 hours in length, or about one Earth day.

Path style

Using the drop-down menu, the path style can be changed so that is drawn as a smooth connected line, a dotted line with points at each position, a dotted line with a graphical representation of the object at each position, or a continuous line with either dots or graphic objects at each position.

Interactive Object Paths

If you would like to create a path "interactively" using *TheSkyX*'s ***Date and Time*** control as the object moves, turn on the ***Interactive*** checkbox. When in the ***Interactive*** mode, paths will be created for the selected solar system objects as the time is changed using ***Date and Time*** controls.

When the ***Interactive*** checkbox is on, a ***Stop*** command is issued to the date time controls so that you can choose the desired skip increment. Use the ***Step Forward*** or ***Go Forward*** (or ***Backward***) controls to see the paths as they are generated.

Click the ***Remove Interactive Paths*** button to remove all paths from the Sky Chart. Note that paths can be up to 500 "time increments" long. Once they reach this maximum length, the object will continue moving but the path will no longer be recorded.

Path Labels

TheSkyX affixes labels to paths so that you can reference an object's position at any given time along the path.

To change labels for one or more object paths, first select the object(s) on left of the ***Object Paths*** dialog. If more than one path is selected, the first selected will be the template for the other paths (other paths will inherit the position, frequency and label type of the first selected).

When creating paths interactively, make sure to set the desired labeling options ***before*** changing time using the ***Date and Time*** controls.

To see the label data, or to adjust how labels are generated, click the ***Path Labels*** button near the top right side of the Object Paths window. You will see a number of options, such as the position of the label, label frequency, and options for the label data (day, month, date, etc.). Let's change the label parameters in our Mars example to show us the date and time of several points along Mars' path.

1. Click the ***Path Labels*** button in the Object Paths window.
2. The label position is set at ***top***, and the frequency at ***6***, by default, so let's just leave those as they are for now.
3. In the ***Label Options*** drop-down menu, select ***Date and time***.
4. Click the ***Update*** button.

You will now notice that the path labels in the Sky Chart now show the date and time of six points along the generated path. If you want to change the label details again, simply follow the previous steps, substituting the new parameters under the Path Labels section.

Label List

In the Path Labels section, you will notice a label list under the label parameters. *TheSkyX* allows you to view and change any label along your generated path. Scrolling in this list will reveal the label and the date and time of each incremental point along the generated path. (In our example above, we generated a path 30 days in length, so the label list contains data for 30 days.) You can change any label to anything you like by double clicking on a label cell and entering text. Clicking ***Update*** will update your path and show the new labels.

Path Labels Options

TheSkyX affixes labels to object paths based upon default parameters or those selected by the user. Understanding these will help you to get the most out of *TheSkyX's* object paths function.

Position

A label's position can be changed here. You can elect Top, Bottom, Left, or Right.

Frequency

This function adjusts the frequency at which labels appear on the object path. The frequency can be changed by directly entering a number into the field, or by using its arrow buttons.

Label option

Here, you can change the data content of labels. Labels can display date, time, date and time, day and month, or day only. Additionally, labels can be turned off completely by selecting ***None***.

Label list

This list shows all labels on a given object path and lists the labels as well as the date and time of each point along the path.

You can change the content of any label by double-clicking in a label's cell and entering text.

The Calendar

Mankind has been using calendars of one kind or another to mark the passage of time for thousands of years. *TheSkyX's* Calendar charts the phases of the Moon, sunrise and sunset, and viewing opportunities for a special kind of satellite event called an *Iridium flare*, on a monthly basis. You can display and print a calendar for a single month or the entire year.

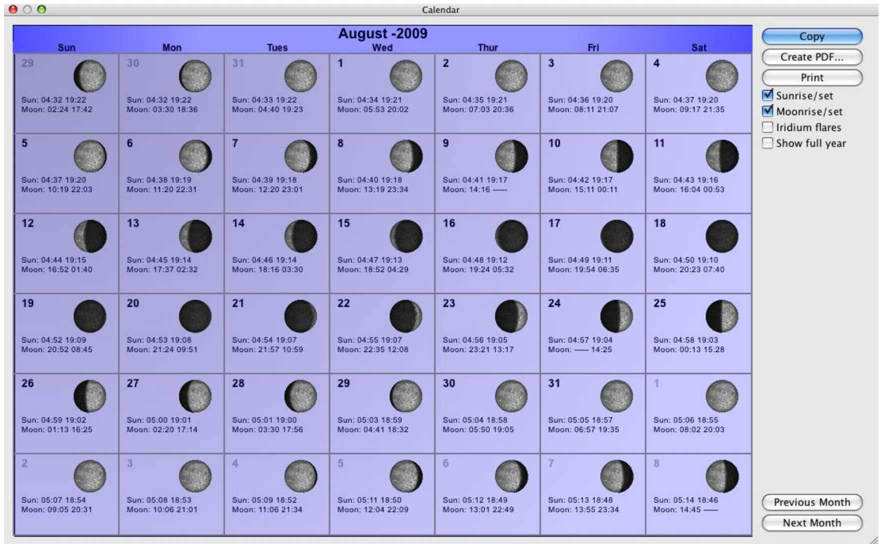


Figure 58: The Calendar window (Tools menu > Calendar command).

Copy Calendar to Clipboard (Copy button)

The current month's calendar can be exported by copying it to the Clipboard using the ***Copy*** button, and then pasted into other applications that accept graphics (in *Portable Network Graphics* or PNG format).

Please include the Software Bisque copyright if you publish a calendar on the web or in a monthly astronomy bulletin.

Create a Calendar as a PDF (Create PDF button)

Calendars created as Portable Document Format (PDF) documents can be emailed and viewed, or printed using free software on Windows, or freely with the Preview application on the Mac.

PDF calendars, by default, are saved to the directory named:

Software Bisque/TheSkyX <Edition Name Here>/Exported Data

In your home folder (the one with the house icon in Finder on the Mac or the current user's *My Documents* folder on Windows).

Print Calendars (Print button)

Clicking the Print button sends the calendar to your printer. Make sure that your printer is turned on and ready to go before doing so.

Show Sun or Moon Rise and Set Times (Sunrise/set, Moonrise/set checkboxes)

Turn on the ***Sunrise/set*** or ***Moonrise/set*** checkbox to show the local sunrise (moonrise) and sunset (moonset) times for each day on the calendar.

Show Times of Iridium Flares (Iridium Flares checkbox)

In order to show the predicted times for flares in the calendar, *TheSkyX* must first generate an Iridium Flare Report. To do so, click the ***Iridium Flares*** command on the ***Tools*** menu, specify the desired search parameters, then click the ***Find Flares*** button to generate a report of upcoming flares.

After an Iridium Flare report is generated, turning on the ***Iridium Flares*** checkbox on the Calendar window shows the magnitude, time, direction and altitude of each flare in the Iridium Flare report.

Show Yearly Moon Phase Calendar (Show Full Year checkbox)

Turn on the Show Full Year checkbox to view the phases of the Moon for the current year.

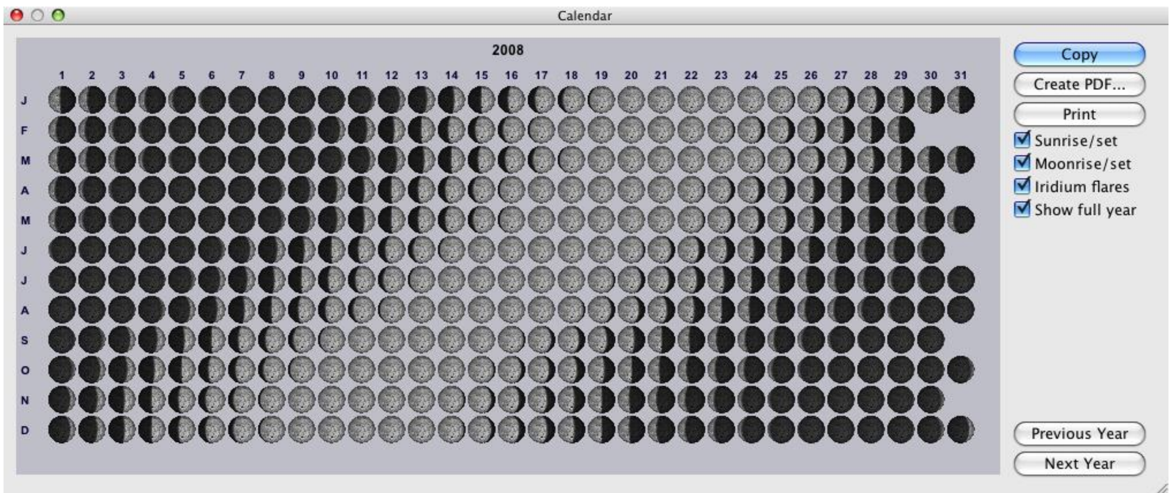


Figure 59: Phases of the Moon for one year.

Future and Past Calendars (Previous/Next Month/Year buttons)

When the ***Show Full Year*** checkbox is off, click the ***Next*** or ***Previous Month*** button to view a future or past month's calendar.

If you select the ***Date & Time*** tab, a small calendar for the current month will be displayed. Here's a very interesting feature: if you click on any date in the calendar, the Sky Chart automatically shifts to show you what the sky will look like on that date, for the current time. Notice also that the four major phases of the Moon are displayed in the calendar.

For a more detailed calendar, go to the ***Tools*** item in the Main Menu. Scroll down to ***Calendar*** and select it. A larger, printable calendar is displayed. Note that you can select various kinds of information to be included in the calendar by checking the appropriate boxes on the right-hand side of the window.

Exploring the Sky Chart

In this section we'll focus on how to adjust and navigate the Sky Chart. The best way to learn our program is simply to use it. Feel free to play around with the various buttons and menu commands you see in the tool bars. *TheSkyX* won't break, and it won't bite you.

Changing the Date and Time

The clock built into your computer is constantly tracking the date and time. *TheSkyX* reads this and displays whatever is above your horizon right now, but it can also show you the sky for different times of day or night.

By default, *TheSkyX* starts up using the computer's clock to show time advancing at ***1× (real time)*** with the ***Go Forward*** button pressed (meaning time is advancing how you'd expect).

From the ***Input*** menu, select the ***Date and Time*** command to show the ***Date and Time*** window (Figure 60).

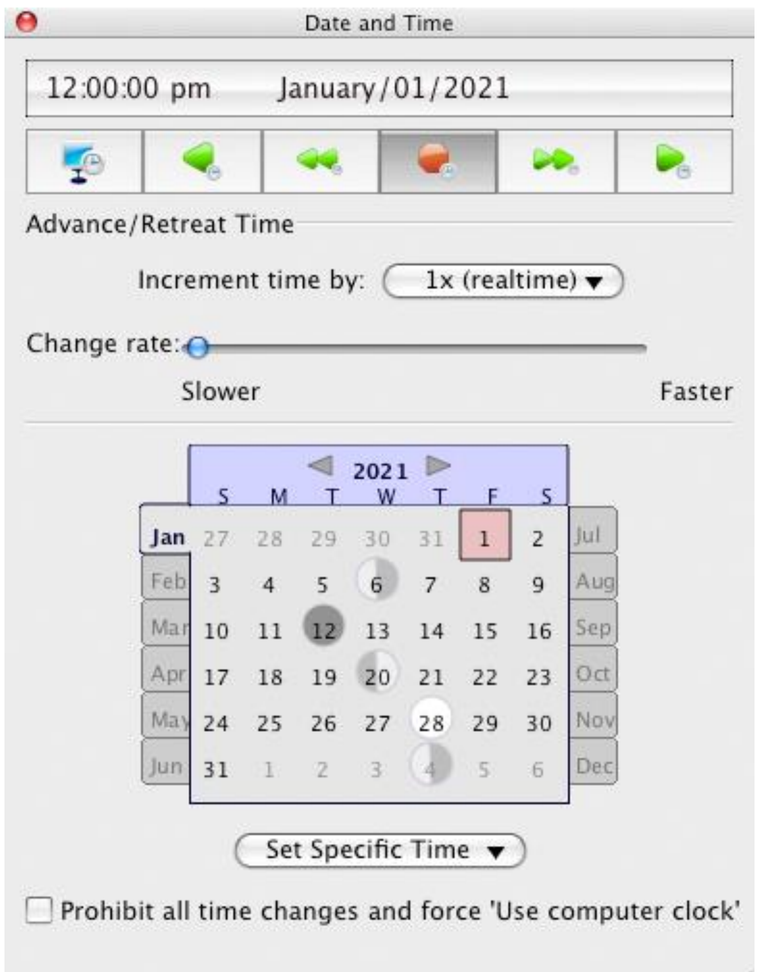


Figure 60: The Date and Time window (*Input > Date and Time* command).

Entering the Date and Time (Date & Time Control)

Use *TheSkyX's* Date & Time control that is located near the top of the Date and Time window to enter any date, after January 1, 4,712 BC and before December 31, 10,000 AD.

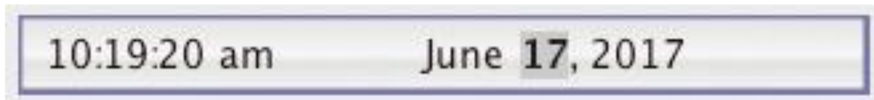


Figure 61: The Date & Time control on the Date and Time window and on the Date & Time Toolbar (Display > Date & Time Toolbar).

Do to so, click the mouse on the date or time element you wish to change, then type the desired value for:

- hours
- minutes
- seconds
- AM/PM
- month
- date
- year
- AD/BC

To set a specific month, click the month text to highlight it, then press the key for the first letter in the month. For example, press "D" for December. Pressing the "J" key repeatedly toggles the months January, June and July. If your mouse has a scroll wheel, use it to move up and down through the months. Or, use the up/down arrow keys on the keyboard.

To toggle between ***AM/PM,*** highlight the text, use the scroll the mouse wheel or up/down arrow keys on the keyboard.

The current month can also be selected using the calendar on the ***Date and Time*** window.

The Daylight Saving Time (DST) or Standard Time (STD) text next to the local time is updated automatically based on the date and your location.

Formatting the Date and Time

The format of the date and time can be changed to suit your preferences. Double-click on the Date & Time control to show the date and time formatting options. See "Have it Your Way with Preferences" on page 163.

Calendar Control

TheSkyX's Calendar control on the Date and Time window provides two mouse click access to any date for the current year. If necessary, click the ***Date and Time*** command from the ***Display*** menu to turn this window on; click the ***Date & Time*** tab on the stacked windows to bring it to the front.

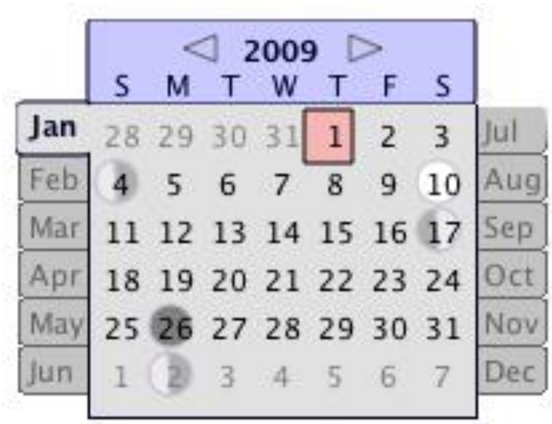


Figure 62: The Calendar control on the Date and Time window (*Display > Date and Time* command).

The top of the calendar control shows the year. Click the forward/backward arrows to advance/retreat one year at a time.

The edges of the calendar show the months of the year. Click any tab to bring it forward.

Black numbers for dates indicate the days in the current month, light gray numbers are shown for the prior or next month. The current day is highlighted light red. Click on any day to highlight it; the Sky Chart is adjusted accordingly. Click the month name tab to reveal the calendar for that month.

Time Controls

Buttons for controlling the flow of time are available by clicking the ***Date and Time*** command on the ***Display*** menu and on the ***Date and Time Toolbar***.

Figure 63: Time Controls on the Date and Time window (*Display* menu) and the Date and Time Toolbar (from left to right: *Computer Clock, Go Backward, Step Backward, Stop, Step Forward, Go Forward*).

Use the Computer's Clock (Computer clock)

When the Computer Clock button is clicked, *TheSkyX* gets the date and time from the computer's clock. It also resets the time skip increment to ***1*×** ***(real time)*** and sets the ***Go Forward*** time skip option.

Verifying TheSkyX's Time

Accuracy is of the utmost importance in your observations. Select the ***Verify TheSkyX's Time*** command from the ***Tools*** menu to check *TheSkyX's* time against the U.S. Naval Observatory's Master Clock. You can also click the corresponding toolbar button if you have the Orientation Toolbar activated (check ***TheSkyX > Preferences > Toolbars).***

Note: This tool requires an internet connection.

Move Backward in Time (Go backward)

Even though time marches on, *TheSkyX* can make time go backward by clicking the ***Go Backward*** button. This can be handy to replay an astronomical event and is sort of like having your own DVD player on history.

Step Backward in Time (Step backward)

Unlike the ***Go Backward*** button, the Step Backward button can be used to incrementally retreat time by the Time Skip Increment amount.   Use this to find the first contact of an eclipse, or determine the precise time when a minor planet occults a star, for example.

Stop Time (Stop)

Use the ***Stop*** button to halt the motion of stars and other objects from your earth-based perspective.

Step Forward in Time (Step forward)

Use the ***Step Forward*** button to incrementally advance time by the Time Skip Increment amount.

Go Forward in Time (Go forward)

Use the ***Go Forward*** button to advance time. When the ***Time Skip Increment*** is set to ***1× (real time)***, *TheSkyX* is showing you how the real sky looks at any instant.

Advancing or Retreating Time (Increment Time By)

Figure 64: Increment Time control.

Use the Increment Time By control to specify the rate or interval to advance or retreat time.

The default time interval options include:

- ***1*× *(real time)***: Time advances or retreats based on the computer’s clock.
- ***10*×*, 100*×*, 1000***×: Time changes by a factor of 10, 100 or 1000 times the normal rate.
- 1 second
- 1 minute
- 1 hour
- 1 day
- 1 lunar month
- 1 year
- ***Sunrise:*** The time skip interval is the length of time between sunrises for each day.
- ***Sunset***: The time skip interval is the length of time between sunrises for each day.
- ***Start Twilight***: The time skip interval is the length of time between morning astronomical twilight for successive days.
- ***End Twilight***: The time skip interval is the length of time between evening astronomical twilight for successive days.
- Custom: Click the ***Custom*** command to show the ***Custom Time Flow Increments and Rates*** window.

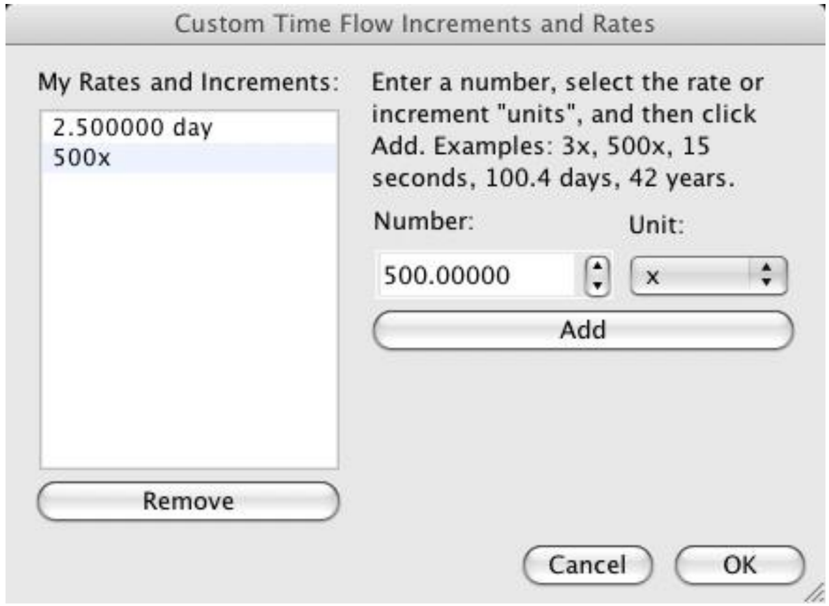


Figure 65: Define custom rates and time skip increments using the Custom Time Flow Increments and Rates dialog.

User-Defined Rates and Time Skip Increments (My rates and increments)

This list shows the rates and increments that you've defined by clicking the Add button to the right.

Define a Numerical Increment or Rate (Number)

Enter any decimal number for the rate or increment you wish to define. For example, 2.56 days, or 500x.

Define the Flow Rate or Time Skip Increment Unit (Unit)

Specify the unit for the rate or time skip increment. The lower case "×" unit means "a rate that is N times greater than actual time. Only whole numbers (integer) values are permitted for time skip rates.

Add Rates and Increments (Add)

Once you've entered a number and a rate, click Add to add it to the list My Rates and Increments list.

Custom rates are saved automatically, and restored when *TheSkyX* is opened.

Remove Rates and Increments (Remove)

Select one or all of the rates and increments, then click the Remove button to remove them from the list.

Quickly Change Time (Change Time)

The ***Change Time*** slider on the ***Date and Time*** dialog allows you to quickly advance or retreat time at the current rate.

This control is useful for reviewing lunar eclipses, occultations and Iridium flares.

Now that you're familiar with the time controls, below the calendar there is an item called ***Set Specific Time***. Click it.

You'll see a list of different "times" – not in hour and minute format, but in terms of astronomical events. The list of common events includes:

- ***Now***: *TheSkyX* uses the computer's clock to show time
- ***Sunrise***: The time of day when the rising Sun reaches the "*refracted horizon*" – the line on the refracted sky that corresponds to the observer's horizontal.

Hint: Refraction in the earth's atmosphere bends light, so, at sea level, the Sun's upper limb is visible about 3 minutes *before* it is actually above the local horizon.

- ***Noon***: The time of day when the Sun is centered on the meridian. This is not necessarily 12:00 p.m.
- ***Sunset***: The time when the Sun appears just below the "refracted horizon".
- ***Midnight***: 12:00:00 a.m. local time.
- ***Morning (Begin Astronomical Twilight)***: The time when astronomical twilight begins.
- ***Evening (End Astronomical Twilight)***: The time when astronomical twilight ends.
- ***New Moon***: The date and time in the current month when the Moon's phase is zero percent.
- ***First Quarter***: The date and time in the current month when the waxing Moon's phase is approximately 50 percent.
- ***Last Quarter***: The date and time in the current month when the waning Moon's phase is approximately 50 percent.
- ***Full Moon***: The date and time in the current month when the Moon's phase is approximately 100 percent.
- ***Moonrise***: The time of day when the rising Moon intersects the refracted horizon.
- ***Moonset***: The time of day when the setting Moon is below the refracted horizon.
- ***Vernal Equinox***: The date and time for the current year when spring begins in the northern hemisphere.
- ***Summer Solstice***: The date and time for the current year when summer begins in the northern hemisphere.
- ***Autumnal Equinox***: The date and time for the current year when autumn begins in the northern hemisphere.

- ***Winter Solstice***: The date and time for the current year when winter begins in the northern hemisphere.

The last item in the list allows you to enter the Julian Date of an event.

The Moon's phase events search the current month. For example, if *TheSkyX's* month is set to any date in July, 1592, the New Moon is July 24, even if the date is later than July 24.

When you select any of these options, the Sky Chart shows you what the sky will look at that time for the current date. Try several of the options and watch how the chart changes.

You can make time speed up and even go backwards. In the ***Tools*** menu, choose the item called ***Time Skip***. Try one of the various options. The Sky Chart will continue moving backward or forward in time until you select ***Stop***, or the ***Use Computer's Clock*** option.

Finally, you can also enter a specific date and time by selecting the ***Input*** item from the Main Menu and choosing ***Date and Time*** (note there is also a shortcut key for this displayed, within the menu – *TheSkyX* will always display shortcut keys in the menu whenever they are available).

Prohibit All Time Changes and Force 'Use Computer Clock'

Setting the date and time in *TheSkyX* is normally free flowing; you can simulate the night sky from one hundred years ago just as easily as tonight's sky with a few keystrokes or mouse clicks.

Setting the incorrect date and time when controlling a telescope can result in personal injury or damage your equipment.

When this checkbox is turned on, changes to *TheSkyX's* time settings are not allowed so that Sky Chart always uses the computer's clock to establish the date and time. It is turned on automatically when controlling a telescope, and turned off automatically when a telescope connection is terminated, or *TheSkyX* is closed. To avoid confusion, the state of this checkbox is not saved or restored.

Reports

TheSkyX makes generating calendar reports of Sun and Moon activity, equinoxes and solstices, planet ephemerides and meteor showers a snap. Set the Sky Chart to any year you choose, and select **Tools >** ***Reports*** to see a wealth of astronomical data specific to the given year.

Equinox/Solstice Report

This report displays the date and exact time of each equinox and solstice for the Sky Chart's current year. To see a different year's values, simply change the Sky Chart's year in the Date and Time tab or toolbar.

Meteor Radiant Report

Keep on top of meteor shower activity with this handy report. With the ***Meteor Radiant Report***, you can instantly see the ***Month/Day***, ***RA***, ***Dec***, and ***Hourly Rate*** of each meteor shower for the Sky Chart's current year. Just as with the other reports, you can obtain values for a different year by changing the date in the Date and Time tab or toolbar.

Planet Report

This is a "catch all" report that lists a variety of solar, planetary and lunar ephemerides and other useful information such as Earth distance, longitude of each visible planet's central meridian, Moon-specific information and more. You can obtain values by changing the date in the Date and Time tab or toolbar.

Sun & Moon Report

This report lists times for ***moonrise***, ***moonset***, ***sunrise***, ***sunset***, and the ***beginning*** and ***ending of*** (astronomical) ***twilight*** for each day of the Sky Chart's current month and year. To see values for a different month or year, simply change the date in the Date and Time tab or toolbar.

Sky Database Reports (All SDBs)

This report shows the name, search prefix, object count, object type and the associated text file for every Sky Database.

Copying Reports

Any of these reports can be copied to the clipboard for pasting into another application by simply clicking the ***Copy*** button at the lower left side of the Reports dialog.

The Look Commands

Our eyes can see only a small portion of the sky at a time. *TheSkyX* can show you the entire sky at once, but it's often more useful to focus the display on one part of the sky at a time, to match what you can see in the real night sky with your unaided eyes.

Changing the direction of your view is accomplished with the ***Look*** commands. These can be found in the ***Orientation*** menu, but they are also available to you as buttons in the ***Orientation*** tool bar.

By default, the Sky Chart is displayed looking south. Click the ***East*** button in the ***Orientation*** tool bar. Note that the star field has changed; the compass direction displayed at the bottom of the screen indicates E, for east. Experiment with the other compass direction buttons.

In addition to the compass direction buttons, a set of arrow buttons can be used to shift your viewing direction incrementally. Click the right arrow button. Notice how the view shifts slightly to the left (how far the Sky Chart shifts depends on your field of view, discussed below), just as if you were outside, looking at the real sky, and turning your head to the right. The left, right, up and down buttons function similarly (if your computer's monitor is small, or the screen resolution is low, the entire toolbar may not fit on the screen, so you may need to click the ***>>*** symbol to display the up and down buttons), mimicking the movement of your head in the indicated directions.

You can also press and hold the CONTROL key then drag the mouse to adjust the position of the Sky Chart.

Orientation Options

A variety of options exist for orienting the Sky Chart. You may choose from a terrestrial sphere, or celestial sphere orientation, or a free rotation mode.

Terrestrial Sphere

Choose the ***Terrestrial Sphere*** command from the ***Orientation*** menu to orient the Sky Chart as if from a vantage point on Earth's surface and according to terrestrial (azimuth and altitude) coordinates.
In this orientation, the simulated planets, stars and other objects move across the sky from east to west, just like the actual night sky. Detecting motion of the actual celestial objects using the unaided eye takes patience. While the stars may appear stationary at first glance, careful observation reveals the effects of earth's persistent on-axis rotation.

A magnified view of the night sky through a telescope with no clock drive quickly reveals the apparent motion as stars drift out of the field. The same is true for the simulated Sky Charts. When the ***Terrestrial Sphere*** option is selected, narrower fields of view, the apparent motion of the stars becomes quite obvious.

If you're working at smaller fields of view, and wish to "stop the world from turning" use the ***Celestial Sphere*** option.

Celestial Sphere

To view the Sky Chart from the origin (center) of the celestial sphere, select the ***Celestial Sphere*** command from the ***Orientation*** menu. Objects are shown based on their equatorial positions and do not move as time advances.

Free Rotation

Choosing the ***Free Rotation*** command from the ***Orientation*** menu allows you to freely rotate the Sky Chart in any direction without being constrained to any coordinate system or convention.

Note: Each of these options is also available as a button on the ***Orientation Toolbar*** (page 170).

Rotating the Sky Chart

While in Free Rotation mode, you can rotate the Sky Chart freely, in any direction, with commands from the **Orientation** menu, or by using the ***Rotate Tool*** found in the **Tools** menu.

Rotating Clockwise and Counterclockwise

First, select ***Free Rotation*** from either the **Orientation** menu or from the Orientation Toolbar. Then, select either ***Rotate Clockwise*** or ***Rotate Counterclockwise*** from the Orientation menu. You can also use the keyboard shortcut ***Alt++*** (that is, press and hold down the ***Alt*** key while pressing the plus key; the Mac keyboard labels this key with the word ***Option***, too) to rotate clockwise. Similarly, ***Alt+–*** rotates the Sky Chart counterclockwise.

Rotate Tool

You can also rotate the Sky Chart to any position angle you choose by using the Rotate Tool. Click the ***Rotate Tool*** from the ***Tool*** menu to activate it. A brownish-red position angle indicator will appear on the Sky Chart with a label indicating its current position angle.

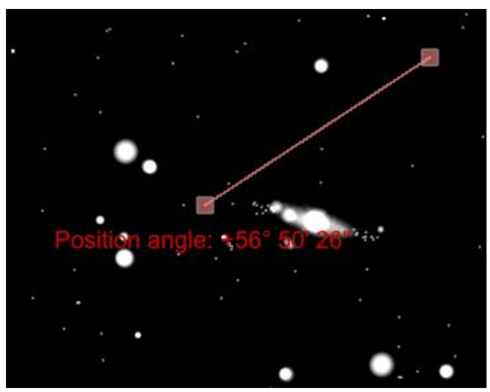


Figure 66: The Rotate Tool.

To use the Rotate Tool, first set a central rotation point by clicking and dragging in the Sky Chart to move the desired central point to the center of the view. To change the position angle freely, click and drag the square at the end of the position angle indicator. Notice that the position angle readout changes as you drag the indicator.

You can also set a position angle using the Rotation settings under the **Orientation > *Navigate*** command. See the ***Navigate Command*** section for more details.

Angular Separation & Position Angle

Determining the angular separation and position angle of two objects is a snap with *TheSkyX*.

Angular Separation & Position Angle Tool

Select **Tools >** ***Angular Separation & Position Angle*** to bring up the tool. You will notice that a pale green indicator with two square endpoints and a square center point appears in the Sky Chart. To determine the angular separation and relative position angle between two objects, simply click and drag the endpoints so that they overlap the objects for which you wish to determine angular separation and position angle values. You can hold down the Control key (Windows) or Command key (Mac) to snap the endpoints to the nearest object for greater accuracy. It's that simple! The desired values will appear in the label below the indicator. Determining angular separation and position angles has never been so simple or as elegant as it is in *TheSkyX*.

Once you are finished with this tool, deselect it by returning the **Tools >** ***Angular Separation & Position Angle*** command.

Note: The Angular Separation & Position Angle tool works in terrestrial or celestial sphere mode and in free rotation mode. You can also click and drag the Sky Chart to adjust the view at any time.

Field of View

You probably know that a circle can be divided into 360 degrees. Imagine a pie cut into six equal slices. The angle between the edges of a given slice is 360/6 = 60 degrees. Astronomers measure angles in degrees, and fractions of a degree: each degree is divided into sixty minutes, and each minute is divided into sixty seconds.

When you look up, you can see only a portion of the entire sky. Imagine for a moment that the sky is an immense spherical bowl above your head. You're seeing an area of the sky that spans a particular angle.

Assuming you have normal peripheral vision, that angle is about sixty degrees – one slice of our imaginary pie in the sky. Another way of saying this is your *field of view* is sixty degrees wide. Some people can see a little more, some a little less, but sixty degrees is about average for adults.

When you look at the sky with binoculars or a telescope, what you see is magnified – in effect, you bring the sky closer, making it easier to see detail and faint objects. The downside of magnification is that it always reduces your field of view, sometimes to just a fraction of a degree. Generally speaking, the greater the magnification, the smaller the field of view.

TheSkyX allows you to set the field of view to any angle, from 235 degrees to a fraction of a degree. This is very useful when you're trying to understand how much of a particular constellation or star field might be visible in a pair of binoculars or a small telescope.

Setting the Field of View

A simple way to change the field of view is to use the ***Zoom In*** and ***Zoom Out*** buttons. The current field of view is displayed next to these buttons. Click on that pop-up menu. A list of preset fields of view is displayed. Some of these correspond to the field of view of a typical pair of binoculars or amateur telescope.

The ***Wide Field*** option shows you the sky from horizon to horizon, 180 degrees. The ***Naked Eye*** option gives you a 100-degree field of view – a bit wider field than what you can actually see with your eyes, but we wouldn't want you to miss anything.

You can also define a ***zoom box*** to zoom in on a particular area of the Sky Chart. Place your cursor on one corner of the area you want to zoom in on. While pressing the shift key, click and hold while you move your cursor to the opposite corner, then click anywhere inside the zoom box to enlarge it (you can click outside the zoom box to cancel this operation).

Stellar Cartography

Just as you would use a map to find your way around a city, state, or country, celestial maps or *star charts* are designed to help you find your way around the sky.

Use your mouse or track pad to move the arrow around the Sky Chart. You'll notice that when the tip of the arrow touches an object, an information box describing that object is automatically displayed. The kind of information displayed depends in part on the nature of the object, but one thing that is always displayed is the location of the object. This is indicated by two different sets of coordinates.

Cosmic Coordinates

Maps of the Earth identify the location of landmarks with two numbers: latitude and longitude. Latitude is measured in degrees north or south of the equator, and longitude is measured in degrees east or west of the Prime Meridian.

A similar system is used for objects in the sky. The *celestial equator* divides the sky into two hemispheres, north and south. The celestial equivalent of longitude is called *right ascension* (*TheSkyX* uses the abbreviation RA) and the equivalent of latitude is called *declination* (dec). Right ascension is measured in hours, minutes, and seconds, from 0 to 24. This may seem odd at first, but there's a very good reason for this peculiar convention: the Earth is rotating. It turns around once on its axis in 24 hours, but from our terrestrial perspective, it looks like the sky is rotating around the Earth every 24 hours. Right ascension is measured eastward from the constellation Aries, the Ram. Specifically, 0 hours RA, the First Point of Aries, is the position in the sky where the Sun crosses the celestial equator on the first day of spring.

Declination is measured in degrees north or south of the celestial equator. The celestial equator is 0 degrees declination. The north celestial pole is located at 90 degrees declination (Polaris, the North Star, has a declination very close to 90 degrees). The south celestial pole is at *minus* 90 degrees declination. You can also translate right ascension into degrees: a complete circle has 360 degrees; dividing 360 by 24 gives 15, so every hour of right ascension is equal to 15 degrees.

Imagine a line running across the sky from due north to due south, splitting the sky in two. This line is called the *meridian*. Better yet, turn on the ***Meridian*** checkbox under the ***Reference Lines & Photos*** group on the ***Chart Elements*** window (page 205) to view it on the Sky Chart. When a celestial object crosses the meridian, it is also at its highest altitude in the sky. This is called the *transit time*. Generally speaking, the best time to observe a celestial object with a telescope is when it's crossing the meridian.

This brings us to another way of identifying the location of an object in the sky: altitude and azimuth. Altitude is simply the number of degrees the object is above the horizon, from 0 (on the horizon) to 90 (directly overhead). Be careful not to confuse altitude with declination – they are not the same thing.

Azimuth indicates the compass direction of an object. Specifically, it is the number of degrees east of north that you need to turn to see the object. Due east, for example, is 90 degrees azimuth.

The problem with using altitude and azimuth for astronomical objects of course is that these numbers are constantly changing as the Earth rotates. *TheSkyX*, however, can calculate these numbers instantaneously, making it easier to know what direction to look when you're outside in the dark, trying to find a particular object at a specific time.

Understanding Projections

Ever since we discovered that the Earth isn't flat, but spherical, cartographers have been looking for ways to represent a curved surface on a flat surface.

A sphere cannot be projected onto a plane without introducing distortion. In the most commonly used projection – called the Mercator projection – objects get larger the farther they are from the equator. This causes Greenland to look nearly as large as the rest of the United States on world maps. Navigators adopted the Mercator projection because a straight line on a

Mercator projection, called a *rhumb line*, represents a constant compass bearing from true north.

Other projections have their own combinations of strengths and weaknesses. *All* projections are compromises – the "best" projection is the one whose advantages outweigh its disadvantages for a particular application.

By default, *TheSkyX* uses the *stereographic* projection for fields of view greater than 60°. A stereographic projection is said to be "conformal." Although (as with all flat maps) the overall projection is distorted, all lines of declination and right ascension intersect at right angles, as they do on the celestial sphere.

The advantage of stereographic projection is that, over small areas of the display, object shapes are only slightly distorted. Constellations remain easy to identify. Compare this with the *polar* projection of a planisphere. There is almost no distortion near the poles, but constellations near the horizon are badly stretched out of shape. (A planisphere is one of those rotating star charts that approximate what's visible in the sky at a given date and time.)

When the Sky Chart is set to a field of view of 60° or less, the projection automatically switches to an *orthographic* projection, which displays the sky more as it would appear on the surface of a sphere. (This is the only projection used at 60° fields of view and smaller.)

Projections

By default, *TheSkyX* uses a stereographic projection for 60° fields of view and greater. The Projections command from the Display menu changes the projection. In the Projections dialog, click the radio button of the projection you want.

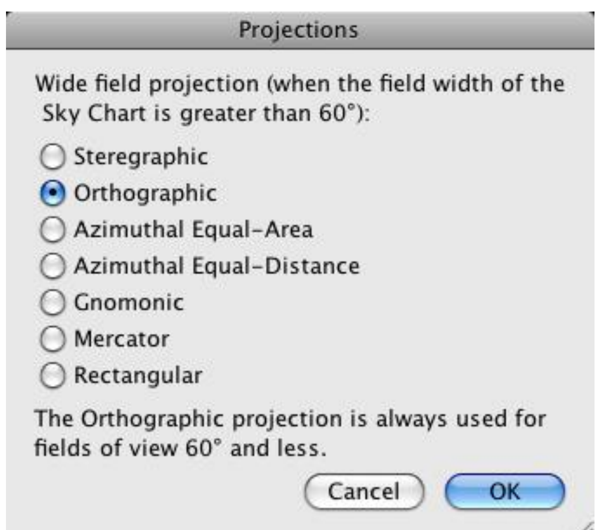


Figure 67: The Projections dialog.

The selected projection is applied to the Sky Chart immediately. It takes effect only when the field of view is greater than 60°– no change occurs if the current field of view is 60° or less.

- **Stereographic –** The default for fields of view equal to and greater than 60°. It keeps lines of right ascension and declination at right angles and minimizes local distortion. Conformal. 235° maximum field of view.
- **Orthographic –** Displays the sky more as it would appear on the surface of a sphere. It's the default (indeed, it's the only available projection) for angles of view 60° and less. Conformal. 180° maximum field of view.
- **Mercator –** Shows the celestial sphere like a conventional map. It allows wider fields of view, including a 360° view that shows the entire celestial sphere. Conformal. 360° maximum field of view.
- **Gnomonic –** This is the "pinhole camera projection." It displays meteor paths as straight lines, as seen when viewing a meteor shower. Non-conformal. 150° maximum field of view.
- **Azimuthal Equal-Distance –** The distance between objects having a particular angular separation on the celestial sphere is the same at any part of the Sky Chart. Non-conformal. 300° maximum field of view.
- **Azimuthal Equal-Area –** The areas of any sections of the celestial sphere subtending a particular solid angle are the same at any part of the Sky Chart. Non-conformal. 235° maximum field of view.

Stars and Constellations

There are some 6,000 stars visible to the naked eye. Most of these stars can only be seen from locations far from the bright lights of a city or town. If you really want to see the stars, you either have to go to Hollywood or get out of Dodge.

Star Names

Some of the brighter stars have proper names, but most don't – there are just too many to give each one a name. Instead, astronomers have devised a system that assigns names to naked-eye stars based on their brightness and the name of the constellation they belong to. Following a centuries-long tradition, the brightest star in a constellation is designated by the first letter of the Greek alphabet, Alpha, followed by the genitive form of the Latin name of its constellation. For example, the brightest star in the constellation Orion is called Alpha Orionis. It also has a proper name: Rigel. (We'll talk more about constellations later. Right now we're going to focus on individual stars.) When the letters run out, stars are identified by various alphanumeric designations.

A funny thing about Rigel: even though it's the brightest star in Orion, its designation is *Beta* Orionis. Astronomers originally thought that Betelgeuse, another star in Orion, was a little bit brighter, but improvements in *photometers* in the 20th century revealed that Rigel is actually the brighter star (it's possible that Betelgeuse might have been brighter in the past, when astronomers first began to designate stars with Greek letters).

Bright Stars and Dim Stars

Long before the invention of the telescope, astronomers also came up with a *numerical* system for classifying stars by their brightness. They decided that the brightest stars would be called First Magnitude. Those half as bright as First would be called Second Magnitude, then Third Magnitude, and so on down to Sixth Magnitude, which denotes the dimmest stars visible to the naked eye.

We use a modified form of this system today. The brightest star in the nighttime sky is called Sirius. It's in the constellation Canis Major, the Big Dog, and it's sometimes called the Dog Star. Its magnitude is *minus* 1.4, which we write as –1.4. This may seem a little confusing, but it isn't that hard to understand. A couple of centuries ago, astronomers decided to make the magnitude scale more precise. They knew the Sun and Moon and some of the planets are brighter than the brightest stars, so these were given negative magnitudes. They also realized that a First Magnitude star is actually a bit more than twice as bright as a Second. In order to keep Sixth Magnitude as the faintest star visible to the naked eye, astronomers recalibrated the magnitude system to follow a *logarithmic* scale. Each stellar magnitude is about 2.5 times brighter than the next lower magnitude so that the difference of five magnitudes is a brightness factor of (exactly) 100.

With a telescope, you can see stars much dimmer than Sixth Magnitude. *TheSkyX* database includes stars down to about 14^{th} Magnitude.

On a clear, moonless night, people who live in cities or suburbs can rarely see stars dimmer than Third Magnitude. If you're just starting to learn the names of the brighter stars and constellations, you should set the magnitude filter in *TheSkyX* to Second or Third magnitude. That way, when you go out at night to compare what you see on your computer to what you can see in the real sky, you won't be confused by a screen display that shows more stars than you can actually see from your location.

Setting the Magnitude Limit

This command tells *TheSkyX* to only display stars, galaxies, clusters, or any other object type, or combination of object types, that has magnitude information, that are brighter or fainter than a selected magnitude. Controls for editing the magnitude limits are found on the ***Chart Elements*** window on the ***Display*** menu.

The following example demonstrates how to change the magnitude limits for all celestial objects.

1. Make sure the Chart Elements window is visible. If it's not, select the ***Chart Elements*** command from the ***Display*** menu to show it.

2. Highlight the ***Celestial Objects*** text by clicking on it. This selects the 40 chart elements in the Chart Elements node.
3. Click the ***Edit Attributes*** button.
4. Near the bottom of the Chart Elements window you'll see a tab labeled ***Magnitude Limits***. You can enter a value between 30.0 and –6.0, or change the magnitude using the sliders.

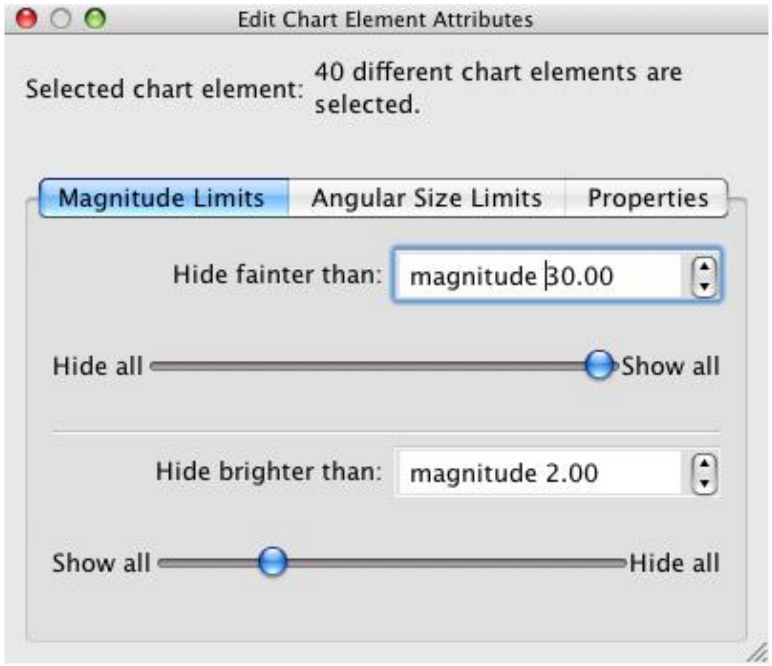


Figure 68: Magnitude Limits tab on the Chart Elements window.

The attributes of chart elements (including lower and upper magnitude, angular size, font properties and colors) can be changed individually or as a group based on the items that are selected in the Chart Elements list.

Number of Selected Chart Elements (Selected)

This text shows the name of the selected chart element or the number of selected chart elements in the Chart Element list.

Show Only Brighter Stars (Hide fainter than)

Specify the magnitude of the *faintest* objects to be displayed on the Sky Chart. For example, if you live in a light polluted city and want to approximate the stars you can see on typical night's sky, enter magnitude 1 or 2.

Show Only Fainter Stars (Hide brighter than)

The ***Hide Brighter Than*** controls provide additional filtering, displaying objects only within a specified brightness range. *Larger* magnitude values represent *dimmer* objects. The brightest objects have negative magnitudes.

As you move the slider the number of stars on the Sky Chart changes to reflect the changing magnitude limits.

Other Chart Elements

Like land maps, star charts can be overlaid with a variety of lines and markings intended to highlight specific celestial features and help you find objects at specific coordinates.

The ***Chart Elements*** menu lets you display or hide various reference lines and symbols, but you should be aware that even though the cosmos mostly consists of empty space, a star chart can get very crowded very quickly. The celestial equator and lines of right ascension and declination can be added to the Sky Chart, for example. Experiment with this feature by clicking on the box next to a listed chart element to see how it affects the display.

A Star to Guide You

For people living in the northern hemisphere, probably the most noteworthy star is Polaris, the North Star. It always stays in the same part of the sky, every night, 365 days a year. The reason for this is fairly simple: Polaris happens to be located almost directly above our North Pole. As the Earth rotates on its axis, other stars rise and set, but because Polaris is right above the pole, it always seems to stay in the same place.

How high Polaris is above your horizon is a direct way to find your latitude. If Polaris is 40 degrees above the local horizon, for example, you must be somewhere on the 40th latitude line. Philadelphia and Denver are both very close this latitude, as are Naples, Italy and Beijing, China. The stars you can see on any given date and (local) time are essentially the same for all of these cities, and any other place along this line of latitude.

More than anything else, latitude determines what you can see in the sky. The North Star is not visible from the Southern Hemisphere, as are most of the stars and constellations near it. And there are all sorts of stars and constellations visible from the Southern Hemisphere that we never get to see in the North (the Moon and planets are visible from both hemispheres). *TheSkyX* can show you what the sky would look like from any place in either hemisphere.

Double Stars

A little more than half of all stars actually travel in pairs, orbiting each other in space. The American astronomer Henrietta Leavitt once quipped that three stars out of every two are double. Most of them appear as single stars to the naked eye. You need good binoculars or a small telescope to resolve them as double stars (there are also triple stars and groups consisting of four or even more stars).

Some double stars are true *binaries*, meaning they are gravitationally bound to each other and orbit a common point in space. Others only appear to be double because they happen to lie along the same line of sight from Earth, but are in fact many light years apart and not tied to each other by gravity.

One of the best-known double stars in the sky is called Mizar. It's located in the handle of the Big Dipper.

Finding Mizar

Mizar is visible only from the Northern Hemisphere, and is easiest to find in the evening sky in Spring.

Select the ***Find*** tab from the vertical tabs on the left side of *TheSkyX's* window.

Type Mizar into the ***Search For*** text input, then click the ***Find*** button. A double red "bull's eye" will encircle the star in the Sky Chart.

The Big Dipper is one of the northern sky's most recognizable *asterisms* (this term is described below). Being able to find it will help you find other nearby constellations, such as Cassiopeia. Once you've mastered these constellations, others will be easier to learn.

Another good thing about being able to find the Big Dipper: it will make it easy for you to find Polaris, and therefore true north. The two stars at the end of the cup of the dipper point to Polaris. Imagine a line connecting these two stars. Extend it in the direction the cup is pouring, about five times the distance between the two stars. The star you see at the end of that line is Polaris.

Variable Stars

Fortunately for us, and everything else that lives on Earth, the Sun radiates energy at a very nearly constant rate. But there are some stars that change in brightness dramatically over the course of a few months, and in some cases, just a few days or even hours. These are called *variable stars*, and *TheSkyX* distinguishes them with a small red "v" to the lower left of the star.

The most notorious variable star is called Algol, a name derived from an Arabic word that means demon. Located in the constellation Perseus, its rhythmic dips in magnitude can easily be observed with the naked eye. Every 2.867 days, over the course of just a few hours, Algol falls from second magnitude (2.1) to third (3.4) and back. During these periodic dimmings, you can gauge its changing brightness by comparing it to other nearby stars. The evening sky in Autumn is the easiest time to find this fascinating object (it is only visible from the Northern Hemisphere). It may have been considered demonic in ancient times, but today we know this innocent star has a companion that orbits it every 2.867 days. Algol dims when that companion passes in front of it from our perspective. Such stars make up a special class called *eclipsing binaries*.

Classifying Stars

Stars differ not only in their brightness, but also in their size, surface temperature, and chemical composition. The one thing they have in common is that they are all spherical – although some spin so fast they tend to bulge in the middle!

All stars are basically immense balls of intensely hot gas that generate heat and light through a process called *nuclear fusion*. The temperature and density in the core of a star are so great that lighter atoms smash into each with enough force to fuse into heavier atoms. In our own Sun, for example, atoms of hydrogen fuse to produce atoms of helium (this process involves several intermediate steps). The fusion process releases energy in the form of electromagnetic radiation – light.

By spreading starlight into a spectrum, astronomers can learn the temperature and chemical makeup of stars. After studying thousands of stars, it became clear that stars fall into various categories, or classes. Some are massive and bright, and have relatively short, tumultuous lives. Others are small and dim, and can shine steadily for tens of billions of years.

A letter and number system is used to define stars in terms of their most important physical characteristics, and these designations are displayed when you point to a star in the Sky Chart. A more complete discussion of *spectral classes* and the physics of stars can be found in any introductory astronomy text.

Giants and Dwarfs

When you see a bright star in the sky, there are two possibilities: the star is close by and relatively average in size, or it is far away and gigantic.

Rigel is the brightest star in the constellation Orion. It is nearly 800 light years away, but is the seventh brightest star in the sky. It is a whopper, with a diameter of about 100 million kilometers. The Sun, by comparison, is about 1.4 million kilometers across.

Astronomers distinguish between *apparent* magnitude and *absolute* magnitude. Apparent magnitude is how bright a star looks in the sky. Absolute magnitude refers to how bright a star would appear if it were located exactly 10 parsecs (32.6 light years) away. The apparent magnitude of Rigel is about 0.2, but its absolute magnitude is nearly –7.0.

More about Constellations

The desire to find order in nature, even where none exists, seems to be built into the human brain. When you look up at the sky on a dark, clear night, the sheer number of stars can be overwhelming. Our distant ancestors must have been in awe of those countless lights randomly scattered across the sky like diamonds.

Because of our instinctive need to find order, cultures all across the globe have organized stars into distinctive patterns called *constellations*. These patterns are purely a product of the human imagination. Nature had nothing to do with creating them.

The constellations we recognize today have mostly come down to us from the ancient Greeks. Many of them represent mythological figures. Orion, for example, one of the most prominent constellations visible in northern wintertime, represents a heroic hunter who first appeared in one of the great epics of classical Greek literature, *The Odyssey*. Orion is accompanied by two hunting dogs that are also immortalized in constellations: Canis Major and Canis Minor, the big and little dogs, respectively.

When you look at Orion, it isn't hard to imagine the figure of a hunter with a raised arm wielding a club. You can see one classic representation of this figure by going to the ***Display*** menu and selecting ***Constellations & Asterisms Options***. You can display line drawings, mythical figures, and constellation boundaries by checking the appropriate boxes. You can also use the slider labeled ***Transparency*** to adjust how bright these renderings appear.

For many other constellations, the connection between its array of stars and what it is supposed to represent is difficult to see, to say the least. They're a little more like abstract art, intended to represent the idea of a thing rather than the thing itself.

Drawing lines between the stars of a given constellation provides a simple "stick figure" view of that constellation. When astronomers think about constellations at all, this is how they usually think of them. The more fanciful mythological drawings of constellations became popular in the early 17th century, especially in the gorgeous star charts engraved by the great German celestial cartographer Johann Bayer (Bayer is also credited with creating the system that designates stars with Greek letters and the genitive name of their constellations, as described previously).

When the constellations we recognize today were originally created, a number of stars were left over – that is, not all stars fit into the established patterns. To avoid confusion, astronomers designated boundary lines between the constellations. Not unlike borders between countries, any star that falls within the borders of a given constellation is said to belong to it, whether it was included in the original depiction of that constellation or not.

Asterisms

There are familiar patterns of stars that don't quite qualify as constellations. Astronomers call these patterns *asterisms*. The Big Dipper and the Pleiades (the Seven Sisters) are probably the two most familiar examples. In Japan, the Pleiades are called Subaru. You've probably seen them driving around your neighborhood.

Some Tips on Using Star Charts

Learning how to connect what you see on a star chart to what you see in the real sky takes some time. We're going to show you a step-by-step process that will make it easier for you to find common stars and constellations. With a little patience and practice, you'll soon become an expert.

First of all, when you go outside and look at the sky, you need to know what direction you're facing. In particular, you need to know how to find true north. City streets often lie along north/south and east/west lines, but this isn't always the case. If you aren't sure which way is north at your viewing location, use a magnetic compass to find it.

When hundreds of stars are displayed on your chart, finding individual stars and constellations can be very challenging. But if you limit the number of stars in the chart to just a few dozen of the brightest stars, you'll have a much easier time learning the sky.

Printing a Sky Chart

Printing a sky chart to take with you when you go outside is also very helpful. *TheSkyX* can print any chart it displays. You can print an "all sky" chart, or select a particular part of the sky you're interested in learning.

Choose the ***File*** command from the main menu. Near the bottom of the menu, you'll see two items: ***Print*** and ***Print Setup*** (if you have more than one printer connected to your computer, ***Print Setup*** can be used to select the printer you'd like to use). Select the ***Print*** command.

The ***Print Chart*** tab of the ***Export Chart*** window is displayed on the screen. In addition to printing charts, *TheSkyX* allows you export charts as *Portable Document Format* (PDF), *Scalable Vector Graphic* (SVG) and *Postscript* files.

To Export a Sky Chart in PDF, SVG or Postscript Format

1. Select the desired option from the ***Format*** list.
2. Click the ***Export*** button.
3. On the ***Export Chart*** dialog, enter the file name to save the chart in this format.
4. Click ***Save***.

PROFESSIONAL

Click the ***Create Bitmap*** tab (or, from the main menu, click the ***Export*** command from the ***File*** menu) to view the options for saving Sky Charts as *bitmaps* or *pixmaps*. Click the ***Copy Sky Chart*** button to copy the current chart to the Clipboard. Click the ***Save As*** button to save the chart as a *Portable Networks Graphics* (PNG) file.

Turn on the ***Create Custom Size*** checkbox to specify the ***Resolution***, in dots per inch (DPI), ***Width*** and ***Height***, in inches, of the bitmap.

If you want to create high-resolution star charts for publication, individual "layers" of the chart can be exported by turning on the desired checkboxes in the ***Chart Layers*** tab.

Clicking the ***Print*** button on the ***Print Chart*** tab sends the chart to the currently selected printer. *TheSkyX* uses the current ***Map Like*** display settings (page 202) and prints stars in black, leaving the sky white. The size of the star is proportional to its magnitude. Non-stellar objects are also printed using the symbols that appear in the ***Map Like*** Sky Charts.

You can choose the orientation of the printout and other printing parameters by clicking the ***Page Setup*** button. When you're ready to print, simply click the ***Print*** button.

The best time to start learning the sky is a clear, cloudless night, when there is no Moon or at most a crescent Moon. Moonlight can interfere as much as city lights when it comes to seeing the stars, and if the Moon is close to Full, you probably won't be able to find any but the very brightest stars and planets. You also want to be in an open space, a place where there are no tall buildings, trees, or annoying artificial lights to interfere with your viewing. Make sure in particular that you have a clear view to the north.

When you get to your observing site, give your eyes at least a few minutes to adapt to the darkness. You'll need a flashlight to read the chart of course, but you should use one that has a red filter. These can be bought at most stores that sell telescopes, or you can simply tape a piece of transparent red film over a standard flashlight. Using only red light will help preserve your night vision. If you take your computer outside with you, the ***Display > Show Night Vision Mode*** command will help preserve it, too.

An Interstellar Perspective

Our Sun is but one of billions of stars in the Milky Way galaxy. For centuries, astronomers have been charting the positions of other stars in our galaxy, and have accurately determined the distances to many thousands of them. This information allows us to step outside our solar system, in effect, and see what the Sun and other stars in our part of the galaxy would look like from dozens of light years away.

The constellations are only figments of our imagination. A constellation's stars may seem to be close together, but are usually very far apart and often have no mutual relationship at all. (Except for being part of the same galaxy, the Milky Way.) The sky looks flat because there are no reference points to help us perceive the distance to the stars with just our eyes. Since the human mind is pretty good at creating order from random patterns, seeing pictures in the sky is no surprise. *TheSkyX* has a 3D stars tool that can help you to understand the spatial relationship between stars that we see at night.

Viewing the 3D Star Map

Selecting ***3D Stars*** command from the ***Tools*** menu will bring up the ***3D Stars*** window. Immediately upon opening the window, the viewer will pan across a 3D rendering of the heavens, with the position of our Sun marked in the center. Click and drag on the star field to get a feel for the nature of the 3D space.

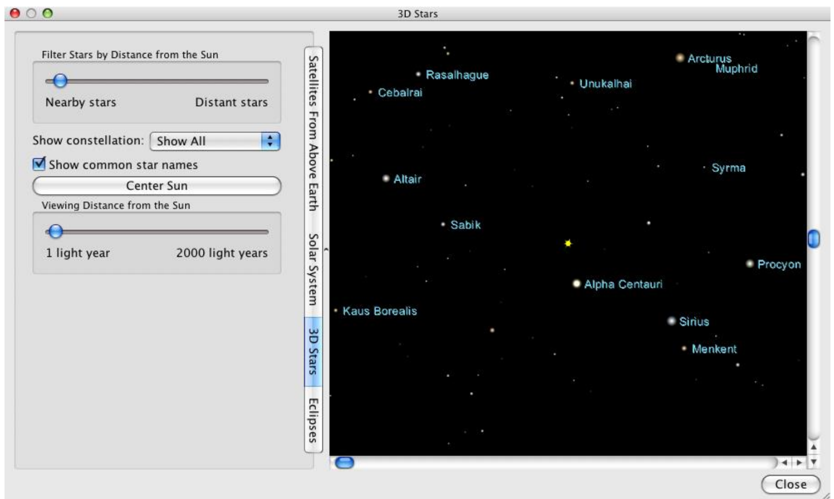


Figure 69: The 3D Stars window.

3D Star Map Controls

On the left, you will see the controls that operate the 3D Stars tool. On the top, you will see a slider that allows you to view visible stars from those relatively nearby to those quite distant.

The bottom slider, labeled ***Viewing Distance from the Sun***, ranges from 1 to 2,000 light years. A light year is a fundamental “cosmic yardstick” used to describe the distance to the stars. One light year is equal to the distance that light travels in one year. Since light travels at approximately 300,000 kilometers per second in a vacuum, then a little math tells us that a light year is equal to about 9.5 trillion kilometers: that’s pretty far! Another interesting fact about light years is that the number of light years distant an object is tells us how long it takes light to arrive here from that object. So, if an object is 2,000 light years away, that means it took the light we see from that object 2,000 years to reach us. Also, it means that we see that object, not as it exists today, but as it existed 2,000 years ago. The further we look out into space, the further we see back in time.

Using the ***Filter Stars by Distance from the Sun*** slider will allow you to see the general stellar structure of our galaxy by displaying stars up to 2,000 light years away from our home solar system. Using this can help you to get a feel for the relative distance of many stars, including well-known favorites, such as Betelgeuse and Rigel in the constellation Orion. Notice that the number of stars that disappear grows as you move the slider to the left, meaning that most of the stars we see at night are quite close to us, relatively speaking.

Viewing a Single Constellation

If you would like to focus on a single constellation, you can do that, as well. Using the ***Show constellation*** pop-up menu, select a constellation; you can choose from any of the 88 official astronomical constellations. Let's use the functions of the 3D Stars tool to explore the region around a famous constellation, Orion, the Hunter.

1. Choose Tools > 3D Stars.
2. Select ***Orion*** from the ***Show constellation*** drop-down menu. You will now see the constellation of Orion, the Hunter in the viewer, surrounded by the constellation boundary box. These boxes are used by astronomers to describe regions of the sky found near the 88 constellations.
3. Check ***Show common star names*** to show the names of the more "famous" stars, the A-listers, if you will. In Orion, the stars of his shoulders, knees, and belt are labeled, as well as the brightest star of his head.
4. Use the ***Filter Stars by Distance from the Sun*** slider to hide or reveal stars based upon their distance from the Sun. Move the slider to the left, and take note of when each star in Orion disappears.
5. Now, using the ***Viewing Distance from the Sun*** slider, adjust the distance back and forth and observe the effect on the constellation's appearance.
6. Try sliding the same slider about one-quarter of the way to the right. Then, click and drag on the constellation. You will see an exploded view of Orion's stars through 3D space. This gives you a great view of the relative distance of each of Orion's stars. Experiment with various viewing distances to get a feel for how it works.
7. Use the ***Filter Stars by Distance from the Sun*** slider to see an excellent demonstration of each star's distance, as they appear and disappear, based upon their distance.

Experimenting with the sliders and with different constellations will serve to give you a good grasp on relative stellar distances. The next time you look up at Orion, think about space in 3D and the vast distances over which that light travelled to get to your eyes.

Closer to Home: Atmospheric Phenomena

As we mentioned earlier, some of the most interesting things we can see in the sky are happening right above our heads, in the upper atmosphere.

Meteors and Fireballs

You've probably seen a so-called shooting star (maybe you've even wished on one). A shooting star isn't really a star at all, but a grain of space dust. When one of these particles hits our atmosphere, it's traveling at tens of thousands of kilometers an hour. Friction makes it glow white hot, turning it into a *meteor*. It may seem surprising that a speck of dust at the edge of space could create a streak of light visible from the ground, but even the brightest meteor is rarely bigger than a pea.

The flying dust grains that cause meteors mostly come from the tails of *comets*. Several tons of this material falls to Earth every single day. If you get away from the lights of the city and watch the sky on a moonless night for an hour or two, you'll see at least a few meteors – maybe quite a few. They're falling everywhere, all the time.

Once in a while something much larger than a speck of dust falls to Earth and creates a spectacular *fireball*. Fireballs can blaze across the sky with such intensity that they literally light up the landscape. They can range in size from a few centimeters to several meters. Bits and pieces of them sometimes survive the fiery descent through our atmosphere and crash into the ground. These fragments are called *meteorites*.

Meteorites are chunks of *asteroids* and they fall into three main categories, based on chemical composition. *Iron meteorites* are the most commonly *found* because they are very distinctive, consisting of ninety percent iron with a bit of nickel mixed in. They are extremely dense, and have magnetic properties.

Stony meteorites look more like common rocks. They are the most common *form* of meteorite but aren't found as often as iron meteorites for two reasons: they look like ordinary, everyday Earth rocks, and they can't be located using a metal detector.

The third class is the *stony irons*, which, as the name suggests, are a mixture of the iron and stony types.

A few people around the world make a good living hunting and selling meteorites. A decent-sized specimen can be worth thousands of dollars to a museum or a private collector. A really big meteorite with an unusual composition can be worth millions. Something to think about next time you see a fireball…

Meteor Showers

The dust trails left by comets that have visited the inner solar system follow predictable orbits around the Sun. Several times a year Earth passes near one of these cosmic debris trains, resulting in a meteor shower. Halley 's Comet, which has a 76-year orbit, is responsible for two annual meteor showers, the Eta Aquarids in early May, and the Orionid shower in mid-October.

Have you ever looked at a set of railroad tracks and noticed, as they stretch into the distance, how they seem to converge to a single point? A similar effect can be seen during a meteor shower. The debris "train" of the shower's parent comet follows the tracks of an imaginary railroad. If you pay attention to the direction most of the meteors in a particular shower seem to be coming from, they all converge back to the same point in the sky – the "vanishing point" of the tracks of the debris train. This is called the *radiant*. *TheSkyX* plots the radiant for all annual meteor showers and estimates the date and time they are expected to peak.

To display meteor shower radiants, select the ***Chart Elements*** tab from Display menu. Within the list of elements, there is an item called ***Reference Objects***. Click it, and a new list of items is displayed. Check the box next to ***Meteor Shower Radiants***.

The radiants for all meteor showers will now be displayed on the Sky Chart. If you move the cursor to the center of any radiant, details on that shower, including when it is expected to peak, will be displayed.

The Northern (and Southern) Lights

The Northern Lights, or *aurora borealis*, can be as stunning as any fireworks display. They appear as curtains of colorful, shifting light, suspended high up in the night sky. Unfortunately, they are generally only visible from high latitudes, and when they might occur is notoriously hard to predict.

Auroral displays are caused by charged particles from the solar wind striking the Earth's upper atmosphere. Our planet's magnetic field guides these particles toward the poles, which is why auroras are only visible from high northern and southern latitudes (the auroral light show is called the *aurora australis* in the southern hemisphere).

Our Celestial Backyard: The Solar System

Our Sun is one of countless stars in the universe. The planets that circle the Sun are its family, figuratively speaking, and it would be hard to deny that Earth is its favorite child. The planet we call home is located at just the right distance to be neither too cold nor too hot for liquid water and life to flourish on its surface. But the rest of the Sun's family – the solar system – is full of diverse and fascinating characters. Some of them may once have harbored some form of primitive life. These bodies are much, much closer than even the next nearest star, and so astronomers like to say they inhabit our celestial backyard.

Finding a planet in *TheSkyX* is simple. Simply go to the ***Edit*** menu and choose ***Find***. Type the name of the planet in the ***Search For*** box. Information about the planet will be displayed. You can center the planet in the Sky Chart by clicking the ***Center*** button near the bottom of the screen. Note that this same procedure applies to every object in *TheSkyX*'s database. If you're unsure of an object's name or catalog number, click the Advanced button to view a comprehensive list of searchable objects.

The Moon

The most familiar object in the night sky is undoubtedly the Moon. It's been Earth's constant companion for more than four billion years. Scientists believe that the Moon was formed shortly after the birth of the solar system, when a molten planet about the size of Mars smashed into the Earth. That planet is no longer around, but much of the fallout from its impact settled into orbit around us and aggregated into the Moon.

The Moon is *tidally locked* to the Earth. Our gravitational pull, over millions of years, slowly put the brakes on the rotation of our satellite. Today the Moon makes one complete rotation for every single orbit it makes around the Earth. Because of this, the same side of the Moon always faces the Earth. We had no way of seeing the far side of the Moon until spacecraft were sent there in the late 1950's. Some people mistakenly call the far side of the Moon the dark side of the Moon. With all due respect to Pink Floyd, the Moon has no "dark" side. Over the course of a lunar day (about 29.5 Earth days) the far side of the Moon gets just as much sunlight as the side facing us.

As the Moon orbits the Earth, it goes through its familiar *phases*, from New to Full and back again. *TheSkyX* can tell you the phase of the Moon on any date, at any time. It is automatically displayed on the star chart in its current phase and proper location whenever it is above the horizon. The orbit of the Moon is not a perfect circle, but an *ellipse*, meaning it has an oval shape (in fact, all orbits, from artificial satellites to planets to stars circling the centers of galaxies, are ellipses). *TheSkyX* will tell you the current distance between the Earth and Moon.

The Moon is one of the most interesting things to look at in binoculars or a telescope. Even a little magnification will reveal the larger lunar craters, and help you see the *mare*, the so-called lunar "seas," which are really cooled lava basins. The Moon has no atmosphere, so liquid water cannot exist there. Our single natural satellite is dry as a bone, but there is some evidence that small amounts of water ice might reside in the permanently shadowed craters near the Moon's poles.

Moon Photo Viewer

TheSkyX includes a detailed map of the Moon based on photographs taken by a spacecraft called Clementine. Clementine was launched into space on a converted intercontinental ballistic missile – a Cold War sword was turned into a lunar plowshare that yielded a rich scientific harvest, giving scientists important new information on the morphology (shape) and mineralogy of the Moon.

To access the Clementine Moon map, go to the ***Tools*** menu and choose ***Moon Photo Viewer***. Your lunar journey begins with a photo showing the region near the feature *Tranquillitatis*, better known as the *Sea of Tranquility*. As you move the mouse cursor over the photo, different features are highlighted in red, and the Moon's longitude and latitude are shown to the left. (To highlight larger features, place the cursor near its center.)

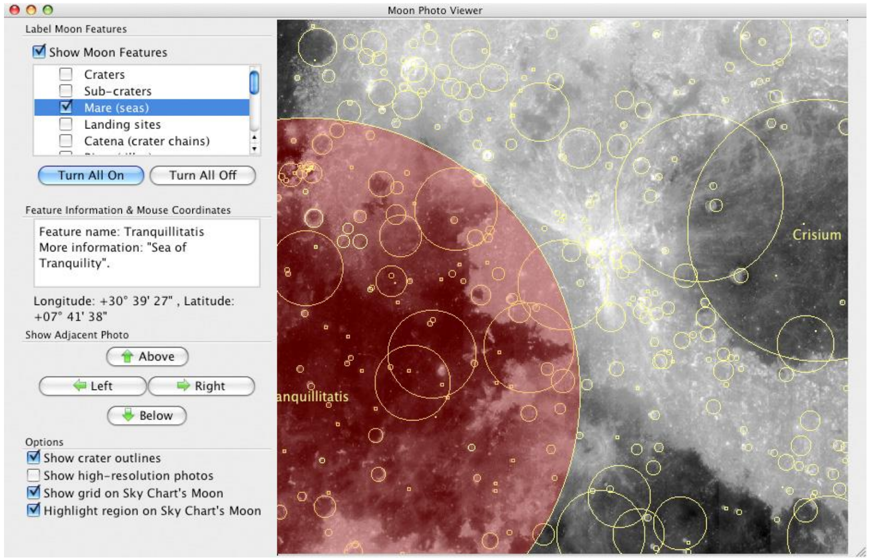


Figure 70: Moon Photo Viewer window.

You can use the Sky Chart's Moon with the Moon Photo Viewer to locate a particular feature in a photo on the Earth-based view of the Moon. Or, you can click on the Sky Chart's Moon to show the photo of that region.

Do to so, first position the Moon Photo Viewer window so that the Sky Chart is also visible on your screen.

Lock On and Frame the Sky Chart's Moon:

1. Clicking the ***Find command*** from the ***Edit menu***.
2. On the Find window, type ***Moon*** and then click the ***Lock On*** button.
3. On the ***Find*** window, click the ***Frame*** button.

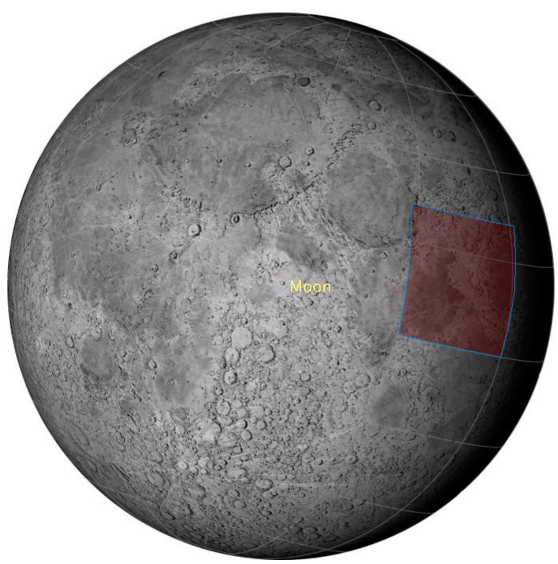


Figure 71: The Sky Chart Moon showing the position of the current Clementine photo (red rectangle) and the Moon grid lines.

The Moon is now fixed to the center of the Sky Chart. Make sure that the ***Highlight Region on Sky Chart's Moon*** checkbox is turned on (page 141). You can now click on the Sky Chart Moon to show the photo of that region on the Moon Viewer window. Or, you can change the Moon Viewer Photo by clicking the ***Left/Right/Above/Below*** buttons and the Sky Chart's Moon will highlight this region in red.

Label Moon Features

A number of interesting lunar features can be labeled on the Clementine photos, including:

- Craters
- Sub-craters
- Mare (lunar "seas")
- Landing Sites
- Catena (crater chains)
- Rima (rilles)
- Lacus (lakes)
- Mons (mountains)
- Dorsum wrinkle ridges
- Promontor promontories
- Vallis (valleys)

Turn on the ***Show Moon Features*** checkbox to display the selected features. The ***Turn All On*** and ***Turn All Off*** buttons can be used to show or hide all features.

Feature Information & Mouse Coordinates

Placing the mouse cursor over the photo reveals additional information, including the precise lunar latitude and longitude and details about the feature. When the ***Show Crater Outlines*** checkbox is turned on, the crater beneath the mouse cursor is also highlighted in red.

Show Adjacent Photo

Press the Left/Right/Above/Below buttons to navigate the Moon's surface.

As you scroll around, you might notice black rectangular regions on some photos. These show areas where no photographic data was acquired during the survey.

Options

The Moon Viewer window offers the following display options.

Show Crater Outlines

Turn on the **Show Crater Outlines** to display yellow circles around the craters on the photos.

Show Grid on the Sky Chart's Moon

Turn on ***Show Grid on the Sky Chart's Moon*** to show lines of latitude and longitude on the Sky Chart's Moon.

Highlight Region on Sky Chart's Moon

Turn on this checkbox to show the location of the current photo on the Sky Chart's Moon. You can also click anywhere on the Sky Chart Moon to show the Clementine photo for that area.

Show High-Resolution Photos

PROFESSIONAL

Turn on this checkbox to show 100-meter resolution Clementine photos in *TheSkyX Professional Edition*.

Setting the Moon's Font
The font used to label Moon features on the Clementine photos is the same font used to label the Sky Chart's Moon. If you wish to change this font, edit the Moon's font attributes from the Chart Elements window (page 192) .

Figure 72: TheSkyX's Moon shows simulated shadows based on the Moon's topography and the current phase. (OpenGL 3.0 or later required).

TheSkyX incorporates digital elevation data from recent lunar space missions to create realistic view of the Moon's surface. (OpenGL version 3.0 or later is required, see "Updating Your Computer's Video Driver" on page 14 for more information.)

The Classical Planets

Not counting Earth, five planets are visible to the naked eye. It has been known since ancient times that the planets slowly change position relative to the stars, which appear to be fixed, never moving with respect to each other from year to year. In fact, the word planet derives from an ancient Greek term that means "wanderer."

All planets in our solar system orbit the Sun (you probably know that the Sun is a star, not a planet). Their orbits lie more or less in the same plane, so as they circle the Sun, their paths are restricted to a narrow band in our sky, which is called the *ecliptic*. The constellations that lie in this plane received special attention from ancient astronomers. Collectively they are known as the *Zodiac* constellations.

The farther a planet is from the Sun, the longer it takes to complete a single orbit. Planets farther from the Sun therefore move more slowly through the Zodiac.

TheSkyX can locate any planet wherever it happens to be on a given night. Below we describe some general features of the planets, starting from the closest in, then moving out to the edge of the solar system.

Mercury

Mercury is the closest planet to the Sun. It takes only 88 days to travel around the Sun once. This is another way of saying that a year on Mercury is 88 days long.

Because Mercury is so close to the Sun, it can be spotted only shortly after sunset and shortly before sunrise, when it is near the "edge" of its orbit from our perspective. It is hard to see much surface detail on Mercury in even the most powerful telescope, but the Mariner 10 spacecraft made three "fly-bys" of Mercury in 1974 and 1975. Pictures from that spacecraft revealed Mercury strongly resembles our Moon, with a heavily cratered surface. It is comparable to our Moon in size, but much denser. Being so close to the Sun, the surface of Mercury is very hot, as you would expect. The average daytime temperature there is above 400º C.

Venus

Commonly known as both the morning and the evening "star," Venus is the brightest natural object in the sky after the Sun and Moon. Its beautiful radiance has dazzled mankind throughout history. Venus is so bright that, from a very dark location, it can cast shadows.

When astronomers first eyed Venus through telescopes, they discovered that the planet is perpetually enveloped in clouds. They never part, keeping the surface of the planet forever shielded from direct view. This fact led to a great deal of fevered speculation about what might be hidden beneath those relentless clouds. Could Venus harbor steamy, tropical rainforests, inhabited by alien dinosaurs or even more exotic forms of life?

Much to the disappointment of science fiction writers, astronomers discovered in the early 1960's that the surface temperature of this deceptively serene-looking planet is hot enough to melt lead. Venus is a hellish, uninhabitable desert. The reason for this is a runaway greenhouse effect. The Venusian atmosphere is almost entirely carbon dioxide (CO_2), a gas notorious for its effectiveness at trapping heat. The fact that high concentrations of CO_2 have raised the surface temperature of Venus so far above what we would otherwise expect is one reason some worry about rising CO_2 levels on our planet. If Venus had the same mix of nitrogen and oxygen in its atmosphere as we have in ours, it would almost certainly be a lovely place to spend your vacation.

When Galileo began to systematically observe Venus with his telescopes, he discovered it goes through phases like the Moon. This helped convince him that the Sun, not the Earth, is the center of motion in the solar system. Venus, like Mercury, is an "inner" planet, meaning that they lie closer to the Sun than we do. This is why these planets are visible only in the early evening or pre-dawn skies – from our location in the solar system, they never appear to travel very far from the Sun.

Earth

Earth is the third planet from the Sun. Scientists sometimes refer to Earth as the Water Planet because more than 70 percent of our surface is covered by liquid water, and water is essential for life. Our world is the only planet in the solar system that can support life as we know it.

A day is defined as the amount of time it takes for Earth to make one complete *rotation* on its axis. A year is defined as the time it takes Earth to make one complete *orbit* of the Sun. The length of a day and year are different on other planets because they rotate at different rates and have different orbits.

The axis about which our planet turns is tilted relative to the plane of our orbit. This is why we have seasons. In the summer, our northern hemisphere is tilted toward the Sun, so the days are longer, and sunlight strikes the Earth more directly, making the northern hemisphere warmer (the opposite is true in the southern hemisphere) than it is in winter. In the wintertime, our northern hemisphere is tilted *away from* the Sun. The days are thus shorter and colder (again, the opposite is true in the southern hemisphere).

A *solstice* occurs when our axis is tilted directly toward or away from the Sun. The winter solstice is the shortest day of the year, and the summer solstice is the longest (depending on your latitude, this may or may not correspond to the times of earliest sunrise and latest sunset – the explanation is a little more complicated than what we're prepared to discuss here).

An *equinox* occurs when the center of the Sun is directly above the Earth's equator. There are two of these each year, one in spring (the *vernal* equinox) and one in fall (the *autumnal* equinox). Equinox is derived from Latin and means "equal night." During an equinox, night and day are both just about 12 hours long.

Like all planets, the orbit of the Earth is not perfectly circular, but slightly elliptical. The Earth is about a million kilometers closer to the Sun in December than June.

Mars

The next planet out from the Sun is Mars. It is about half the size of our planet and takes a little more than two years to go around the Sun once. Mars is very similar to Earth in two important ways. Its day is just over 24 hours long, and its axis of spin is tilted about 23 degrees, almost exactly the same tilt as Earth. This means that Mars has seasons, just like we do. But they last twice as long, since a Mars' year is about twice as long as one of ours (687 Earth days, to be more precise).

Like Venus, the atmosphere of Mars is almost entirely CO_2. Unfortunately it is an extremely thin atmosphere, about 1/100th the pressure of our atmosphere at the equivalent of Martian sea level. During the day, the surface temperature of Mars near the equator can rise above freezing, but that same night it will drop well below –100º C. A little more greenhouse effect on Mars would be a welcome thing. As it is, the air on Mars is too thin to support liquid water on its surface, another blow to all those science fiction writers who imagined alien beings and ancient civilizations on Mars.

Still, Mars is the only other planet in our solar system whose surface is directly accessible to astronauts. Even though liquid water can't exist on Mars today, there is lots of geological evidence to suggest that in the distant past, the atmosphere of Mars was much thicker, and water flowed there freely. This gives scientists hope that Mars may have once harbored simple forms of life. If life did thrive there in the distant past, it may still survive today, perhaps in small "oases" deep underground, where organisms would be protected from the harsh conditions on the surface.

The best time to look at Mars in a telescope is during an *opposition*. About every 26 months, Mars and Earth line up on the same side of the Sun. This is when Mars is at its brightest and closest, and therefore appears at its best in a telescope. *TheSkyX* can calculate the dates of future oppositions and even tell you how large, in arcseconds, the disk of Mars will appear in an Earth-bound telescope.

As Mars approaches opposition, it briefly exhibits *retrograde* motion. This is a fancy way of saying that Mars looks like it turns around and moves backward in the sky for several days. This is simply a trick of perspective. As our two planets orbit the Sun, Earth catches up to and passes Mars. When we pass, Mars appears to move backward with respect to the far more distant stars.

Looking at Mars through a telescope, the first thing an observer usually notices on the disk of the planet are the *albedo* features. These are bright and dark markings that mostly correspond to variations in the coarseness of Martian surface dust. They were first systematically charted and named by the Italian astronomer Giovanni Schiaparelli in the 19th century. He mistakenly believed that the dark features were seas and lakes, and he used the Latin terms *mare* and *lacus* accordingly. Today we know there is no surface water on Mars, but like Earth, the Red Planet does have polar caps. Unlike our polar ice, they are made not just of frozen water but carbon dioxide or "dry ice" as well. During an opposition, you can usually glimpse either the northern or southern cap in a small telescope.

There is a huge difference between seeing Mars in a telescope and looking at images of Mars taken by orbiting spacecraft. Beginning with the Mariner 4 fly-by in 1965, American, Russian, and European spacecraft have revealed Mars to be a world of geological wonders. Huge craters, towering volcanoes, and immense systems of canyons mark and etch its surface.

Mars is orbited by two small moons, named Phobos and Deimos (ancient Greek words for fear and terror, respectively). They are much smaller than our Moon, irregularly shaped, and difficult to see in most amateur telescopes. Some scientists believe these moons are actually wayward *asteroids*.

The Asteroid Belt

A ring of interplanetary debris circles the Sun between the orbits of Mars and Jupiter. These rocky fragments are thought to be remnants from the original disk of material that formed the planets. The gravity of Jupiter prevented these bodies from aggregating into a planet in their own right. There are literally millions of asteroids, but collectively their mass is only about 1/10 the mass of our Moon.

Ceres is the largest asteroid, and the first to be discovered back on New Year's Day in 1801. *TheSkyX* does not include asteroids in its main database, but you can add information on asteroids through the ***Input > Small Solar System Bodies*** menu.

Jupiter

Jupiter is the king of the planets. Ten times wider than Earth, it has more mass than all of the other planets in our solar system combined. Nearly a billion kilometers from the Sun, it takes twelve years to complete a single orbit.

Jupiter has a family of dozens of moons of various sizes and shapes, forming, in effect, a "mini" solar system. At last count, astronomers have charted over 60 moons orbiting this giant world. Many of these bodies are small as a typical asteroid (some of them might even be asteroids that were captured by Jupiter, caught like flies in its gravitational web).

Jupiter is attended by four large moons comparable in size to our own Moon. Because they were discovered by Galileo when he first turned his telescope on Jupiter in 1609, we call them the *Galilean satellites*.

TheSkyX includes telescope and spacecraft images of Jupiter, and can plot the orbits of its Galilean satellites. This is a particularly useful feature if you have a telescope. The moons shift position night to night as they orbit Jupiter, and you can track these motions with a modest telescope, or even a good pair of binoculars. Also, when a Galilean moon passes in front of Jupiter, it casts a shadow on the disk of the planet that can be observed in small telescopes. These *shadow transits* are fascinating to observe, and *TheSkyX* can tell you when they will occur. It also provides timings for another interesting phenomenon involving Jupiter's moons, an *occultation*. These occur when one of the moons enters the giant planet's shadow and passes behind it. Interesting Historical Note: by timing the occultations of the Jovian moon Io, the astronomer Ole Romer was able to make a rough estimate of the speed of light way back in 1676.

Saturn

Author's comment: I'll never forget the first time I saw Saturn through a telescope. I was 11 years old. The telescope was small enough to fit in a lunchbox, but it was made by an extraordinary man named Max Bray, and was more than a match for Saturn. In the eyepiece, I saw a small white disk nestled inside a perfect set of white rings. It took my breath away. Everyone I know who has ever seen Saturn in a telescope remembers it. The most fun I've ever had in over three decades of being involved in astronomy is showing someone Saturn in a telescope for the first time. The planet is best known of course for its extraordinary rings.

Saturn takes nearly 30 years to complete one orbit around the Sun. During this period, our view of the rings is slowly changing. Sometimes they are spread relatively wide and are easy to see, but about every 15 years they line up edge-on to our view. These "ring plane crossings" last a few days or so, and during this time all that can be seen of the rings is a dark, thin line crossing the disk of the planet.

Like Jupiter, Saturn is attended by numerous moons of various shapes and sizes. Titan, the largest, has a mostly–nitrogen atmosphere about one-and-a-half times thicker than the Earth's.

Going Farther

Saturn is the farthest planet that was known to man in ancient times. The invention of the telescope revealed innumerable new worlds never before seen by human eyes, including previously unknown planets in our own solar system.

Uranus

The seventh planet out from the Sun, Uranus is the first planet discovered by telescope. The astronomer William Herschel is credited with recognizing it as a planet over two hundred years ago, in 1781 (other astronomers had seen it, but mistook it for a star – Herschel initially thought it was a comet). Like Jupiter and Saturn, it is a giant, much larger than Earth, and its atmosphere is mostly made of hydrogen and helium. But there are also significant amounts of water, ammonia, and methane ice in this frigid world, and so astronomers refer to it as an *Ice Giant*.

At a distance of almost 3 billion kilometers, Uranus takes 84 years to make a complete trip around the Sun. Its axis of rotation is tilted 98 degrees to the plane of its orbit, as if the planet had been flipped on its side. Like all of the giant planets, Uranus has an extensive family of moons, at least 27. They are named after characters taken from the works of Shakespeare and Alexander Pope. The largest, Titania, is about half the size of Earth's Moon.

On a dark, moonless night, Uranus is just barely visible to the naked eye – if you have very sharp vision and know exactly where to look. *TheSkyX*, of course, can tell you where to find it. Uranus is relatively easy to find in a good pair of binoculars.

Neptune

The next planet out, Neptune, is similar in size and composition to Uranus. It is also considered an Ice Giant. The existence of Neptune was predicted by mathematical analysis of the orbit of Uranus. Deviations in the predicted orbit of Uranus led astronomers to believe that some other large body farther out in the solar system periodically tugs at Uranus. This theory was confirmed when Neptune was discovered close to its predicted position.

In a telescope, Neptune appears cool blue in color. It was first spotted by none other than Galileo, when it happened to be near Jupiter in the sky, but Galileo assumed that this faint blue object was a star, not a planet, and so he is not credited with its discovery.

It takes Neptune over 184 years to make a single orbit of the Sun. Discovered in 1846, it has yet to make a single orbit since it was first recognized as a planet. It lies some 4.5 billion kilometers from the Sun, and is attended by 13 diverse moons. The largest, Triton, is 2700 kilometers in diameter, just a little smaller than our own Moon. Triton orbits Neptune in a *retrograde orbit*, which means that it travels backwards relative to the direction of rotation of Neptune itself. This suggests that Triton did not form with Neptune, but came into being somewhere farther out in the solar system and was later captured by Neptune's gravity.

Pluto and the Ice Dwarfs

We all used to be taught that there are nine planets in the solar system. That is no longer the case. Pluto has been demoted. Today it is not considered a full-fledged planet, but an *ice dwarf*, one of perhaps hundreds of such objects that inhabit the outer reaches of the solar system.

Many people, including a lot of astronomers, are unhappy that Pluto has lost its status as a planet. Controversy is still raging over the decision to reclassify it. If you're wondering who gets to decide whether or not Pluto is a planet, the authority rests on a group called the

International Astronomical Union (IAU). Founded in 1919, the IAU has some 10,000 members, all professional astronomers. Its main purpose is to promote and protect the science of astronomy internationally, but it also has sole authority for classifying and naming astronomical objects. Despite some groups that claim otherwise, you cannot have a star named after yourself or a loved one without going through the IAU.

During their August, 2006 meeting, the IAU membership voted on a new, more rigorous definition of a planet that had been developed by one of its working groups. This new and improved classification scheme included the category “dwarf planets” to cover objects in our solar system that had recently been discovered beyond the orbit of Pluto. Unfortunately for Pluto fans, it perfectly fits the new category, hence the demotion.

Land of the Comets: The Kuiper Belt and the Oort Cloud

One of the most beautiful things you’ll ever see in the sky is a bright comet. Comets are refugees from the outer fringes of the solar system. Mixtures of ice and dust, the astronomer Fred Whipple famously described comets as “dirty snowballs.”

Astronomers believe that most comets spend their lives in either the *Kuiper Belt* or the *Oort Cloud*. Named for the astronomers who first theorized their existence, these regions of space, far beyond the orbit of Pluto, are thought to be repositories of matter left over from the formation of the solar system.

A gravitational nudge from a nearby star or a passing cloud of interstellar dust can send an object from this region careening into the inner solar system. When a comet gets close to the Sun, its ice begins to sublimate. The escaping gas and dust form the *coma* and *tail* that give comets their distinctive appearance.

Most comets are unexpected strangers to our part of the solar system, but some have settled into predictable, short-term orbits. Halley’s Comet is probably the most famous example. *TheSkyX* charts the orbits of several periodic comets. Most of them can only be seen on rare occasions with a telescope, but you never know when a new comet will be discovered and grace our sky in spectacular fashion, as comets Hyakutake and Hale-Bopp did in the late 1990’s.

You can also enter the *orbital elements* of newly discovered comets into *TheSkyX* database using the ***Input*** > ***Small Solar System Bodies*** command. The position of the comet from night to night can then be displayed in the Sky Chart. Orbital elements can be downloaded from Harvard University’s Center for Astrophysics website.

A 3D View of the Solar System

Planetary motion is complex. It took humans thousands of years to figure it all out. Fortunately for us, computers make the tough math a breeze, and they allow us to create useful simulations of the motions of solar system objects.

Modeling Planetary Motion

The planets move in predictable orbits about the Sun, and with the easy-to-use Solar System Tool, you can model their positions and motions with ease.

The Planets

For a 3D solar system simulation including the eight classical planets, plus Pluto, select ***Solar System*** from the ***Tools*** menu. A window then opens showing the solar system simulator. On the right, you see the simulation. You can click and drag on the simulated solar system to change the orientation and view it from varying angles. Time can also be moved forward or backward using the ***Time Skip*** item in the ***Tools*** menu, or the corresponding toolbar buttons. Alternately, you can adjust the time using the ***Date and Time*** item in the ***Input*** menu.

On the left are the menus and controls that affect what you see in the simulator. There is a slider that lets you control the viewing distance from 1 to 50 A.U., or *astronomical units*. An astronomical unit is a basic unit of distance used to describe the distance between objects within the solar system. One A.U. equals the average distance from the Earth to the Sun, about 150 million kilometers. Try out the distance slider to get a feel for how it works.

There are also checkboxes used to toggle on or off the ecliptic grid, orbit depths, and the background stars.

Small Solar System Bodies: Comets

Small solar system bodies include comets and asteroids. *TheSkyX* can display the orbits of these objects in the solar system simulator. By default, there are none available to show, so you will have to download some from the internet. Let's start by downloading some comet data

1. With the Solar System window open, select Input > Small Solar System Bodies. A new window appears with three tabs at the top, Comets, Asteroids (Small Database), and Asteroids (Large Database). Select the Comets tab.
2. A window opens labeled ***Comets Available for Display***. Here, you will see the total number of comets available for display, as well as a list of their names with checkboxes. It is with these checkboxes that you can toggle comets on or off in the Sky Chart or in the solar system simulator.
3. You have three options for importing comet data into *TheSkyX*. You can import them from an existing file, or you may download comet data directly in *TheSkyX* using internet databases. You may download individual comet data by name, or you can download all the data for all observable comets at once. For our example, let's download all observable comets at once. To do this, simply click ***Observable***.
4. The data will then download, and the observable comets will now appear in the list above, on the Sky Chart, and in the solar system simulator.

Note: Be sure that your computer is connected to an active internet connection before attempting to download comet data.

Small Solar System Bodies: Asteroids

The process is very similar when downloading asteroid data from the ***Asteroids (Small Database)*** tab. There, you can choose to import asteroid data from an existing file, by orbital characteristic, such as distant, critical, or unusual, or you may import by asteroid name.

Should you decide to import asteroids from the ***Asteroids (Large Database)*** tab, you will have to visit one of the websites provided and download a file with the desired data. You can then select the file with the ***Choose*** button to reveal the asteroids in the Sky Chart and solar system simulator. Additionally, the checkboxes you see under the ***Asteroids (Large Database)*** tab toggle important display options such as computing asteroid positions at startup and 24-hour object paths for imported asteroids.

Eclipses

One of the most spectacular phenomena in nature is a total eclipse of the Sun. If you've seen one, you'll never forget it, and chances are you'll want to see as many as you can in your life. *TheSkyX* can predict eclipses literally thousands of years in the future. It can tell you where the eclipse will be visible and how long it will last, so naturally it's a great tool for planning a trip to see one of these extraordinary events.

There are three kinds of solar eclipses: *total*, *annular* and *partial*. In a total eclipse, the Moon passes in front of and completely covers the disk of the Sun, making it possible to see the Sun's *corona*, its extended atmosphere, and eruptions of surface plasma called *prominences*. This is truly a unique coincidence: the Sun is 400 times bigger than the Moon, but the Moon is 400 times closer to the Earth, so in our sky, they have almost exactly the same *angular diameter*, about half a degree. No other moon in our solar system can treat its home planet to a total eclipse.

Similar to a total eclipse, an annular eclipse occurs when the Moon goes right in front of the Sun. Due to differences in orbital positions, the angular size of the Moon is a bit smaller than the Sun. At the peak of an annular eclipse, a ring or "annulus" of light appears around the Moon.

In a partial eclipse, the Moon covers a portion of the Sun, so the corona and prominences aren't visible. Still, a partial eclipse can be fascinating to observe – as long as you use an appropriate filter to protect your eyes.

The Solar and Lunar Eclipse Finder lists *hybrid* eclipses that include both total and partial eclipses during the event. For example, the eclipse in April 2023 near Australia begins as an annular eclipse, becomes a total eclipse, then reverts to an annular eclipse. This type of eclipse is designated as *Hybrid A-T-A*.

NEVER LOOK DIRECTLY AT THE SUN WITHOUT A SAFE FILTER! You can instantly and permanently damage your eyesight by looking at the Sun without proper protection.

Lunar eclipses occur when the Moon passes into the shadow of the Earth. If the Moon orbited the Earth in the same plane as the Earth orbits the Sun, a lunar eclipse would happen every month, when the Moon is in its Full phase. But because the orbit of the Moon is tipped about five degrees relative to the orbit of the Earth around the Sun, lunar eclipses only happen about once every eighteen months when the orbits are aligned.

You might imagine that when the Moon passes into our shadow it completely disappears, but it doesn't. Dust in our atmosphere scatters a little bit of sunlight into our planet's shadow. Because dust mostly scatters red light, the Moon typically takes on a dim red or copper glow during the total phase of a lunar eclipse. How dark the Moon becomes depends mostly on how much dust happens to be in the air at the time of the eclipse. One of the fun things about viewing a lunar eclipse is that you never know exactly what shade of red or how dark the Moon will appear.

Viewing Eclipses

Selecting Tools > Solar & Lunar Eclipse Viewer from the menu bar will bring up the Solar & Lunar Eclipse Viewer Window.

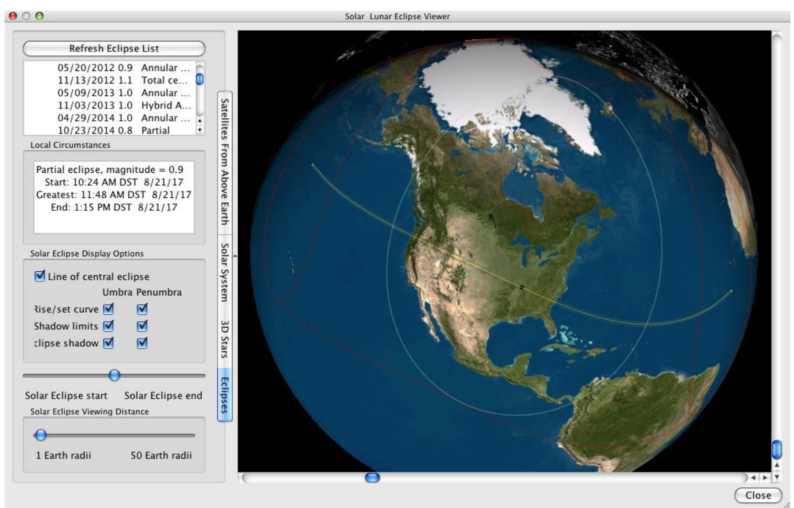


Figure 73: The Solar and Lunar Eclipse Viewer window.

In it, you will see a list of upcoming eclipses, a box displaying local circumstances for a selected eclipse, the eclipse viewer, and several checkboxes and sliders used to control the viewer.

Solar Eclipse Viewing

While using protective eyewear is certainly not necessary when viewing a solar eclipse in *TheSkyX*, the importance of using proper protection when observing the actual Sun at any time can never be overstated. Experienced observers should consider the following guidelines when observing a total eclipse:

i. get a proper eclipse viewing filter – do NOT improvise – and use it right up until the sky darkens rapidly,
ii. enjoy the total phase naked eye as nature intended,
iii. use the filter again as soon as the corona has been outshone by the diamond ring.

In the eclipse viewer, solar eclipse paths are viewed on a three-dimensional Earth globe, showing the eclipse shadow's path, rise and set curves, and umbral and penumbral limits.

To view a solar eclipse, scroll down the list near the top of the window and select a solar eclipse. Immediately, you will notice that the eclipse viewer will update to show the pertinent data on the Earth globe. A ***small green circle*** indicates your home position, as entered in the location section of *TheSkyX*. Additionally, you will notice a black circle along with colored lines representing important data about the selected eclipse. The following is a brief description of these markings.

The ***Black Circle*** marks the umbral (darker) eclipse shadow as projected onto Earth. This is the region where eclipse totality is possible.

The ***Yellow Line*** represents the line of central eclipse. It shows the eclipse's center line path over the globe. ***Yellow Ovals*** at the beginning and end points of the yellow line represent the umbral rise and set curves

The ***Grey Line*** represents the limits of the umbral shadow.

The ***Red Lines*** show both the rise and set curves and the shadow limits of the penumbra (lighter shadow).

The ***White Line*** marks the penumbral shadow on the Earth globe.

All of these markers can be toggled on or off by using the checkboxes under ***Solar Eclipse Display Options*** on the lower left of the window.

Once you have selected an eclipse from the list, you will notice that the ***Local Circumstances*** box now displays the local information regarding the eclipse, such as its local visibility, magnitude, start and end times, and moment of greatest eclipse. Once an eclipse is selected, the Sky Chart automatically updates to display the eclipse from your selected location.

Using the slider immediately below the ***Solar Eclipse Display Options***, you can view the path of the eclipse in progress, ranging between its start and end points. Simply slide it to the left to move toward the start point, and sliding it to the right will move toward the eclipse's end point.

Note: Another way to move time is to click Go Forward in the toolbar. Selecting an eclipse automatically stops time in *TheSkyX*, but by restarting it, you can watch the eclipse progress in the viewer in real time, or at any speed you choose.

Below the eclipse start/end slider is the slider marked ***Solar Eclipse Viewing Distance***. With the slider all the way to the left, the eclipse viewer is set to view the globe from a perspective of one Earth radius away. Slide the slider to the right, and you will gradually increase the viewing distance up to 50 Earth radii. If you have a scroll-wheel mouse, you can adjust the viewing distance by moving the cursor over the viewer and rolling the scroll wheel up (for closer distance) or down (for farther distance). Clicking and dragging the mouse will rotate the globe, adjusting the angle at which the eclipse path is viewed.

Note: In case your view of the globe is cut off, this window is resizable by clicking and dragging on the lower right corner.

Lunar Eclipse Viewing

Also included in the eclipse list are lunar eclipses. These are shown from the perspective of Earth's surface in the Sky Chart.

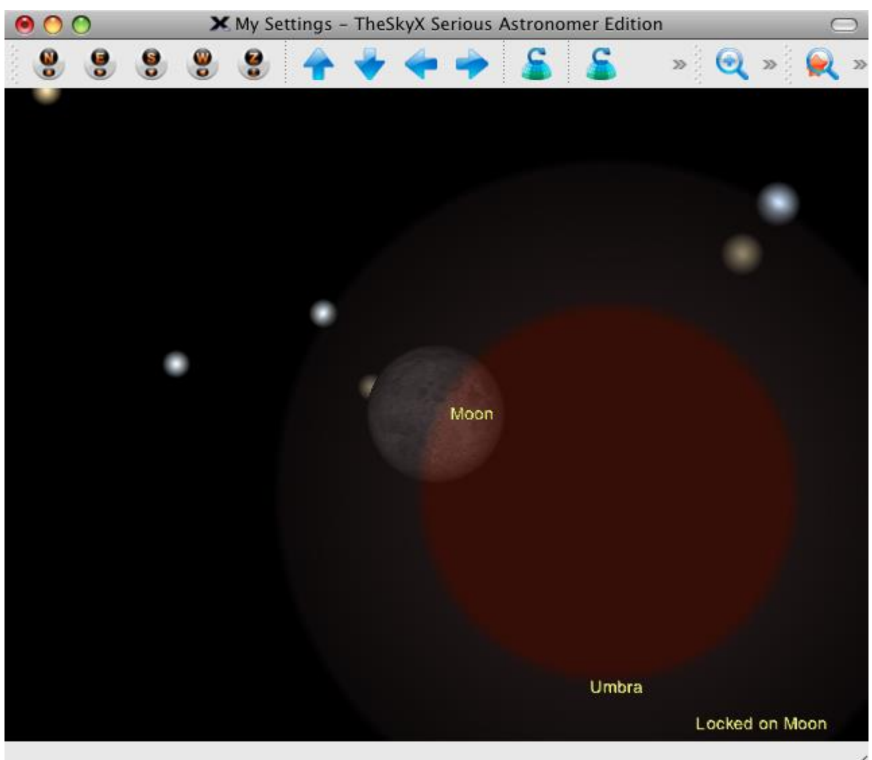


Figure 74: Lunar eclipse showing the umbra and penumbra (the light gray background above).

By selecting a lunar eclipse from the list, the Sky Chart will automatically update to show the chosen eclipse. Note that the Moon and penumbra and umbra of Earth's shadow appear with labels.

Looking at the ***Local Circumstances*** box will show the start date and time for the selected eclipse, as well as the maximum shadow coverage in lunar diameters. As with solar eclipses, time is stopped when an eclipse is selected, but can be started again whenever you wish to view the eclipse in motion. Using this tool, you can take note of shadow contact times when preparing for the exciting spectacle that is a lunar eclipse.

Spacecraft

Before 1957, nothing made by human hands existed above our atmosphere. But in that year, the Soviet Union launched the world's first artificial satellite, Sputnik. Since then, thousands of satellites have been launched into Earth orbit.

TheSkyX downloads *orbital elements* or *two line elements* (TLEs) from the web to keep track of thousands of satellites and other orbital debris. Using these numbers, *TheSkyX* can calculate where satellites will appear in the sky for any location on Earth.

To manage which satellites are shown, click the ***Satellites*** command in the ***Input*** menu.

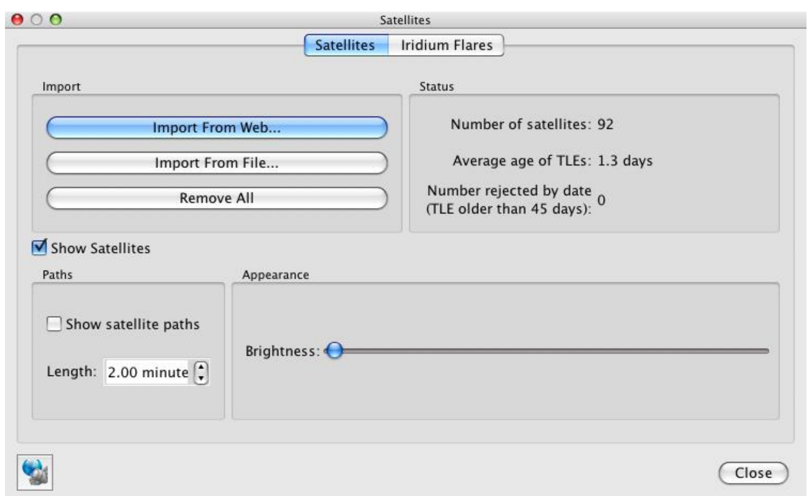


Figure 75: The Satellites dialog (Satellites command from the Input menu).

Satellite TLE data can be imported from the web or from a text file that contains the properly formatted data. *TheSkyX* uses orbital element information from Space Command Center's TLEs to predict and display satellites' positions. Two-line element data must be updated frequently and are available for most satellites on the web.

Gravitational forces, among other things, constantly perturb the orbit of a satellite around earth, so its position is not precisely predictable over long periods of time. *TheSkyX* automatically updates selected TLEs for your each time it is launched.

Download Satellite TLEs from the Web (Import From Web button)

Current satellite TLE data are retrieved from Dr. T.S. Kelso's Celestrak web site.

Clicking the ***Import from Web*** button shows the Import Satellites from Celestrak dialog.

Figure 76: The Import Satellites from Celestrak dialog.

Turn on the desired categories, then click the Download button to retrieve them from the web. Importing all the satellites will most likely sap your computer's processor, so choose wisely.

Import from File

TLE data residing in a text file, rather on the web, can be imported and displayed by clicking the Import From File button. The text file must contain TLE data only. For example, the TLE data for the GOES 2 satellite looks like this:

GOES 2
10061U 77048A 98127.50441330 .00000045 00000-0 10000-3 0 97472 10061 13.1659 29.4732 0005723 183.8196 16.8163 1.00281760 21356

Status

The Status section shows the total number of satellites that were successfully loaded, the average age of the TLE data (the "newer" the better) and the number of TLEs that have been rejected because they are older than 45 days.

Use the ***Advanced*** tab on the ***Find*** window to locate a particular satellite.

Show Satellites

When this option is turned on, satellite positions are computed and displayed on the Sky Chart.

Show Satellites' Paths

Turn on this checkbox to draw a line on the Sky Chart that represents the upcoming path that the satellite will follow.

Length of Satellite's Path (Length input)

Enter the length of time, in minutes, of the satellites' paths.

Fun Example: Observing the International Space Station (ISS)

Watching the International Space Station fly overhead is a truly exciting event. *TheSkyX* can be used to predict when the ISS will travel overhead, and show you its path.

To find the best passes for the ISS, do the following.

1. Click the ***Satellites*** command on the ***Input*** menu.
2. Click the ***Import From The Web*** button.
3. Turn on the International Space Station radio button.
4. Click the ***Download*** button.
5. Click the ***Satellites From Above Earth*** button on the Satellites dialog (lower left corner of the window).
6. Select ***ISS (ZARYA)*** from the list of satellites, then click the ***Find Best Passes*** button.

A list of the times when this satellite is visible above the horizon is displayed. Double-click the items in the list to show the pass from an above-Earth perspective. Turn on the Update Chart radio button to show the path on the Sky Chart.

Iridium Flares

Beginning in 1998, a network of sixty-six communication satellites called Iridium was launched into orbit. At any given time, at least one of them is above the horizon for any location on Earth (not counting the territory around the north and south poles). Sometimes, as an Iridium satellite moves across the sky, sunlight bounces off its antennas and solar panels, creating a brief but brilliant *Iridium flare*. *TheSkyX* can calculate when the next flare will be visible from your location (they only happen in early evening or shortly before dawn). Click the ***Tools > Iridium Flares*** command to find the next flare that you can observe from your backyard.

Choose the ***Iridium Flares*** command from the ***Tools*** menu.

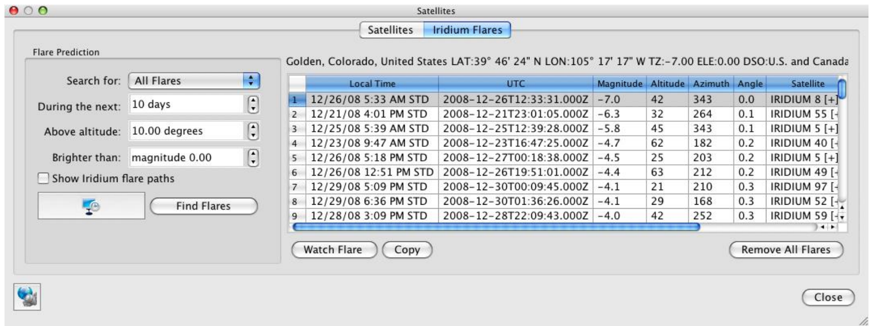


Figure 77: The Iridium Flares tab on the Satellites dialog (Tools > Satellites command).

Specifying the Type of Flare to Find (Search For pop-up menu)

Flares can be located based on what time of day they occur.

- ***Daytime Flares*** occur between sunrise and sunset
- ***Nighttime Flares*** occur between sunset and sunrise
- ***Dawn/Dusk Flares*** occur during the morning and evening hours

Choose the ***All Flares*** item to search for flares that occur any time, day or night.

Length of Time to Search (During the next)

Enter the number of days from now to search for flare events. Flare prediction involves some heavy duty computing, so you may want to limit the length of the search to less than a week so on slower computers.

Minimum Height Above the Horizon (Above altitude)

Mountains, trees or nearby buildings can hide flares that occur at lower altitudes. Enter the lowest altitude that a flare can be seen from where you will be observing.

Limiting Magnitude of Flare (Brighter than)

Enter the magnitude of the faintest flare you want to find. Faint nighttime flares are easy to spot; but if you're looking for a daytime or evening flare, make sure to enter magnitude minus 2 or brighter (the lower the magnitude, the brighter the flare).

Show Iridium Flare Paths

Turn on this option to show a line on the Sky Chart that shows where the flare occurs and how long the flare lasts.

Set Time to Now (Computer clock)

This button resets *TheSkyX's* date and time to the computer's clock.

Begin Searching for Flares (Find flares)

Click this button to begin the search for flares. Even a very fast computer requires a minute or more to locate all the flares for the next month.

Iridium Flare Report

The right side of the window shows a report containing the following information for each flare.

- Local time when the flare begins.
- Coordinated Universal Time when the flare begins.
- Maximum magnitude of the flare.
- The altitude and azimuth position at maximum magnitude.
- The angle, in radians, between observer's line of sight and Sun, subtended at the satellite.
- The name of the Iridium satellite.
- The mirror number on the satellite that is causing the flare and its angle.
- The Julian date of the flare.

Click a column header to sort the column's contents from smallest to biggest (that is, an ascending sort). Clicking a particular header more than once will invert the sort. For example, clicking the Magnitude header once sorts the flares from brightest to faintest. Clicking it twice sorts from faintest to brightest (a descending sort).

Simulating the Flare (Watch flare)

Now the fun begins. Clicking the Watch Flare button orients the Sky Chart so that the selected flare is visible near the center of the window. If no flare is selected, the first flare in the report will be simulated. A green laser pointer momentarily appears, showing you exactly where to look to view the start of flare. They're *really easy* to miss in the actual sky.

The excitement builds as the satellite's mirror begins to reflect the Sun's light and grow brighter for the next few seconds.

Now that you've seen a simulated flare, your goal is to go outside and actually observe the real thing. Take your friends or family along; after viewing the flare, they'll think you are an astronomy wizard.

Satellites from Above Earth

Often people who have not studied or practiced astronomy are amazed that many satellites are visible to the naked eye. Most times, satellites are observed by chance when someone looks up and catches a glimpse of something moving among the stars. *TheSkyX* has a useful tool that aids with satellite observation and can tell you not only when and where to look, but also the name and purpose of many satellites in the sky.

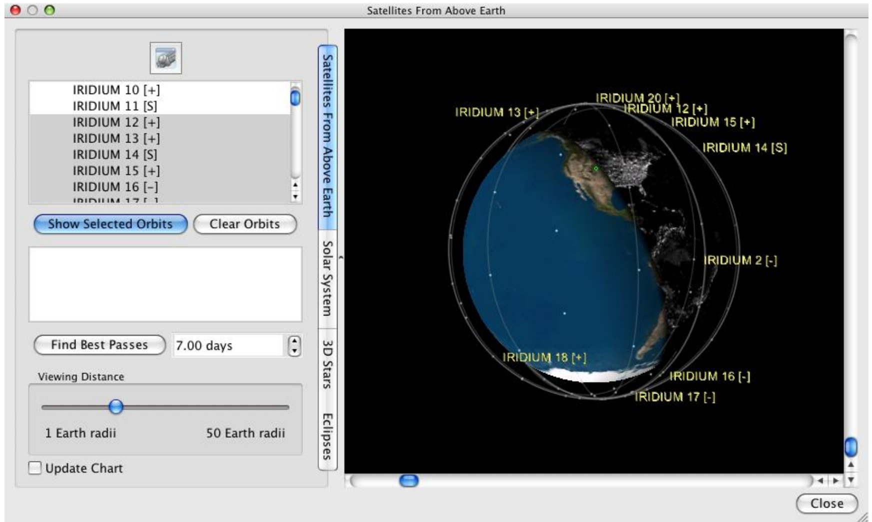


Figure 78: The Satellites Above Earth tab (Tools > Satellites From Above Earth).

Review: Viewing Satellites and their Orbits

To observe satellites, select the ***Satellites from Above Earth*** command from the ***Input*** menu. If this is your first time using the satellites tool, there will not be any satellites listed, and you will have to download some satellite Two-Line Elements (TLE's) before any satellite data can be shown. You can think of a TLE as a big set of numbers that describes a satellite's orbit.

To obtain TLE data, click the ***Satellites*** button, or select ***Satellites*** from the ***Input*** menu. The ***Satellites*** window appears. From here, you can choose to import satellite data from the web or an existing file. Later, you can also choose to clear all satellite data by clicking ***Remove All***.

Note: Ensure that TheSkyX's date is set to within 45 days of the current date to avoid date rejection when downloading satellite for import.

Let's start by downloading some satellite TLEs from the web. To do this, simply click ***Import From Web…*** on the ***Satellites window***. You can then choose the satellite category or categories you wish to download from the internet database, Celestrak. After you have selected the desired satellite categories, click ***Download***.

Return to the ***Satellites From Above Earth window***, and you will see the satellites plotted as points around the Earth globe. Also, note that the satellites are also viewable in the Sky Chart.

On the ***Satellites From Above Earth window***, a list featuring your newly downloaded satellites appears on the left. By selecting a satellite(s) from this list and by clicking ***Show Selected Orbits***. The satellite orbits will appear in the viewer. Sliding the ***Viewing Distance*** slider will change the view from a distance of 1 Earth radius up to 50 Earth radii. If your mouse is equipped with a scroll wheel, you can use it to adjust the viewing distance, too. If need be, the lower right corner of the window can be dragged to resize it.

By clicking ***Update Chart***, the Sky Chart is updated to show the recent satellite data from a ground-based perspective. Now you will be able to amaze your friends and neighbors with your uncanny ability to "predict" satellite appearances in the heavens!

Astronomical Conjunctions

When two or more planets appear near one another – within a few degrees or less –the objects are said to be in conjunction. But don't be fooled. Although the objects appear close by from our earth-bound perspective, the two objects are still hundreds or thousands of astronomical units apart. There's no need to worry about a collision.

Finding out when two or three planets will be in conjunction is easy with *TheSkyX*'s Conjunction Finder. It can locate conjunctions between any two or three planets and/or the Sun and Moon, as viewed from Earth.

Select the ***Conjunction Finder*** command from the Tools menu and then mark two or three objects in the Objects list. Earth is listed for reference only; it cannot be selected as part of the search.

Click the Start button to begin the search. *TheSkyX* uses the value entered in the ***Within (degrees)*** number input to determine how close the objects must fall before a conjunction is reported. Once a conjunction is found, the Sky Chart is updated to show it.

Beyond the Backyard: Our Home Galaxy

Our Sun is but one member of a huge assemblage of hundreds of billions of stars that comprise our home galaxy, the Milky Way. Our galaxy is also peppered with vast, colorful clouds of gas and dust, called nebulae, and other exotic objects.

The invention of the telescope revealed that there is much more in the night sky than stars and planets. In the 18th century, the French astronomer Charles Messier began to catalog some of these mysterious objects to make sure he didn't mistake them for new comets. The Messier Catalog is still in use today. It includes star clusters, and various kinds of *nebulas* and *galaxies*. These so-called "deep sky" objects are favorite viewing targets of amateur astronomers.

There are literally millions of objects in the sky that astronomers want to keep track of. Various catalogs have been developed for this purpose. *TheSkyX* includes several of them in order to chart these objects on the Sky Chart.

The Milky Way

The ancient Greeks believed that the Milky Way was exactly that: spilled milk. History failed to record whether anyone cried over it. It wasn't until Galileo invented the astronomical telescope that the true nature of the Milky Way was revealed: millions of stars too distant to be resolved by the naked eye. We now know that the stars of our particular galaxy form an immense pinwheel shape, with several spiral arms extending out from its center. When you look at the Milky Way, you're looking at a section of one of these spiral arms (galaxies come in a variety of shapes and sizes, from spherical to irregular – more on this later).

An unfortunate fact of modern life is that the Milky Way is too faint to be seen from within cities and most of their suburbs. You need to be far from city lights and any other source of light pollution to appreciate how extraordinarily beautiful it is. *TheSkyX* can display the Milky Way at various levels of brightness, simulating what you might see from the outskirts of a small town or an isolated mountain peak. Astronomers have come up with the very cool-sounding term *isophote* to describe regions of equal brightness in the Milky Way.

In the ***Display*** menu, the item ***Milky Way Options*** allows you to choose to display the Milky Way graphically, with isophotes corresponding to two levels of brightness, or as a wide-angle photograph of the Milky Way superimposed in the proper position on the Sky Chart. As with constellation figures, you can adjust the transparency of the Milky Way to simulate how much (if any) of it you can see from your location.

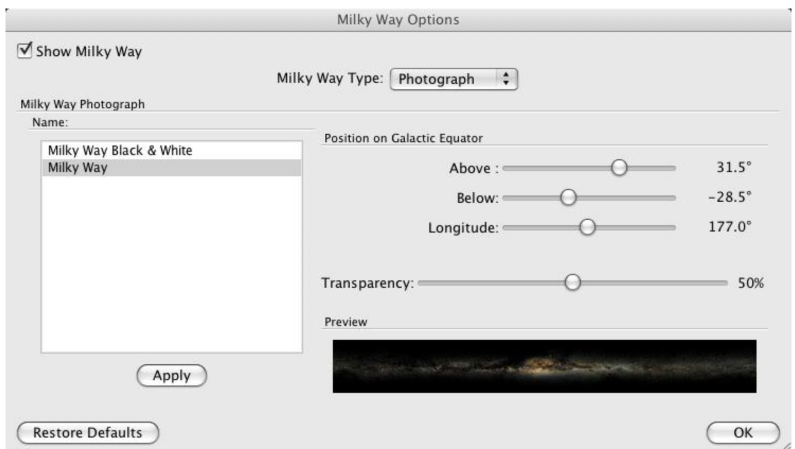


Figure 79: The Milky Way Options window (Click the Milky Way Options command from the Display menu).

Turn Milky Way On/Off (Show Milky Way)

Show or hide the Milky Way photograph or isophote drawings by turning this checkbox on or off.

Displaying the Milky Way (Milky Way Type)

Choose how to show the Milky Way on the Sky Chart.

Milky Way Photograph

Options in this group allow you to configure how the Milky Way Photograph appears on the Sky Chart.

Name of Milky Way Photograph (Name)

A color and black and white Milky Way photos are supplied with *TheSkyX*. Double-click on the name, or highlight it and click the ***Apply*** button to show in on the Sky Chart.

Note that the Milky Way photo shown in the Photo-Like display mode only.

Position on Galactic Equator

The position of the Milky Way photograph with respect to the galactic equator can be configured. Changes to these settings are applied to the Sky Chart immediately.

Degrees Above Galactic Equator (Above)

Use this slider to adjust how far above the galactic equator (in degrees) the top of the photo will appear.

Degrees Below Galactic Equator (Below)

Use this slider to adjust how far below the galactic equator (in degrees) the bottom of the photo will appear.

Longitudinal Position (Longitude)

Use this slider to adjust where the left edge of the photograph appears on the galactic equator.

Transparency of the Photograph (Transparency)

Use the slider to change the transparency of the Milky Way photograph.

The Milky Way Photo will not appear when the Display Mode is set to ***No OpenGL*** (page 16).

Beyond Our Galaxy

About a hundred years ago astronomers believed that our galaxy, the Milky Way, contained pretty much everything in the universe. But as telescopes became larger and more powerful, it became clear that there are other galaxies beyond the Milky Way – lots of them, in fact. According to the latest estimates, there are some fifty to one hundred *billion* galaxies in our universe comparable in size to the Milky Way.

Our galaxy is also surrounded by a halo of some hundred and fifty star clusters. These clusters contain hundreds of thousands to millions of stars arranged in relatively compact, spherical shapes. These *globular clusters* are made up mostly of ancient stars, some of them over ten billion years old.

Just as some planets have moons, the Milky Way and many other galaxies are orbited by smaller “satellite” galaxies. The Milky Way has at least two. They were originally described by Persian astronomers, but today we call them the Magellanic Clouds in honor of Ferdinand Magellan, a 16th century European explorer who observed and charted them on one of his epic voyages into the Southern Hemisphere. Our galactic companions are most easily seen from that hemisphere, although at certain times of year they can be glimpsed from very low Northern latitudes. They are beautiful objects, and to the naked eye look like small shreds of the Milky Way. Even though they lie only 20 degrees apart in the sky, they are separated by 75,000 light years in space. With a telescope you can resolve some of their stars, and also see nebulae and star clusters that reside within them.

The Milky Way is just one of billions of galaxies that populate the Universe. Besides the Magellanic Clouds, only one of these other galaxies is visible to the naked eye. It's called the Andromeda Galaxy because it lies within the boundaries of that constellation. Every other galaxy requires a good pair of binoculars or a telescope to see.

TheSkyX's database includes thousands of galaxies within reach of amateur telescopes. They can be displayed in the ***Non-stellar Objects*** section of the ***Chart Elements*** window.

Galaxies of various shapes and sizes exist right out to the edge of observable space. We live in a truly extraordinary universe. We hope the *TheSkyX* will enrich and expand your appreciation of it.

Have it Your Way with Preferences

Select the ***Preferences*** command from *TheSkyX* menu (or click ***Tools > Preferences*** under Windows) to reveal a host of options that allow you to configure the appearance and contents of the toolbars, what information appears on the status and report windows, as well as advanced options.

The ***Preferences*** window shows four buttons along the top. Click one to view the options associated with it.

Toolbars

The standard set of toolbars and the toolbars you create are listed on the left side of the window. When the check mark next to the toolbar name is on, the toolbar is visible on the main window. Toolbars can also be turned on and off by right-clicking (⌘+click on the Mac) the mouse over the toolbar, and then selecting the desired command from the pop-up menu.

Click the ***Customize*** button to configure the commands or *actions* that appear on each toolbar, or add new toolbars with the commands you want.

Use the ***Toolbar Button Options*** to configure the size and appearance of the buttons on the toolbars.

Customizing Toolbars

The default toolbars access the most commonly used commands. You can change the buttons or commands that appear on these toolbars to add or remove buttons, or create custom toolbars with any set of commands that meet your work flow.

To edit the actions on a toolbar:
Highlight the toolbar you wish to edit from the Toolbars list, or click the ***New*** button and enter the name of a new toolbar.
Highlight the desired action in the ***Actions*** list then click the green right-pointing arrow to add this action to the ***Current Toolbar Actions*** list.

Once selected in the ***Current Toolbar Actions list***, the action can be positioned on the toolbar by pressing the up/down arrows or removed by clicking the left arrow.

Figure 80: Customize Toolbars window (*TheSkyX > Preferences* command on the Mac, *Tools > Preferences* command Windows, *Customize* button).

List of All Actions in TheSkyX (Actions List)

Menu commands, dialogs and button actions are listed in the ***Actions*** list on the left side of the window. Each action can be added to (or removed from) a standard or custom toolbar. The ***<SEPARATOR>*** action places a vertical line between actions on the toolbar.

List of Defined Toolbars (Toolbars)

The currently available toolbars are listed on the top right of the window. The names of the standard toolbars are shown in green text and cannot be removed or renamed. Custom toolbar names appear in black text.

Actions in the Toolbar (Current Toolbar Actions List)

The list of actions that will appear on the toolbar are shown on the bottom right of the window. Selecting an action allows it to be moved up or down by clicking the up/down arrow, or removed by clicking the left arrow. See “Toolbar Actions” on page 165 for a description of each action.

The right arrow adds the selected action to the toolbar.

Resetting Standard Toolbars (Restore All Button)

Click this button to restore all the toolbars with their default buttons.

Toolbar Actions

The ***Actions*** column of the ***Customize Toolbars*** window lists each toolbar and the toolbar’s default buttons. Scroll down the list to view other actions that can be added to toolbars.

Display Toolbar

Figure 81: The default Display toolbar.

	Action	Description
	Solar System	Shows the Solar System window (page 148).

	3D Stars	Shows the 3D Stars window (page 148).
	Field of View Indicators	Shows the Field of View Indicators window (page 93).
	Map Like	Show the Sky Chart with a white background that simulates a printed star chart.
	Photo Like	Show the Sky Chart with a black background to simulate what a photo of the sky looks like.
	Satellites From Above Earth	Shows spacecraft orbiting the Earth (page 154).
	Show Constellation Boundaries	Turn constellation boundary lines on or off.
	Show Daylight	Turn this option on to simulate the morning, daytime and evening sky. When Show Daylight is turned off, the sky appears black to reveal stars and other objects, even during the day.
	Show Ecliptic	Turn on or off a line that shows the path of the Sun.
	Show Equatorial Grid	Turn on or off a lines that show a grid of right ascension and declination coordinates.
	Show Horizon Grid	Turn on or off a lines that show a grid of azimuth and altitude coordinates
	Show Mirror Image	Show the Sky Chart as it appears in a telescope with an odd number of mirrors (page 40).

	Show Night Vision Mode	Changes *TheSkyX's* window to red to preserve dark adaptation (page 267)
	Solar System	Show or hide solar system objects.
	Star Options	Show the Star Options window to configure the appearance of stars on the Sky Chart (page 202).
	Toggle Labels	Turn the labels of objects on the Sky Chart on or off.
Edit Toolbar		

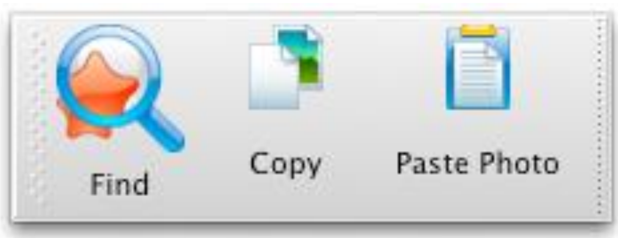


Figure 82: The default Edit toolbar.

	Copy	Copy the current Sky Chart to the Clipboard as a picture.
	Find	Locate objects in *TheSkyX's* databases by name, catalog number or from a list of objects (page 48).
PROFESSIONAL	***Paste Photo***	Overlays a photo from the Clipboard on the Sky Chart.
Field of View Toolbar		

Figure 83: The default Field of View toolbar.

	Field of View Chooser	Choose the Sky Chart's field of view from this list of predefined or custom field widths.
	Zoom In	Increase magnification by decreasing the Sky Chart's field width. Click and hold this button to zoom in continuously.
	Zoom Out	Decrease magnification by increasing the Sky Chart's field width. Click and hold this button to zoom out continuously.

File Toolbar

Figure 84: The default File toolbar.

	Open	Open or load a Sky Chart Settings file.
	Save	Save the current Sky Chart Settings.

Look Toolbar

Figure 85: The default Look toolbar.

	Look East	Look east at a 100 degree field of view.
	Look North	Look north at a 100 degree field of view.
	Look South	Look south at a 100 degree field of view.
	Look West	Look west at a 100 degree field of view.
	Look Up	Look straight up, at the zenith.

Objects Toolbar

Figure 86: The default Objects toolbar.

	Show Clusters	Show or hide star clusters.
	Show Double Stars	Show or hide double stars.
	Show Galaxies	Show or hide galaxies.
	Show Nebulas	Show or hide nebulas.
	Show Stars	Show or hide stars.
	Show Variable Stars	Show or hide variable stars.

Orientation Toolbar

Figure 87: The default Orientation toolbar.

	Celestial Sphere	Display the Sky Chart using an equatorial coordinate-based projection with the direction to the celestial pole toward the top of the window (page 119).
	Free Rotation	In this projection, the Sky Chart can be rotated to any position angle (page 119). This option is helpful when aligning photos with the simulated chart.
	Rotate Tool	Turn on the Rotate Tool to set the Sky Chart’s position angle (page 120).
	Terrestrial Sphere	Display the Sky Chart using a horizon-based projection with the local zenith located at the top of the window (page 119).

Small Screen Toolbar

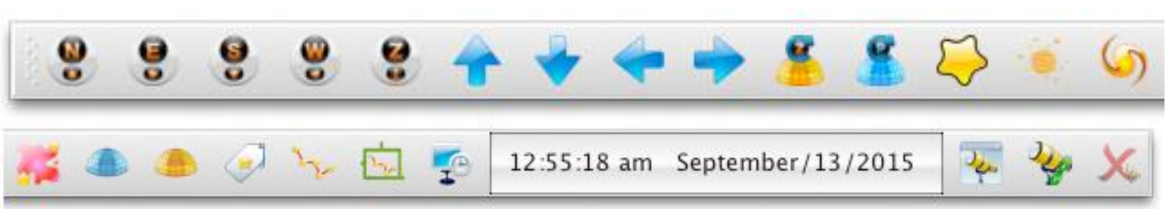


Figure 88: The default Small Screen toolbar.		
	Abort	Stops the current telescope slew (page 306).
	Connect	Establishes communication between TheSkyX and the telescope's controller (page 287).
	Look East	Orient the Sky Chart looking East at a 100 degree field of view.
	Look North	Orient the Sky Chart looking East at a 100 degree field of view.
	Look South	Orient the Sky Chart looking East at a 100 degree field of view.
	Look West	Orient the Sky Chart looking East at a 100 degree field of view.
	Move Down	Orient the Sky Chart looking East at a 100 degree field of view.
	Move Left	Adjusts the Sky Chart's field of view to simulate looking to the right (page 37).
	Move Right	Adjusts the Sky Chart's field of view to simulate looking to the left (page 37).
	Move Up	Adjusts the Sky Chart's field of view to simulate looking upward (page 37).
	Telescope Setup	Shows the Telescope Setup window (page 283).
	Time Control	Shows the date and time for the current Sky Chart (page 112).

<table>
<tr><td colspan="3">Telescope Toolbar

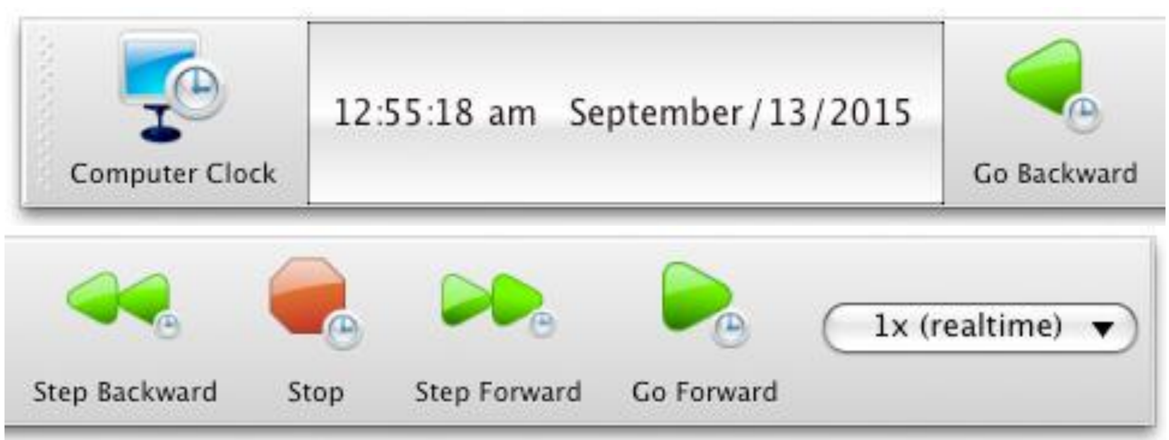

Figure 89: The default Telescope toolbar.</td></tr>
<tr><td></td><td>Find Home</td><td>Slews the telescope to its home position.</td></tr>
<tr><td></td><td>Park</td><td>Slews the telescope to the park position.</td></tr>
<tr><td></td><td>Slew</td><td>Slews the telescope to the target object.</td></tr>
<tr><td colspan="3">Time Toolbar


Figure 90: The default Time toolbar.</td></tr>
<tr><td></td><td>Computer Clock</td><td>Get the date and time from the computer’s clock (page 112).</td></tr>
<tr><td></td><td>Go Backward</td><td>Decrement time continuously at the current rate or skip increment (page 112).</td></tr>
<tr><td></td><td>Go Forward</td><td>Increment time continuously at the current rate or skip increment (page 114).</td></tr>
<tr><td></td><td>Set Time Flow</td><td>Choose the rate or increment of</td></tr>
</table>

		time to advance or retreat (page 114).
	Step Backward	Decrement time one skip increment each time this button is clicked (page 113).
	Step Forward	Increment time one skip increment each time this button is clicked (page 113).
	Stop	Freeze time (page 113).
	Time Controls	Shows the date and time for the current Sky Chart (page 112).
All Other Commands		
	Add Pointing Sample	Adds a TPoint pointing calibration sample (page 308). See the TPoint Add On User Guide for details about modeling telescopes.
	Add or Edit Observation	Creates or edits the observer log for the target object (page 236).
	Add to List	Add the target object to the Observing List. You can also press and hold the SHIFT key while clicking an object on the Sky Chart to add it to the Observing List (page 231).
	Angular Separation & Position Angle	Show the Angular Separation and Position Angle tool (page 121).
	Binocular 50°	Change the Sky Chart's field of view to 50°.
	Calibrate Photo	Show the Camera Add On's

		Calibrate Photo window.
	Center	Center the target object on the Sky Chart.
	Center Cross Hairs	Center the telescope cross hair on the Sky Chart (page 306).
	Check for Updates	Check to see if a newer version is available.
	Clear Park Position	Forgets the current telescope park position (page 294).
	Connect Telescope	Establishes a connection with the currently selected telescope (page 287).
	Copy Text	Copies the selected text to the Clipboard.
	Cut	Cuts or removes the selected text and places it on the Clipboard.
	Disconnect Telescope	Terminates the connection with the currently selected telescope (page 287).
	Exit/Quit	Quits *TheSkyX*.
	Finder 10°	Change the Sky Chart's field of view to 10°.
	Frame	Frame the current target object (page 51).
	Full Screen	Show the Sky Chart using the entire desktop (page 46). Press the ESC key to exit Full Screen mode.

	Highlight Center Constellation	Highlights the constellation that is located near the center of the Sky Chart (page 205).
	Lock On	Pins a solar system target object to the center of the Sky Chart (page 55).
	Maximum	Zooms to the maximum field of view for the current projection.
	Minimum 30"	Change the Sky Chart's field of view to 30 arcseconds.
	Move Down	Adjusts the Sky Chart's field of view to simulate looking downward (page 37).
	Move Left	Adjusts the Sky Chart's field of view to simulate looking to the right (page 37).
	Move Right	Adjusts the Sky Chart's field of view to simulate looking to the left (page 37).
	Move Up	Adjusts the Sky Chart's field of view to simulate looking upward (page 37).
	Naked Eye 100°	Change the Sky Chart's field of view to 100°.
	New	Restores the chart settings to default values (page 46).
	Next	Show the next photo of the object (page 51).
	Night Vision Setup	Configure screen to preserve dark adaptation (page 267).
	Overlay DSS Photo	Show a Digitized Sky Survey Photo on the Sky Chart (page

		80).
	Point to Target	Show a green laser pointer directed at the current target object.
	Previous	Show the next photo of the object (page 51).
	Print Info	Print information about the target object.
	Push Scope To	Show on-screen graphics that help find objects when using a hand-controlled or push to telescope (page 281).
	Remove DSS Photos	Hide and remove Digitized Sky Survey Photos from the Sky Chart (page 80).
	Remove Satellites	Remove satellite two-line elements from Sky Chart and from auto-download list (page 200).
	Reset Chart to Defaults	Restore the chart settings to default values (page 46).
	Rotate Clockwise	Rotate the Sky Chart counterclockwise.
	Rotate Counterclockwise	Rotate the Sky Chart clockwise.
	Save As	Save the chart settings with a specific file name.
	Set Park Position	Save the current position of the telescope as the park position (page 294).
	Set Track Rates	Set the telescope's tracking rates to match the target object (page

		306).
	Show Milky Way	Show the Milky Way Galaxy on the Sky Chart.
	Show Photo+	Show a photo or H-R diagram for the target object (page 51).
	Show in Constellation	Adjusts the field of view to the approximate size of the constellation surrounding the target object and points the green laser pointer at the object.
	Sleep	Minimizes CPU usage by halting all real-time computations.
	Slew Prior	Slew the telescope to the last target object, if one is available (page 299).
	Star Brightness Down	Decrease star brightness.
	Star Brightness Up	Increase star brightness.
	Star Contrast Down	Decrease the contrast between brighter and fainter stars.
	Star Contrast Up	Increase the contrast between brighter and fainter stars.
	Suspend Connection	Temporarily stop sending command to, and receiving commands from, the mount or telescope.
	Sync	Synchronize the telescope's position using the coordinates of the target star (page 288).
	TPoint Add On User Guide	View the TPoint Add On User Guide in PDF format.

	Telescope 1°	Change the Sky Chart's field of view to 1°.
	TheSkyX Help	View documentation (page 30).
	TheSkyX User Guide	View the TheSkyX Professional and Serious Astronomer Edition User Guide in PDF format.
	Toggle Linked Photo	Show or hide the Image Link photo (page 243).
	Track Satellite	If the target object is a spacecraft, show the Satellite tracking window (page 302).
	Turn Sidereal Tracking On	Set the mount's tracking rate to the sidereal rate.
	Turn Tracking Off	Set the mount's tracking rate to zero.
	Unpark	Unpark the mount at the start of the observing session.
	View From	Lock on the target planet, comet or asteroid in the 3D Solar System View (page 148).
	What's Up?	Show a report of interesting objects that are visible tonight (page 92).
	Wide Field 180°	Change the Sky Chart's field of view to 180°.
	Zoom In	Decrease the Sky Chart's field of view.
	Zoom Out	Decrease the Sky Chart's field of view.
	Zoom Tool	Show the Zoom Tool on the Sky

		Chart (page 36).
Dialogs		
	About TheSkyX	Show *TheSkyX's* About window to reveal the software version, Edition and copyright information.
	Auto Pointing Calibration	Show the TPoint Add On Auto Pointing Calibration window. See the TPoint Add On User Guide for details.
PROFESSIONAL	***Bisque TCS***	Show the Bisque TCS window. See the Paramount MX User Guide for details.
	Calendar	Show the Calendar window showing the phase of the moon, rise and set times of the sun and moon and other events.
	Calibration	Show the TPoint Add On Calibration window for collecting pointing samples. See the TPoint Add On User Guide for details.
	Chart Elements	Show the Chart Elements window (page 40).
	Conjunction Finder	Find astronomical conjunctions (page 160).
	Constellation & Asterism Options	Show options for displaying constellations and asterisms.
	Create Sky Database	Create an auxiliary database from any ASCII text data.
PROFESSIONAL	***Create Tour***	Create an astronomical tour.
	Database Manager	
	Date and Time	
	Digital Setting Circles	

	Digitized Sky Survey	
	Edit Chart Elements	
	Export Chart	
	Horizon & Atmosphere Options	
PROFESSIONAL	***Image Link***	
	Imaging System Setup	
	Iridium Flares	
	Labels	
	Location	
	Manage Observing List	
	Milky Way Options	
	Moon Photo Viewer	
	Mosaic Grid	
	My Chart Elements	
	Navigate	
	Non-Stellar Object Options	
	Object Paths	
	Observing List	
PROFESSIONAL	***Open FITS***	
PROFESSIONAL	***Place Photo***	
	Preferences	
	Print Setup	
	Print	
	Projections	
	Reference Lines & Photos	
	Reports	
	Run Java Script	
	SGT Align	
	Satellites	
	Show DSS FITS Photo	
	Slide Show	
	Small Solar System Bodies	
	Solar and Lunar Eclipse Viewer	
	Star Search	
	Synchronize	
	TCP Server	
	TPoint Add On	
	Telescope Limits	
	Telescope Window	
PROFESSIONAL	***Tours***	

	Track Satellite Window	
	Verify TheSkyX Time	
My Chart Elements		
	Add Area of Interest	
	Add Arrow	
	Add Chart Scale	
	Add Ellipse	
	Add Graphic	
	Add Label	
	Add Lines	
	Add Object	
	Add Object Label	
	Add Polygons	
	Add Telrad™	

Status Windows

TheSkyX offers three different status windows that can be configured to show information about the current time, telescope position, and other report attributes.

Chart Status

The Chart Status window (***Display > Chart Status***) provides helpful information about the sky chart. By default, the current location, date and time are shown, but up to 21 chart status attributes be added.

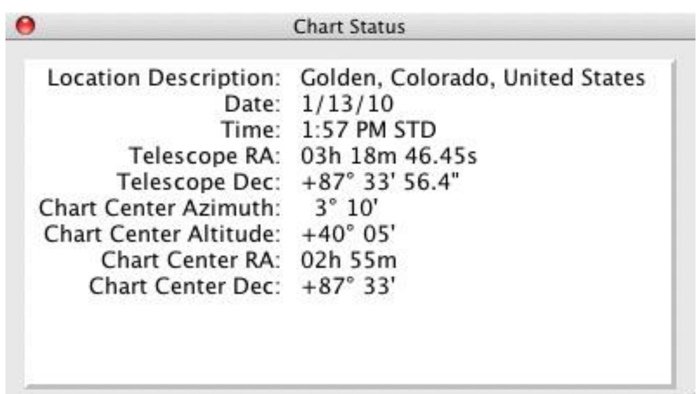


Figure 91: Chart Status window (Display > Chart Status).

To change the contents of the Chart Status report, select the ***Preferences*** command from *TheSkyX* menu on the Mac (***Tools > Preferences*** under Windows) then click the ***Status Windows*** icon. In the ***Status Window*** list, select ***Sky Chart Status***.

Highlight the items in the ***Attribute List*** that interest you, then click the right-arrow button.

Note that double-clicking the *left* side of the Sky Chart Status report shows the Sky Chart Status report options on the ***Preferences*** dialog. Double-clicking the *right* side of the report shows the attribute-specific dialog. For example, double-clicking on the Location text reveals the Location dialog.

Digital Setting Circles and Status Bar

The contents of the report that appears on the Digital Settings Circles window (page 309) and the Status Bar window can be configured identically as the Chart Status window. Just make sure to select the appropriate option on the ***Status Window*** list.

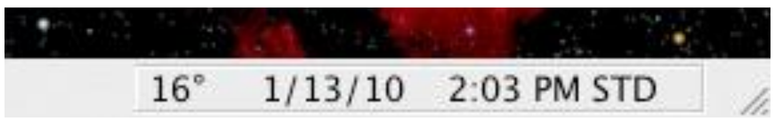


Figure 92: A Status Bar can be shown at the bottom of Sky Chart.

Report Setup

The object-specific properties (for example, an object's magnitude, or the spectral class of stars or the Moon's ecliptic longitude) , that appear in the Object Information Report and Tool Tips Report is configurable to your needs.

- The Object Information Report appears on the ***Edit > Find*** dialog.
- The ***Tool Tips Report*** is the small window that appears when you place the mouse over an object on the Sky Chart.

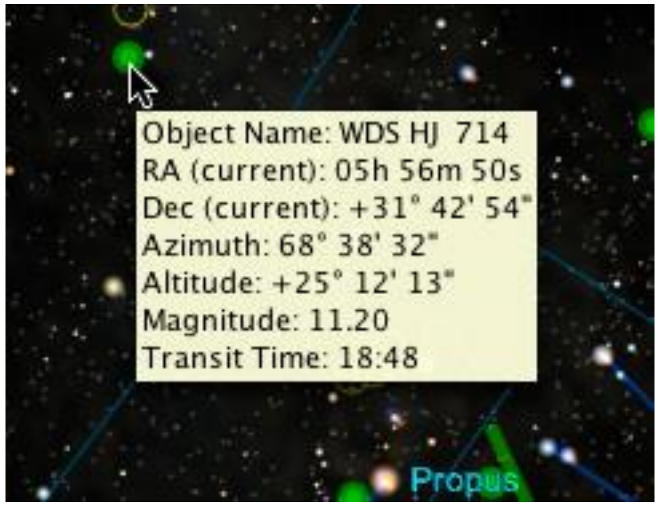


Figure 93: Tool tip on the Sky Chart.

Date & Time Control

The format of the date and time displayed in the Date & Time control (page 111) can be configured to meet your requirements.

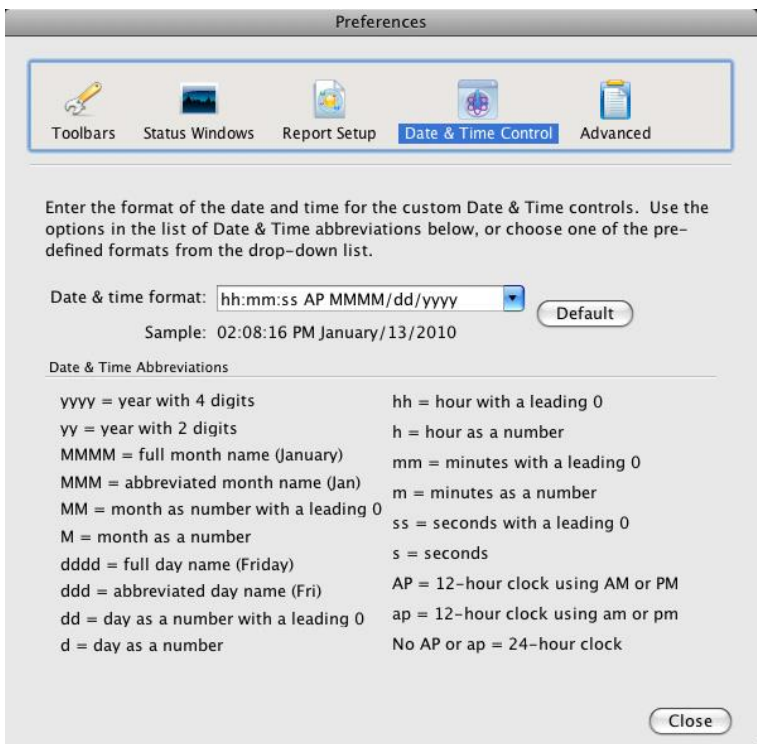


Figure 94: Date & Time Control options on the Preferences window.

To open the Date & Time Control window select the ***Preferences*** command from *TheSkyX* menu (or ***Tools > Preferences*** in Windows) then click the ***Date & Time Control*** icon.

In concept, formatting the date and time is simple. On the ***Date & Time Format*** text box, just type the format of the date and time that you want, or select one of the predefined formats from the drop down list. However, please take a moment to carefully read the text on this window. It should be self-explanatory, but this seemingly simple option is extremely flexible and it might take you a few tries to get the format just the way you want it.

Date & Time Format Configuration

The allowable date and time format abbreviations in the Date and Time format text are shown in the table below.

Abbreviation	Explanation
AP	Shows *AM* or *PM* in capital letters. Omitting the AP from the format will the time using a 24-hour time, or "military time" instead of the standard time format.
Ap	Shows *am* or *pm* in lower case letters. Omitting the ap abbreviation from the format will the time using a 24-hour time, or "military time" instead of the standard time format.
d	A single lower case d shows the day as a number from 1 to 31.
dd	Two lower case d's in succession indicate the abbreviated name of the day should be displayed. For example, dd shows the text *Fri*.
dddd	Four successive lower case d's indicate the complete name of the current day should be displayed. For example, entering dddd shows the day of the week, such as *Friday*.
H	A single lower case h shows the hour without a leading zero. For example, 1 a.m. is shown as *1*.
hh	Two successive lower case h's show the hour with a leading zero when appropriate. For example, 1 a.m. is shown as *01*.
M	A single upper case M shows the month as a number between 1 and 12.
m	A single lower case m shows the minutes without a leading zero when appropriate. For example, 5 minutes after the hour is shown as *5.*
MM	Two successive upper case M's indicate the abbreviated name of the current month should be displayed. For example, MM would show *Jan*.
mm	Two successive lower case m's show the minutes with a leading zero. For example, 5 minutes after the hour is shown as *05*.
MMMM	Four successive upper case M's indicate the complete name of the current month should be displayed. For example, MMMM would show *January*.
s	A single lower case s shows the seconds without a leading zero when appropriate. For example, 5 seconds after the minute is shown as *5.*
ss	Two successive lower case s's show the seconds with a leading zero.

Abbreviation	Explanation
	For example, 5 seconds after the minute is shown as *05*.
yy	Two successive lower case y's indicate the year should omit the century, and show as just the decade and year. For example, yy shows *15*.
yyyy	Four successive lower case y's indicate the year should be shown using four digits. For example, yyyy shows the century and year: *2015*.

Advanced Preferences

Click the ***Advanced*** icon to show the *application-wide* options that normally do not need to be modified. We recommend leaving the options alone unless you are an advanced user, or you've contacted technical support and have been instructed to alter one or more settings.

The exceptions to this rule are:

- Turning on/off the chart scroll bars
- Showing the target frame rate (the frequency at which the Sky Chart is updated)
- Turning on/off the status bar
- Setting the ***Target Frame Rate*** (to conserve power on battery operated computers)
- Turning on/off the zoom tool
- Playing the startup sound
- Showing the splash screen at startup

The table below describes the advanced preferences.

Option	Description
Miscellaneous Preferences	
Name	Shows the user's name that was entered when *TheSkyX* was first launched. This name is not, *necessarily*, your Software Bisque account sign in name.
TheSkyX Serial Number	Shows the serial number that was entered when *TheSkyX* was first launched. The serial number is stored in the *appsettings.ini* text file located in the "Application Support Files" folder (page 24).

Option	Description
TPoint Add On Serial Number	Shows the serial number that was entered for the *TPoint Add On*. The serial number is stored in the appsettings.ini text file located in the "Application Support Files" folder (page 24).
Dome Add On Serial Number	Shows the serial number that was entered for the *Dome Add On*. The serial number is stored in the appsettings.ini text file located in the "Application Support Files" folder (page 24).
Edition	Lists the current Edition of *TheSkyX* that is installed.
Copy Sample Files to Application Support Folder	Turn this checkbox on to copy all user-configurable files to the "Application Support Files" folder (page 24) when the application is launched. The default value is ***True***.
OpenGL Detection Mode (Restart Required)	Select the graphics acceleration mode used by *TheSkyX*. See "Updating Your Computer's Video Driver" on page 14 and "Running TheSkyX without OpenGL" on page 16 for a complete discussion on this setting. *TheSkyX* must be restarted for changes to this option to take effect. The default setting is ***Automatic***.
Enable OpenGL 2+ Features	Relief on the Moon's surface can be simulated using "OpenGL shader" capabilities, which requires OpenGL 2.0 or later. Turn this checkbox on to enable this feature. The default setting is ***False*** (the checkbox is turned off).
FOV Mask Transparency	Set the transparency (a value between 0 and 255) for a field of view indicator's "masked" region (page 96). The default value is ***0.00***. Maximum value = 255.0. Minimum value = 0.0.

Option	Description
Automatically Save Chart Settings Upon Exit	Turn this checkbox on so that *TheSkyX's* settings are automatically saved each time the application is closed. The default setting is ***True***.
Prompt to Save Modified Chart Settings	Turn this checkbox on to be asked whether or not to save changes when the application is closed. The default setting is ***False***.
Auto Update Satellite TLEs Older than (Hours)	Enter the number of hours that must pass before satellite TLEs are considered "out of date". TLEs older than this value are automatically updated from the web when TheSkyX is launched. The default value is ***20*** hours. Maximum value = 1200. Minimum value = 1.0.
Zoom In/Out Percentage	Enter the relative amount of change to the field of view of the Sky Chart when zooming in or out, as a percentage of the current field of view. The default value is ***3.00***. Maximum value = 100.0. Minimum value = 0.0.
Move Left/Right/Up/Down Percentage	Enter the relative amount of change in the position of the center of the screen while scrolling left, right, up, as a percentage of the current field of view. The default value is ***2.50***. Maximum value = 100.0. Minimum value = 0.0.
Fade Transition Time	Enter the length of time, in seconds, to transition or fade between Sky Charts when the position of the chart is changing. The default value is ***0.35*** seconds. Maximum value = 3.0. Minimum value = 0.0.

Option	Description
Show Frame Rate	Show the frequency, in frames per second, at which the Sky Chart is updated. This value appears on the bottom left of the Sky Chart. Default value is ***False***.
Target Frame Rate	Specify the "steady state" frame rate frequency at which to update the Sky Chart. The higher the frame rate, the more CPU and GPU processor cycles required to display the Sky Chart. The default value is ***30*** frames per second. Maximum value = 200. Minimum value = 0.
Show Chart Scroll Bars	Show or hide scroll bars on the Sky Chart. The default setting is ***False***.
Show Status Bar	Show or hide a small window on the bottom of the Sky Chart that provides Sky Chart status. The default setting is ***False***.
Play Startup Sound	Play *TheSkyX's* introduction "jingle" each time the application launched. The default setting is ***True***.
Show Startup Splash Screen	Shows an introduction graphic and status messages while *TheSkyX* is being initialized. The default setting is ***True***.
Show Zoom Tool	Show or hide a graphic on the upper left side of the Sky Chart that can be used to adjust the chart's field of view. The default setting is ***True***.
Bad Pointing Sample Criterion (Degrees)	When adding a calibration point during a TPoint Add On pointing calibration run, the ***Bad Pointing Sample Criterion*** specifies the maximum angular separation allowed between the telescope's position and the actual coordinates of the calibration point. If the angular separation between the equatorial coordinates (ra/dec) of

Option	Description
	the calibration point and the telescope's position exceeds this value, an error message is displayed, and the point is not added to the calibration data. The default value is ***0.50*** degrees. Maximum value = 50.0. Minimum value = 0.0.
Maximum Objects in Observing List (Restart Required)	For a given database query, enter the maximum number of objects that can appear in the Observing List at one time. The default value is ***2000*** objects. Upper limit = 20,000. Lower limit = 100. *TheSkyX* must be restarted for changes to this option to take effect.
Sleep on Minimize (Windows Only)	Turn this checkbox on so that *TheSkyX* will not perform any operations might affect the CPU usage, including screen updates, downloads, etc. The default setting is ***True***.
Legacy, External Pulse Focuser Control Small Size	This deprecated setting is used for pulse focuser control during CCDSoft @Focus automated focusing. The default value is ***50***. Maximum value = 0. Minimum value = 5000.
Legacy, External Pulse Focuser Control Large Size	This deprecated setting is used for pulse focuser control during CCDSoft @Focus automated focusing. The default value is ***1000***. Maximum value = 0. Minimum value = 5000.
Advanced Camera User Interface (Restart Required)	Turn this checkbox and restart *TheSkyX Professional Edition* to allow autoguiding with the imaging camera, and imaging with the autoguiding camera in the Camera Add On. This checkbox is turned off by default.
Separate Interface for	Turn this checkbox on if the imaging system's autoguider uses a

Option	Description
Autoguider's Devices (Restart Required)	different focuser, filter wheel, or rotator than the imaging detector so that each device can be operated independent of the imager's hardware.
Log ccdsoftCamera and sky6RASCOMTele Methods	Turn this checkbox on to create a log file named LogISN.txt (where "N" is the current imaging system, starting at 0) of the ccdsoftCamera and sky6RASCOMTele methods that have been called via TheSkyX's automation model (page 541).
Black Box Recorder (Restart Required, Windows only)	TheSkyX can optionally record, and optionally transmit Windows crash log reports to Software Bisque. This information in crash log reports can help find the cause of the crash more quickly and enabling this feature will not affect the software's performance. • The default setting is ***Off*** • Choose the ***Save to Disk*** option to save crash log reports in the folder named ***Black Box Recorder Data*** of the Application Support Files folder (page 24). Please attach this report in an email to ForumsAdmin@bisque.com • Choose the ***Send to Software Bisque*** to automatically upload crash log reports to a Software Bisque server when a crashes occur.
Minor Planet Center URLs	
Observable Comets	The web address (or URL) for retrieving the list of observable comets from the Minor Planet Center. Default URL: http://www.minorplanetcenter.net/iau/Ephemerides/Comets/Soft06Cmt.txt
Comets and Asteroids by Name	The web address (or URL) for retrieving the list of comets and asteroids by name from the Minor Planet Center. Default URL: http://scully.cfa.harvard.edu/cgi-bin/mpeph2.cgi
Distant Asteroids	The web address (or URL) for retrieving the list of distant asteroids from the Minor Planet Center. Default URL:

Option	Description
	http://www.minorplanetcenter.net/iau/Ephemerides/Distant/Soft06Distant.txt
Critical Asteroids	The web address (or URL) for retrieving the list of critical asteroids from the Minor Planet Center. Default URL: http://www.minorplanetcenter.net/iau/Ephemerides/CritList/Soft06CritList.txt
Unusual Asteroids	The web address (or URL) for retrieving the list of unusual asteroids from the Minor Planet Center. Default URL: http://www.minorplanetcenter.net/iau/Ephemerides/Unusual/Soft06Unusual.txt
Bright Asteroids at Opposition	The web address (or URL) for retrieving the list of bright asteroids at opposition from the Minor Planet Center. Default URL: http://www.minorplanetcenter.net/iau/Ephemerides/Bright/2011/Soft06Bright.txt
Satellite Tracking Preferences	
Maximum Declination (Degrees)	Enter the maximum declination to track the satellite. Tracking is aborted automatically when the declination of the satellite exceeds this value. The default value is ***85*** degrees. Maximum value = 0. Minimum value = 90.
Minimum Average Tracking Error to Start (Arcseconds)	Enter the minimum tracking error between the satellite's position and the telescope's position before tracking begins. The default value is ***100*** arcseconds. Maximum value = 0. Minimum value = 300.
Lost Track Factor (of Track	This value represents the maximum allowable average tracking error

Option	Description
Box)	(as a percentage of the size of the current tracking box size) for the "state"" of the mount to be considered "tracking". When the average tracking error exceeds this value, tracking is automatically aborted. The default value is ***9***. Maximum value = 0. Minimum value = 10.
Minimum Altitude (Degrees)	Enter the minimum altitude to track the satellite. Tracking will not begin until the altitude of the satellite reaches this value; tracking is aborted when the altitude of the satellite falls below this value. The default value is ***5*** degrees. Maximum value = 0. Minimum value = 85.
Track Box Size (Arcminutes)	Displays the current size of the satellite track box, in arcminutes (page 305).
Offset Bump Size (Arcseconds)	Displays the amount of adjustment or "bump size", in arcseconds to move the telescope when the bump up, down, left, right buttons are clicked (high-end satellite tracking only).

Customizing Chart Elements

There are over ninety different chart elements that can be displayed in the *TheSkyX*. The universe is made up of vast emptiness, punctuated by an infinite variety of objects with an infinite variety of form. From stars, nebulae, and galaxies, to ecliptic lines, coordinate grids, and reference lines, they are all here. What follows is an introduction to each chart element. To toggle any chart element on or off in the Sky Chart, simply check the box next to its name in the window.

Editing Chart Element Attributes

Before we continue to discuss chart elements, it would be prudent to say a word their customizability. The attributes of most Chart Elements are configurable, giving you the ultimate flexibility in customizing the Sky Chart.

Items such as the color, transparency and graphic used to display an object, the font style for chart labels, the thickness, color and type of reference lines are all editable.

Simply double-click on any object in the ***Chart Elements*** tab, and the ***Edit Chart Element Attributes*** window opens. Here, you can change fonts, line attributes, object fill color, and symbol options. Also, for objects that have them, you can adjust the ***magnitude limits***, and ***angular size limits*** by selecting the appropriate tab in the same window. Experimentation is perhaps the best teacher when exploring the customizable item attributes for chart elements.

Not every attribute of every chart element is editable, as many are not applicable or do not make sense. These attributes will appear grayed out and are not selectable.

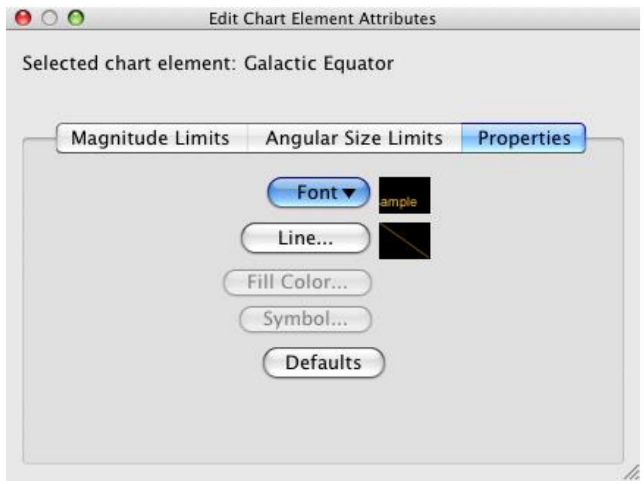


Figure 95: Properties tab on the Edit Chart Element Attributes for the Galactic Equator.

In Figure 95, the Properties tab for the ***Galactic Equator*** chart element is shown. Notice that the ***Fill Color*** and ***Symbol*** buttons are grayed because the galactic equator is a line so it does not have an associated fill color or symbol.

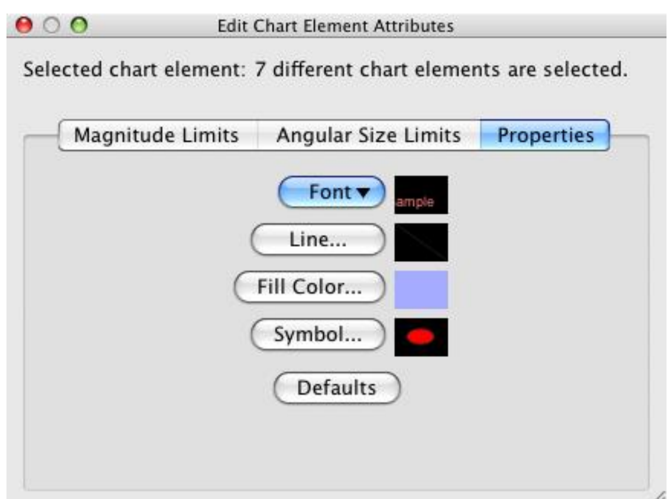


Figure 96: Properties tab on the Edit Chart Element Attributes when more than one element is highlighted.

The ***Edit Chart Elements*** window can be used to set the magnitude limits, angular size limits and properties of multiple object types, too. For example, on the Chart Elements window, highlight the ***Galaxies*** text under the ***Non-stellar Objects*** node of the ***Celestial Objects*** group and then click the ***Edit Attributes*** button.

The ***Selected Chart Element*** text shows that seven different chart elements (that is, all the different classifications of galaxies) have been selected. Any attribute changes will now be applied to each object type.

As another example, you could limit magnitude of *every object on the Sky Chart* to only those between magnitude 8 and 10 by selecting the ***Celestial Objects*** group, then setting the ***Hide Fainter Than*** number input to 10 and the Hide Brighter Than to 8.

Editing Attributes by Right Clicking

The attributes of a chart element can also be edited by right-clicking the mouse (⌘+click on the Mac) over the element on the Sky Chart, and then clicking the ***Edit <Chart Element> Attributes*** where ***<Chart Element>*** is the element beneath the cursor.

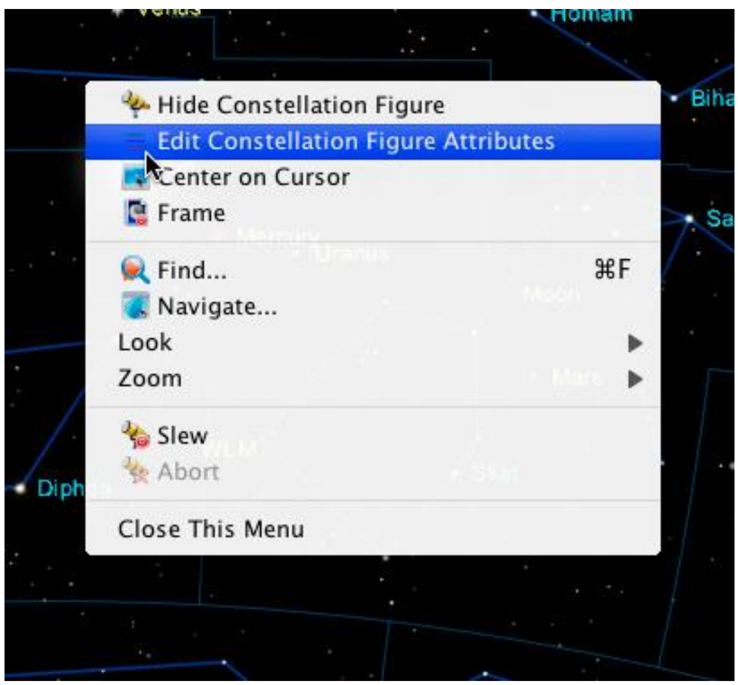


Figure 97: Right-clicking (⌘+click on the Mac) on a constellation line shows a context pop-up menu.

Celestial Objects

Here, you will find all of the real objects of the universe that are included in *TheSkyX's* database.

Non-stellar Objects

Celestial objects other than individual stars and the objects of our solar system, such as galaxies, nebulae, and star clusters, can be found under the heading ***Non-stellar Objects***.

Galaxies

Galaxies, sometimes called "island universes," are the largest building blocks of the observable universe. Galaxies are classified according to their shape. You can choose among galaxy types that you wish to display in the Sky Chart. You can choose to show Type C, elliptical, lenticular, spiral, and irregular galaxies, as well as galaxy clusters. Under ***Non-stellar Objects > Galaxies,*** the list of checkboxes will allow you to toggle on or off galaxies based upon their type. Notice that there are several different graphical points indicating galaxy type; these allow for quick identification in the Sky Chart.

Nebulas

There are many kinds of clouds of gas and dust in the sky, such a cloud is known as a nebula. Each of the different kinds of nebulae can be selected for display in the Sky Chart.

Bright Nebula

Bright nebulae are nebulae that emit or reflect light visible to the naked eye and appear as glowing clouds in the night sky. In some bright nebulae, called *emission nebulae*, the radiation from nearby stars ionizes the gas in these nebulae, and causes it to glow. A well-known emission nebula is the Orion Nebula in the sword of Orion, the Hunter. In still others, the light from stars bounces off of dust particles in the nebula, thereby illuminating it; these nebulae as known as *reflection nebulae.* A famous reflection nebula is that around the Pleiades.

Dark Nebula

Not all nebulae emit light. Sometimes they are dark and are only visible by being amongst or in front of regions of ionized gas (bright nebulae). A famous dark nebula is the Horsehead Nebula, also known as Barnard 33, in the constellation of Orion, the Hunter. A dark nebula is a region of cold, dense dust and gas. They are so dense as to block the light from background stars or from a nearby emission nebula. Star formation occurs within the dark nebulae, but such formation has not yet reached a level great enough for nebular ionization to occur. The Great Rift of the Milky Way is a dark nebula that is visible to the naked eye from a dark sky site.

Planetary Nebula

Planetary nebulae are special kinds of nebulae occurring near a dying star or white dwarf. When stars about the eight times the mass of our Sun or smaller begin to decline, they swell and contract, throwing off the outer layers in the process, and eventually leaving a white dwarf at the center. The white dwarf's radiation causes the cloud of gas to glow. These objects are called planetary nebulae because they looked like planets in the telescopes of astronomers during the 18^{th} and 19^{th} centuries. They do not have anything to do with the planets of our solar system, though. They are all quite far away. An interesting fact is that our Sun will end up as a planetary nebula in some 5 billion years from now.

Star Clusters

Visible in the sky are several clusters of stars. These are stars which formed together in the same region of space at about the same time. Star Clusters come in two varieties, open and globular.

Open Clusters

An open star cluster is a group of a few hundred stars up to a few thousand stars. These stars all formed from the same nebula, or cloud of gas and dust. These stars still interact with each other gravitationally, albeit loosely. Some open clusters, such as the Pleiades, in Taurus, the Bull, are still surrounded by remnants of the cloud from which the component stars formed. Others, such as the Hyades, also in Taurus, do not reveal distinct nebulosity.

Globular Clusters

Globular clusters are ancient, high density clusters of stars existing beyond the plane of the Milky Way or other galaxies. They are so-called because they look like globes in the sky. Some people have described them as looking, in telescopes, very much like salt spilled onto a black table cloth. These clusters orbit the galactic core in the region beyond the disk, known as the halo. Globulars are composed of old stars, and are remarkably free of gas and dust, presumably because that material was long ago turned into stars. Some globulars are visible to the naked eye, such as Omega Centauri and M13 in Hercules, though M13 requires very dark skies and good vision.

Cluster + Nebulosity

Some clusters contain nebulosity, either reflection nebulae caused by light from the component stars bouncing off of dust and gas surrounding them, or emission nebulae, which glow due to ionization of the cloud by the component stars' radiation. Use this item to toggle such clusters on or off.

Other Sources

Quasar

Quasars, ***quas***i-stell***ar*** radio sources, are among the oldest known objects in the universe. They are all very far away, lying hundreds of millions or even billions of light years away from Earth. The first quasars were discovered in the late 1950's by radio astronomers. For years, the debate raged as to their nature. Today, it is believed that they are supermassive black holes. Tremendous energy emits from such a black hole region rising from the tremendous turmoil of the material orbiting and flowing into the black hole, in what is known as the accretion disk. It is possible that such objects are the precursors to modern galaxies, and would therefore account for the presence of the supermassive black holes found at many galactic cores.

X-ray Source

Many high-energy objects in the universe emit x-rays, such as stars, nebulae, and galaxies. Unusually strong x-ray emissions indicate a very high energy situation, such as a black hole's accretion disk. In fact, it was by observing strong x-ray sources, such as Cygnus X-1, that black holes were eventually brought from the realm of the theoretical to that of the real. Other powerful x-ray sources include quasars, certain double stars, such as those with a neutron star or white dwarf component, and some galaxy clusters.

Radio Source

Some objects emit large quantities of radio waves, these are known as radio sources. *Pulsars* (short for pulsating star) are perhaps the most well-known examples of astronomical radio sources. Pulsars are rapidly rotating neutron stars with a beam of radio radiation that sweeps by Earth like the beam from a lighthouse. The result is a pulsing radio signal detectable in radio telescopes. The first pulsar was discovered by Jocelyn Bell and Antony Hewish in 1967.

Radio astronomy is a complete subfield of astronomy that has its roots in the 1930s, when the radio emissions of the Milky Way were first discovered. Radio astronomy really took off after World War II. In the 1950s, Cambridge's Ryle and Hewish created important radio maps of the sky. Other milestones occurred in the 1960s with the research of Frank Drake at Green Bank, West Virginia, and the ground-breaking discovery of the cosmic microwave background by Penzias and Wilson in New Jersey.

NGC Probable Star

These are objects that are listed in the New General Catalogue (NGC) as being probable stellar objects. Probable objects are those predicted mathematically or through a combination of mathematics and observations.

Other NGC

NGC stands for *New General Catalogue*, a catalog of astronomical objects most notable for its size and the fact that it includes all types of deep-sky objects. It was first compiled in the 1880s on commission of the Royal Astronomical Society by J.L.E. Dreyer, using William and John Herschel's observations. Since then, it has continued to grow in size and has been thoroughly revised twice.

Turn the ***Other NGC*** checkbox on or off to toggle those objects belonging to the NGC and not specifically to any other object group.

Mixed Deep Sky

To toggle those objects that do not fall into any other category of non-stellar object, choose the ***Mixed Deep Sky*** checkbox. *TheSkyX* classifies objects in the famous Messier catalog as a mixed-deep sky.

Solar System Objects

The many objects of our solar system are discreetly displayable in *TheSkyX*. Choosing which to show in the Sky Chart is as simple as clicking a checkbox.

Moon, Sun, Planets

Here, you will be able to toggle the Moon and the eight classical planets, (including Earth), a host of small solar system bodies (comets, asteroids), satellites, and the Sun. You will notice that each of the naked eye planets, plus the Moon and Sun, each has a unique graphic point style to instantly distinguish them in the sky chart.

Here, you can select from any of the solar system objects. By clicking the tree arrow next to ***Solar System Objects***, you will see that you can choose among the Moon, the eight classical planets, small solar system objects (you'll find Pluto here), satellites, and the Sun.

Small Solar System Bodies

Under ***Small Solar System Bodies***, you will find a button with the same label. Clicking this button (or, clicking the ***Small Solar System Bodies*** command from the ***Input*** menu) will open a window allowing you to import small solar system bodies, such as comets and asteroids, into *TheSkyX* by using either an existing file, or by downloading orbital data from the internet.

Comets

Getting comet data imported into *TheSkyX*, follow these four, simple steps.

1. With the Solar System window open, select Input > Small Solar System Bodies. A new window appears with three tabs at the top, Comets, Asteroids (Small Database), and Asteroids (Large Database). Select the Comets tab.
2. A window opens labeled ***Comets Available for Display***. Here, you will see the total number of comets available for display, as well as a list of their names with check-boxes. It is with these check-boxes that you can toggle comets on or off in the Sky Chart or in the solar system simulator.
3. You have three options for importing comet data into *TheSkyX*. You can import them from an existing file, or you may download comet data directly in *TheSkyX* using internet databases. You may download individual comet data by name, or you can download all the data for all observable comets at once. For our example, let's download all observable comets at once. To do this, simply click ***Observable***.
4. The data will then download, and the observable comets will now appear in the list above, on the Sky Chart, and in the solar system simulator.

Note: Be sure that your computer is connected to an active internet connection when attempting to download comet data.

Asteroids

The process is very similar as comet data when downloading asteroid data from the ***Asteroids (Small Database)*** tab. There, you can choose to import asteroid data from an existing file, by orbital characteristic, such as distant, critical, or unusual, or you may import by asteroid name.

Should you decide to import asteroids from the ***Asteroids (Large Database)*** tab, you will have to visit one of the websites provided and download a file with the desired data. You can then select the file with the ***Choose*** button to reveal the asteroids in the Sky Chart and solar system simulator. Additionally, the check-boxes you see under the ***Asteroids (Large Database)*** tab toggle important display options such as computing asteroid positions at start-up and 24-hour object paths for imported asteroids.

Small Database Versus Large Database Asteroids

There are *lots* of asteroids out there; over 430 *thousand* have been cataloged to date.

The sheer number of them presents problems for charting programs. If you want to show them all, there's no easy way to continually update their positions without *really* slowing down the computer. And, if you want to show the path of one *particular* asteroid, "wading through" them all to find the one you want can be frustrating.

For optimal functionality, *TheSkyX* breaks asteroids into separate databases, *Small* and *Large*.

Small Database Asteroids

Limited to 1000 total on Sky Chart.
Can be imported by name, orbital characteristic, a text file or by entering the individual orbital elements.
Can create Object Paths (page 102) for any or all of them.
Sky Chart coordinates are updated continually.

Large Database Asteroids

An unlimited number can be shown on the Sky Chart.
Can be imported from a standard IAU text file.
Cannot create Object Paths (page 102).
Can show the 24-hour path vector.
Sky Chart coordinates are updated only after the text file is imported, or by clicking the ***Compute Asteroid Positions*** button on the ***Asteroids (Large Database)***.

When you click on an asteroid to identify it, its elements are numerically integrated to update them to the current equinox. The coordinates in the Object Information report are computed to an accuracy of ±1 arcsecond.

Asteroid Paths

The position and 24-hour path of any asteroid, over any time period, and for any number of selected small database asteroids, or for all asteroids.

To View a 24-hour path for all Large Database Asteroids:

Click the ***Small Solar System Bodies*** command on the ***Input*** menu.
Click the Asteroids (Large Database) tab.
Turn on the Draw a line for each asteroid showing its path for the next 24 hours checkbox.

To Create the 24-hour path for any of the Small Database Asteroids:

1. Click Input > Small Solar System Bodies.
2. Click the Asteroids (Small Database) tab.
3. Load the desired asteroids and click ***Close***.
4. Click Tools > Object Paths.
5. Select the asteroids in the ***Asteroids*** list.
6. On the ***Create Paths*** tab, enter ***1 hour*** (or any other increment).
7. On the **Count** text input, enter ***24 hours*** or any other number of increments.
8. Click the ***Create Path*** button.

A path for the selected asteroids for the select time increment is drawn.

Satellites

Artificial satellites can be viewed on the Sky Chart as they appear from your backyard, or from a position above Earth.

From the ***Chart Elements*** window, click the ***Satellites*** button, or select the ***Satellites*** command from the ***Input*** menu, to open the ***Satellites*** window. In this window, you can import satellite or Iridium flare data from an existing file or from the internet. Checkboxes allow you to toggle the satellites and orbital paths in the Sky Chart. The ***Brightness*** slider allows you to control the brightness of satellites, making them easier to spot against a starry background.

Viewing Satellites and their Orbits

To observe satellite orbits, select ***Tools > Satellites from Above Earth***. If this is your first time using the satellites tool, there will not be any satellites listed, and you will have to download some satellite two-line elements (TLEs) before any satellite data can be shown. You can think of a TLE as a set of numbers that describes a satellite's orbit.

To obtain TLE data, click the ***Satellites*** button, or select ***Satellites*** from the ***Input*** menu. The ***Satellites*** window appears. From here, you can choose to import satellite data from the web or an existing file. Later, you can also choose to clear all satellite data by clicking ***Remove All***.

Note: Ensure that TheSkyX's date is set to within 45 days of the current date to avoid date rejection when downloading satellite for import.

Let's start by downloading some satellite TLEs from the web. To do this, click the ***Import From Web…*** button. You can then choose the satellite category or categories you wish to download from the internet database, Celestrak. After you have selected the desired satellite categories, click ***Download***.

Return to the ***Satellites From Above Earth*** window, and you will see the satellites plotted as points around the Earth globe. Also, note that the satellites are also viewable in the Sky Chart.

On the ***Satellites From Above Earth*** window, a list featuring your newly downloaded satellites appears on the left. By selecting a satellite(s) from this list and by clicking ***Show Selected Orbits***. The satellite orbits will appear in the viewer. Sliding the ***Viewing Distance*** slider will change the view from a distance of 1 Earth radius up to 50 Earth radii. If your mouse is equipped with a scroll wheel, you can use it to adjust the viewing distance, too. If need be, the lower right corner of the window can be dragged to resize it.

By clicking ***Update Chart***, the Sky Chart is updated to show the recent satellite data from a ground-based perspective. Now you will be able to amaze your friends and neighbors with your uncanny ability to "predict" satellite appearances in the heavens!

Viewing Iridium Flares

Some satellites become incredibly bright for short periods of time. This phenomenon is due to the fact that their orbit brings them into precise alignment as to reflect a large quantity of sunlight down to Earth in a precise location. This is most commonly observed with the Iridium communication satellites, and is therefore referred to as an Iridium Flare.

TheSkyX can predict and display Iridium Flares using the satellite function.

1. Select ***Input > Satellites***, or, if the ***Satellites from Above Earth*** window is open, click the ***Satellites*** button.
2. Choose the ***Iridium Flares*** tab.
3. You can search for all flares, or limit your search to just daytime, nighttime, or dawn/dusk flares. For this example, choose ***All flares***.
4. Leave the next few menus at their default settings.
5. Click ***Find Flares***, and *TheSkyX* will connect to an internet database to retrieve Iridium Flare data. Be sure that your computer is connected to the internet for this.
6. Once the upcoming flares appear in the list, click the ***Watch Flare*** button, and the flare will appear in the Sky Chart, along with a pointer directing you to the flare's position.

Now you know just where to look when it's time for the next Iridium Flare.

The ***Satellites*** window also features a button labeled ***Satellites From Above Earth***, clicking this button opens the tool of the same name. For more on using viewing satellites, please see the section ***Satellites From Above Earth****.*

Stellar Objects

From the ***Chart Elements*** window, under the ***Stellar Objects*** heading, you will see the stellar objects displayable by *TheSkyX*; stars, double stars, suspected variables, supernovae, and variable stars. Any of these are selectable via the checkboxes.

Stars

Immense luminous spheres occurring in the night sky, stars make up the better part of the mass of the universe observable to the naked eye. They generate their light from nuclear reactions in their cores. These nuclear reactions fuse hydrogen and helium to form elements up to atomic number 26: iron. Stars occur in a variety of sizes and colors. The color of a star is due to its temperature; red stars are relatively much cooler blue stars. Our Sun is a middle-sized star. The sizes of star points in the Sky Chart does not reflect actual size, but is an expression of relative apparent brightness, with larger points representing stars of greater apparent brightness.

Star Options

You will also see a button labeled ***Star Options***. Clicking this button opens a useful window that contains controls allowing you to adjust the ***Appearance*** of stars as well as options for their ***Proper Motion***. Tabs at the top of this window allow you to select between the two.

Clicking the ***Appearance Tab*** brings up several sliders. The ***Fainter/Brighter*** slider adjusts the apparent brightness of the stars in the Sky Chart. The ***Contrast*** slider adjusts the contrast of the Sky Chart image. Less contrast can be useful those learning to identify constellations. The ***More Fuzzy/More Solid*** slider lets you change the star points from fuzzy, nebulous orbs, to solid balls, and many points in between. You can adjust the number of stars appearing in the Sky Chart by using the ***Less/More Stars*** slider. Additionally, the halos seen around the star points can be controlled by the ***No/Bright Halos*** slider.

Star Color

Star color can be adjusted here in terms of the saturation of the spectral color of stars. Also, the stars may be colored according to the selected ‘Star’ attribute color via a checkbox.

If you would like the stars to appear red in ***Night Vision Mode***, check the checkbox labeled ***Red in Night Vision Mode***.

Map Like vs. Photo Like Display

You may also choose between a Map Like chart, where the Sky Chart appears similar to a traditional printed chart, or a Photo Like chart, where the Sky Chart appears as photo-realistic view of the sky, by choosing the radio button at the bottom of the window.

Proper Motion

TheSkyX continually calculates stars' proper motion, that is their *actual* motion in the heavens, not just the rising and setting, called *apparent motion.* To access the proper motion options from the ***Star Options*** window, click the ***Proper Motion*** tab. From here, you can turn off proper motion at any time by un-checking ***Compute Proper Motion***. You can also choose to ***Show Proper Motion Vectors*** by checking the box labeled as such. Using the field labeled ***Proper motion vector length***, you can enter a value between 0 and 99 years.

Suspected Variable

Many stars in the heavens are not steady in their energy output. Such stars are known as *variable stars*. There are many different types of variable star. (Please see ***Variable Stars*** for more information.) Choose ***Suspected Variable*** to toggle on or off those stars which appear, based upon best observations, to exhibit variable star tendencies, but are not yet confirmed.

Supernova

Perhaps the most energetic single event in the cosmos, the supernova is a relentless stellar explosion, whose effects are felt across vast expanses of space and time. There are a few different types of supernovae, all with the same effect: an exploded star. These events release incredible amounts of energy, much more than the Sun will release over its entire lifetime! In addition to an enormous emission of light, there is also a shock wave emanating from the star. Material in this shock wave reaches incredible speed, and matter is slammed together hard enough for it to fuse into heavier elements and to emit light. It is this fusion that is thought by some scientists to produce all elements heavier than iron in the Universe.

Variable Star

A variable star is a star whose energy output is not constant, but varies in a regular pattern. Some variable stars are useful in determining cosmic distances. There are many different types of variables, but two main types of variable star, eclipsing binaries and Cepheids, make up the majority of variables in the night sky.

An eclipsing binary is a binary star with two component stars of unequal brightness. When the brighter one is in "front" as viewed from Earth, the star appears to be brighter, and it appears dimmer when the dimmer one is in "front." A notable eclipsing binary is Algol in the constellation of Perseus.

A Cepheid variable is a star whose energy output varies because the star swells and shrinks at regular intervals. It is believed that these stars do this because of their internal structure and rotation causing a harmonic resonance. The prototype Cepheid variable is δ (delta) Cephei. Cepheids are useful because they can be used to determine distances. Their variation periods are directly related to their brightness. Using this information, an observed Cepheid's apparent brightness can be compared with its brightness as determined by observing its period to calculate its distance. An historic use of this principle was when Edwin Hubble proved that the spiral nebulae were distant, separate galaxies in 1922 by observing Cepheid variables within them.

Non-Stellar Objects

Just as with stars, *TheSkyX* offers a number of options for displaying non-stellar objects. Select ***Display > Non-stellar object options*** to bring up the Non-stellar Object Options dialog. You can also access this dialog from the ***Chart Elements*** tab, under ***Non-stellar Objects***.

Non-Stellar Object Options

Many of these options are designed to reduce computer resources while rendering the Sky Chart. Others are designed to reduce the number of non-stellar objects rendered to help you to hone in on just the objects you wish to observe.

Non-Stellar Object Density

The top two sliders are used to adjust the non-stellar object density in fields of view greater than 60° (top slider) and less than 60° (bottom slider). Simply click and drag the slider to the left or right for less or greater object density.

You can also choose to plot objects whose entries overlap in various catalogs, such as NGC, IC, and PGC. Turn on the ***Plot overlapping catalog entries*** checkbox to use the option.

TheSkyX plots small galaxies as either filled ellipses or as a galaxy symbol. If you prefer a symbol, select the ***Plot small galaxies as a "galaxy symbol…"*** checkbox. For more on galaxy symbols, see the ***Galaxies*** section in the ***Chart Elements*** tab.

Non-Stellar Object Drawings

The style and appearance of non-stellar object drawings can be set with the drop-down and slider here. Choose either ***Filled*** or ***Hollow*** from the drop-down menu to set the non-stellar object drawing style. The slider below the drop-down menu morphs the drawings between ***More fuzzy*** and ***More solid*** appearance.

In Place Photos

TheSkyX can show NGC, IC, and PGC non-stellar objects as in place photos from the Digitized Sky Survey. It can also clip the photos to the catalogued shape of the object, if you so choose. Select the appropriate checkboxes in this section to turn on these options.

You can also set the ***Default frame size when object size is unknown*** with this section's value field. The default setting is 10.00 arc-minutes, but you can change that value to suit your needs by using the up/down arrows or by directly entering a value in the field.

Solar System Options

If you want the Sun and Moon to appear as ***transparent ellipses***, select the first checkbox in this section.

You can also choose to ***Show Earth's shadow*** by selecting this checkbox.

To exaggerate the angular size of the Sun and Moon in fields of view 90° and wider, set the desired value in the bottom-most field in the Non-Stellar Object Options dialog. You can choose values between 1.0 and 10.0 times.

When you are satisfied with the non-stellar object options settings, click ***Close*** to return to the Sky Chart.

Reference Lines and Photos

The Sky Chart can optionally show reference lines that reveal celestial coordinates, the meridian, ecliptic, galactic equator and others to help you find your way.

Constellation and Asterism Options

Click the ***Constellation & Asterism Options*** button (or the ***Constellation & Asterism Options*** command from the ***Display*** menu) to configure items such as asterisms, constellation drawings, constellation boundaries, constellation figures and constellation labels.

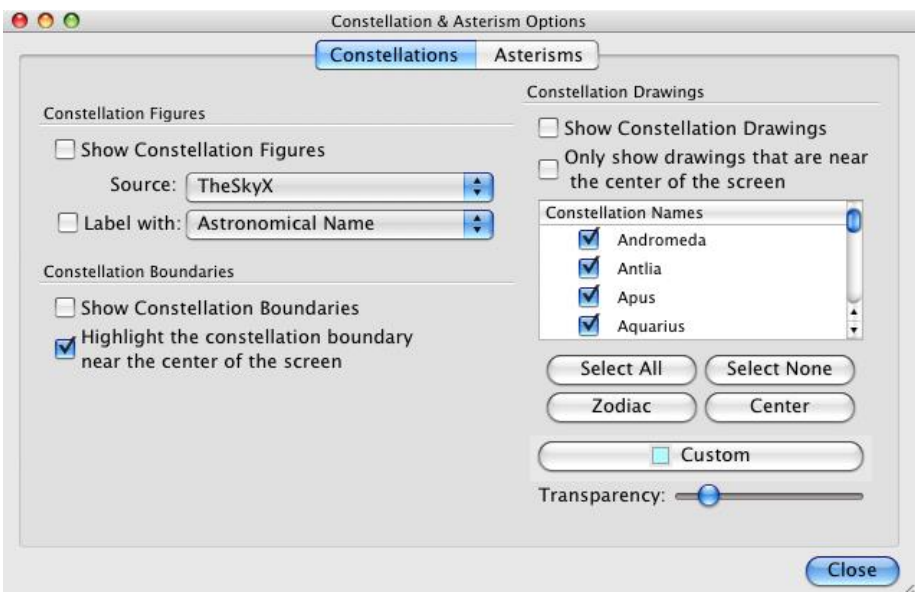


Figure 98: The Constellation & Asterism Options window.

Each of the above items is able to be toggled, and there are a number of options available to you by clicking ***Constellation & Asterism Options***. Doing so opens a window of the same name.

Two tabs, labeled ***Constellations*** and ***Asterisms*** appear at the top. Under the ***Constellations*** tab, note that there are sections each for constellation figures, boundaries, and drawings, with a number of customizable options for each.

Asterisms

Click the ***Asterisms*** tab, and you will see a list of available asterisms, along with a checkbox enabling asterism labels to be shown in the Sky Chart. To show an asterism, locate it in the list and ensure that it is checked. The chosen asterism will then appear in the Sky Chart.

Also you can choose all asterisms at once by clicking the ***Show All*** button, or no asterisms by clicking the ***Show None*** button.

Highlighting an asterism from the list and clicking the ***Center*** button is a handy way to locate and learn asterisms; they will be centered in the Sky Chart once the button is clicked. *TheSkyX* probably contains more asterisms than you have come across before, so spend some time and have some fun discovering new ones.

Constellation Drawings

To display beautiful constellation drawings from Johannes Bayer's *Uranometria*, check the box labeled ***Show Constellation Drawings***. Additionally, if you would like see only the drawings for constellations currently at the center of the screen, click the ***Only show constellations that are near the center of the screen***.

Below that is a list of the 88 constellations with checkboxes, along with buttons for selecting ***All, None,*** the ***Zodiac*** constellations, and those constellations at the ***Center*** of the screen. You can select exactly which constellations appear by utilizing the corresponding checkbox (check ***Andromeda*** to display the Andromeda drawing).

Click the button with the color above the ***Transparency*** slider to change the color of the constellation drawing overlay. You can pick from a list of colors, or you can choose your own color from the color wheel by clicking the color square in the lower right (the one with the three black dots). The transparency of the constellation drawing overlay is controlled by the ***Transparency*** slider: move it to the right for increased transparency, and left for increased opacity.

Constellation Boundaries

Astronomers use the constellations to map out the sky. But, instead of using just the drawings themselves, astronomers have laid out the entire sky in 88 sections, each attributed to a constellation found within that section. To view these sections, or constellation boundaries, check ***Show Constellation Boundaries***. If you would like to highlight the central constellation region in the Sky Chart, simply click ***Highlight constellation boundary at center of Sky Chart***.

Constellation Figures

Click the ***Show Constellation Figures*** checkbox: dot-to-dot figures appear in the Sky Chart. Today, there are a number of conventions for drawing the constellation figures, such as those from Astronomy and Sky & Telescope magazines, as well as those from H.A. Rey, and *TheSkyX*'s own. Choosing between the many styles is as easy as using the pop-up menu.

You can also choose to label the constellations, and you can customize that label among many options. This is especially useful, as there is much confusion about constellation pronunciation, especially the genitive forms, such as Cephei or Aurigae. Checking the box labeled ***Label with:*** brings up the labels, and the pop-up menu lets you pick from a number of label options, including pronunciation for the constellation name and the genitive forms (used for describing objects that "belong" to a constellation, such as the star Epsilon Eridani).

Ecliptic

The ecliptic is the apparent path of the Sun through the sky throughout the year. This path also represents the general plane of the solar system, and it is because of this that the Moon and the planets can be found on or very near this line in the sky. That is a handy fact, as it greatly limits the possible areas for planets to appear, therefore making them more easily found.

To turn the ecliptic line on in *TheSkyX*, click the ***Ecliptic*** checkbox in the Chart Elements window. Likewise the ecliptic can be turned off by clicking the ***Ecliptic*** checkbox again. The ecliptic, like most chart elements, is customizable by double-clicking on ***Ecliptic*** in the chart elements window, or by right-clicking on the ecliptic in the Sky Chart.

Equatorial Grid

An equatorial grid can be plotted onto the Sky Chart by turning on the ***Equatorial Grid*** checkbox. This spherical grid is based upon Earth's equator projected into space, or the *celestial equator*. The grid also displays coordinates of right ascension and declination overlaid onto the Sky Chart.

The grid's attributes are fully customizable (see "Customizing Chart Elements" on page 192).

Horizon Grid

A grid that is based on the local theoretical horizon can be shown by turning on ***Horizon Grid*** checkbox. This grid displays coordinates of azimuth and altitude overlaid onto the Sky Chart.

The grid's attributes are fully customizable (see "Customizing Chart Elements" on page 192).

Horizon

Turning on the ***Show Horizon*** checkbox displays a photograph or shaded region that represents the *local horizon*. The default local horizon is drawn as a featureless line at 0° altitude. You can redefine the line so it represents the horizon at your viewing site (see "Horizon and Atmosphere" on page 208). Adding natural objects and obstructions to the horizon gives a better idea of what is and isn't visible, and the approximate times at which objects rise or set.

Horizon and Atmosphere Options

To best approximate your observing site, *TheSkyX* allows you to show custom horizons and simulate atmospheric conditions including showing clouds, the Sun and Moon's glow and displaying simulated meteor showers.

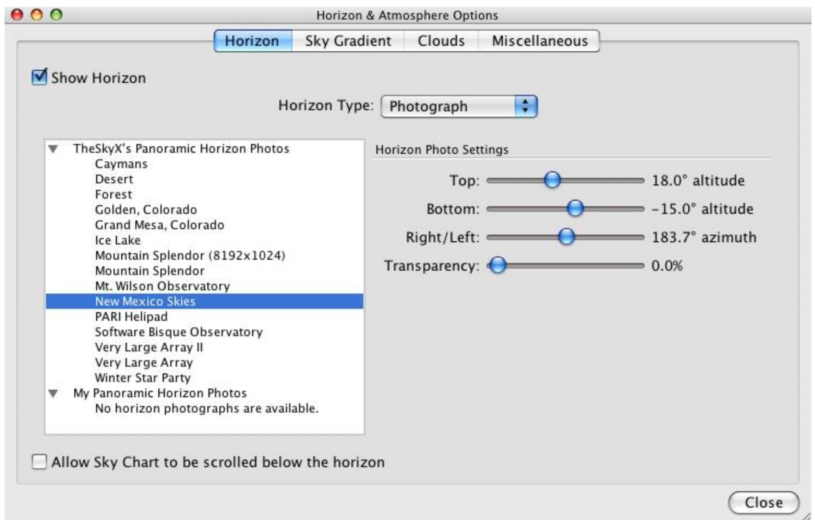


Figure 99: The Horizon tab on the Horizon and Atmosphere Options dialog.

Horizon and Atmosphere Options

Under this section, you can choose to display the horizon as a panoramic photograph or a custom drawn horizon, as well as show clouds, meteor radiants and other options.

In the Horizon & Atmosphere Options window, you will notice four tabs at the top: Horizon, Sky Gradient, Clouds, and Miscellaneous.

Under the ***Horizon*** tab, you can toggle the horizon and change it to one of several available virtual observing spots by choosing from the list at the left.

Using the sliders on the right, under ***Horizon Photo Position***, you can fine-tune the positioning of the horizon photos to best simulate each observing location. You can also adjust the transparency of the horizon photo.

If you would like to be able to scroll the sky chart below the horizon, click the ***Allow Sky Chart to be scrolled below the local horizon*** checkbox.

Custom Drawn Horizons

Near the center of the ***Horizon & Atmosphere*** window is a pop-up menu labeled ***Horizon Type***. This is set to ***Photograph*** by default, but by changing it to ***Custom Drawn***, you can use the mouse to draw a horizon outline based on your observing location.

Left to right on the gray-blue-black shaded graphic represents the azimuth of your location. Due north, or zero degrees azimuth is on the left, azimuth increases to the right through east (90°), south (180°), west (270°) and then back to north. The vertical axis represents the altitude of the local horizon, starting at zero degrees or horizontal on the bottom, increasing up to 90 degrees, or "straight up" at the top of the graphic.

Note that the default size of the ***Horizon & Atmosphere Options*** window shows the sky up to 60 degrees altitude or so. If you need to draw portions of your local horizon higher than this, just make the window larger so that the graphic shows the entire region above the horizon.

Click and drag in the blue shaded region along the correct coordinates to draw the custom horizon mask.

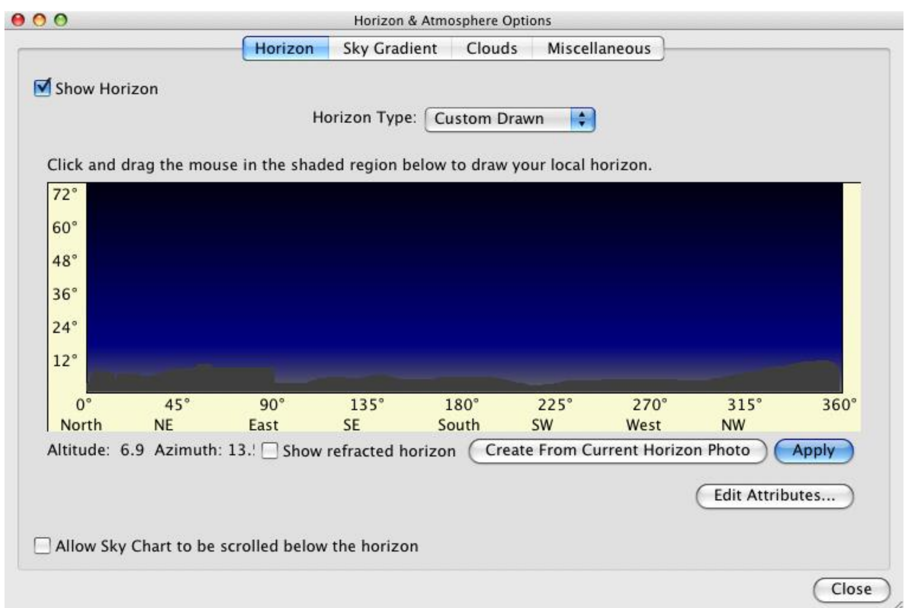


Figure 100: The Custom Drawn horizon options window.

Turning on the ***Show Refracted Horizon*** checkbox will draw a line on the refracted sky that corresponds to the observer's horizontal. Near the horizon, the atmosphere refracts (bends) the light so much that objects below the "physical" horizon are visible.

Clicking the ***Create From Current Horizon Photo*** button generates a horizon mask based upon the photo selected when the ***Photograph*** horizon type is selected. Once you are satisfied with your custom drawn horizon mask, click ***Apply***.
Click the ***Edit Attributes*** button to configure:

- how the custom horizon is filled
- the transparency or opacity of the horizon fill color
- the style and color of the line that is drawn on the horizon's boundary
- the font used to show the N, S, E, W and related directions text

See "Customizing Chart Elements" on page 192 for more information about changing the attributes of chart elements.

Creating and Using Your Own Panoramic Horizon

If you own a digital camera and popular image processing software, you can create your own horizon panorama by stitching together a sequence of photos that spans 360 degrees. Once this photo is created, copy it to the ***Horizons*** Application Support folder (see "Application Support Files" on page 24 for more information). It will automatically appear under the ***My Panoramic Horizon Photos*** node in the Photos tree.

Collecting the Photos

If you wish to create a panoramic horizon, the following hardware and software is *recommended*:

- A digital camera
- A tripod
- Panorama or "stitching" software that supports the PNG file format (PhotoShop Elements™, PhotoShop CS4™ or The Panorama Factory™, for example).
- Image processing software to make the "sky" portion of the photo transparent (PhotoShop Elements™ or PhotoShop CS4™, for example).

Photo Taking Tips

- Early morning, late evening, or an overcast day works best for even light distribution.
- Use the widest field settings for your camera or telephoto lens. Don't zoom or magnify the photo.
- If you use a tripod, make sure it is level so that the "ends" of the panorama match. Modern stitching software can account for errors here.
- For best results, expert photographers recommend using up to a *fifty to eighty percent overlap* for adjacent photos.

Figure 101: Panorama before transparency is added.

Figure 102: Panorama after transparency is added.

Tips for Creating Panorama Photos

- Both the *width* and the *height* of the panorama must be a multiple of 512 pixels. If the width is not a multiple of 512 pixels, a portion of the photograph may be truncated or missing when it is displayed on the Sky Chart. The supplied panoramic photos are 4096 x 512 pixels or 8192 x 512 pixels, for example.
- The photo must be 4 channel RGB (8 bits per channel) format.
- Use your favorite stitching software to combine the individual images. Search the web for a list of software that can perform this operation. The Panorama Factory software works well.
- After stitching the adjacent photos together, the panorama must have an transparent region that identifies the "sky". Use your favorite image processing software to create an "alpha channel" or "transparency" layer to define a mask of the transparent regions, and then save this as a PNG photo. Your image processing software should have detailed information about how to accomplish this.
- Larger images consume more computer *and* video RAM. Generally, the smaller the panorama, the better.
- Consider opening one of the horizon photos that come with *TheSkyX* in your image processing software to use a "template" for creating your own panorama.

There are many web sites dedicated to creating photographic panoramas. Search for "panorama" and "panorama tools" or "image stitching".

Selecting the Panorama Photo

When you have completed and saved the final panorama, copy it to the *Horizons* folder. The location of this folder depends on your operating system.

Mac

On the Mac, custom horizon photos should be saved in the ***Horizons*** folder that is located in the *TheSkyX's Application Support Files* folder (page 24):

~/Library/Application Support/Software Bisque/TheSkyX <Edition Name Here>/Horizons

The '~' represents the location of your home directory (technically, /Users/<username> or the $HOME folder). Look for the little icon of a house under ***Places*** in Finder's Sidebar to find it.

Windows

On Windows, custom horizon photos should be copied to the ***Horizons*** folder located in *TheSkyX's Documents* folder:

< Documents>\Software Bisque\TheSkyX <Edition Name Here>\Horizons

Where < Documents> is either the folder <root>\Documents and Settings\<username> under Windows XP or <root>\Users\<username> for Windows Vista, Windows 7 and Windows 8; <Edition Name Here> is either *TheSkyX Professional Edition* or *TheSkyX Serious Astronomer Edition*.

The horizon photo tree on the ***Horizon*** tab of the ***Horizon & Atmosphere Options*** dialog detects that a new photo is available and updates the list. Select its name, to update the Sky Chart. You'll need to adjust the ***Horizon Photo Position*** settings to get things "just right" for your panorama.

Sky Gradient

TheSkyX even lets you adjust the color of the sky. While this is best used to match sky conditions at your real-life observing location, you can always use it for fun, too. Click the ***Sky Gradient*** tab to see how.

Hint: Sky Gradients only apply when the Show Daylight command is checked on the Display menu.

On the left, you will see a list of different sky color gradients corresponding to different times of day and sky conditions.

On the right, you will see the controls for editing the sky color gradient. Under ***Edit Sky Gradient***, you will see the name of the selected sky gradient, the selected cloud tint (if any), a color preview of the selected sky gradient, as well as various buttons used to adjust the sky gradient.

Let's make a change to the default daytime sky gradient to represent a paler day.

1. Click the ***Show Daylight*** command from the ***Display*** menu to turn on daylight simulation.
2. Click the Horizon & Atmosphere Options command on the Display menu.
3. After the new window opens, click on the ***Sky Gradient*** tab.
4. In the drop-down menu, Sky Gradient Type, choose Selected Sky Gradient.
5. Select a sky gradient form the list to edit, this time let's choose ***Daytime***. This gradient simulates the color of the sky during sunlight hours. If you would like, you may change the ***Description*** by editing the text in the field to the right.

6. Now, on the right you will see the daytime sky color gradient in a sample box. On the far right, you will also see little gray triangles that correspond to start points for the gradient colors. Double-click the top-most triangle.
7. The color wheel opens, allowing you to select a new color. Choose any color you like from the wheel and click ***OK***. Do this for the remaining triangles until you are satisfied with the sky color gradient in the sample box. If you would like to remove a gradient point, click ***Remove Point***. You can also click ***Paste Photo*** to import a sky photograph.
8. Once you have the sky gradient set to your liking, you can fine-tune it with the ***Darker/Lighter*** slider, located below the sample box.
9. To save your new gradient, click ***Save Gradients***. This action will save all changes made to gradients during the current session. To return to default settings, you can always click ***Defaults***, even after saving changes.
10. Once you have saved and selected your new sky color gradient, it appears in the Sky Chart.

Clouds

Select the ***Clouds*** tab in the Horizon & Atmosphere dialog to bring up options for cloud images, position, and transparency. Handily, these options will update live in the Sky Chart as you choose them.

Cloud images

On the top left, notice the checkbox marked ***Show Clouds***. Selecting this option will turn the clouds on or off completely.

Choose a cloud image from those listed in the box to the left labeled ***Cloud Photo Name***. Click the ***Apply*** button or double-click on the cloud photo you want to use to apply it to the Sky Chart. You can also see a preview of your cloud choice to the right of the dialog box.

Cloud Transparency

Maybe you have hazy, thin clouds at your observing site and you would like *TheSkyX* to model similar clouds in the Sky Chart. Simply click and drag the ***Transparency*** slider to achieve the level of transparency you desire. The exact transparency percentage appears to the right of the slider.

Cloud Photo Position

You have complete control over the position and orientation of cloud images in *TheSkyX*. Choose a top and bottom limit for your cloud image by using the sliders to the right. You can also spin the cloud image around your point of view by using the ***Right/Left*** slider. Note that your selections for each slider are marked in degrees or either altitude (***Top/Bottom***) or azimuth (***Right/Left***).

Miscellaneous

Options for the Sun's halo, the Moon's halo, and meteors appear under the ***Miscellaneous Tab*** in the Horizon & Atmosphere dialog.

Sun's Halo

Turn on this checkbox to show the simulated Sun's halo on the Sky Chart. You can also stipulate an angular size (in degrees) for the solar halo. The Sun's halo is The default size is 10.00°.

Moon's Halo

This checkbox controls the simulated halo that appears around the Moon at night. Turn it on to have the Moon's halo appear on the Sky Chart under the following conditions:

- In the evening, after astronomical twilight's end, through morning, when astronomical twilight begins. (The angular size of the Moon's glow increases slowly as twilight approaches, and is displayed at the maximum size afterward.)
- The Moon is less than five degrees below the horizon, or astronomical twilight is in effect, whichever is earlier.
- The Sky Chart's field of view is greater than 10 degrees.

The halo's default angular size is 50.00°, but you can change it to whatever you wish using the ***Size*** box (0.00°-99.99°).

Meteors

Several options exist for displaying sporadic meteors and meteor showers.

Checking the ***Show Meteor Shower Radiants*** checkbox will show the radiant points for upcoming meteor showers in the Sky Chart. You can select how far into the future you want *TheSkyX* to look in plotting upcoming meteor shower radiants by entering a value in the ***Show only those during the next:*** field. The default value is one week (7 days), but you can change it to whatever you wish. This feature is particularly useful when planning to observe a meteor shower.

You can also choose to show random, or sporadic, meteors in the Sky Chart by selecting the ***Show meteors (randomly)*** checkbox, and then choosing an hourly rate. These sporadic meteors will not be based on actual forecasts, but are a great way to add extra realism to the Sky Chart. In the real sky, you can expect to see anywhere from five to 15 sporadic meteors per hour.

Milky Way Options

The Milky Way may be toggled by clicking the ***Milky Way*** checkbox in the Chart Elements window. There are a number of options for Milky Way display available by clicking the ***Milky Way Options*** button.

Once you have clicked the ***Milky Way Options*** button, the corresponding window will open. With the central drop-down menu, you may choose either ***Photograph*** or ***Isophotes*** as your Milky Way type. Choosing ***Photograph*** will display a photo-realistic depiction of the Milky Way in the Sky Chart. Alternately, choosing ***Isophotes*** will give you a view reflecting areas of equal brightness.

Celestial North Arrow

If you would like to have a handy guide orienting you to true North, as a compass does, turn on the ***Celestial North Arrow*** checkbox in the ***Chart Elements*** window. A red indicator will appear in the upper left-hand corner of the Sky Chart, pointing North and East to help you stay oriented.

Reference Objects

There are a number of markers for various reference objects available in *TheSkyX*. Many are self-explanatory, but here is a short description of those with a more technical aspect. Remember that each chart element is editable by double-clicking on its name in the list.

Area of Interest, Arrow, Chart Scale

See the "My Chart Elements" on page 227 for an explanation of these object types.

Dome Slit

The graphic that is displayed when *TheSkyX* is coupled to, and positioning an astronomical dome.

Meteor Shower Radiants

This marks the radiant point (or point of apparent origin) of a meteor shower.

Mosaic Grid

This is the grid produced when setting up to take a photo mosaic of a region in the sky. This grid represents each component frame of the mosaic.

Reference Line

A user-drawn line of reference.

Reference Point

A user-generated reference point.

Telescope Limit

This is a reference line that marks the slewing limit of the telescope currently set up in *TheSkyX*.

Target Object

This object marks the set target of your telescope or the object otherwise currently selected in the Sky Chart.

Telrad

If you have a telescope setup entered into *TheSkyX*, the field of view of your Telrad™ viewfinder will appear on the Sky Chart with this option turned on.

Telescope Cross Hairs

With a telescope set up, these cross hairs show where it points in the Sky Chart.

Pointing Sample

A position on the celestial sphere that has been used by TPoint to calibrate the telescope and improve the telescope's pointing.

Tour Title

When viewing a tour, this object toggles the title of the tour on or off in the Sky Chart.

Zoom Box

This option is a place holder so that the zoom box attributes can be edited (see "Editing Chart Element Attributes" on page 192). To show or hide a zoom box, press and hold down the SHIFT key while dragging the mouse (see "Zoom Box" on page 37).

Managing Databases

TheSkyX includes a host of standard astronomical databases (see "Appendix A: Databases and Cross References" for a complete list). *TheSkyX* can also be used to create custom databases from text-based data (see "Custom Databases"). The Database Manager on the ***Input*** menu provides a means to turn on and off these databases, depending on your needs.

Using the Database Manager

To access the database manager, choose the ***Database Manager*** command from the ***Input*** menu. On the ***Database Manager*** window, you will see an expandable tree list of databases to the left; to the right are tabs for ***General*** information, database ***Items***, ***Advanced*** options, and ***Replaced Objects***.

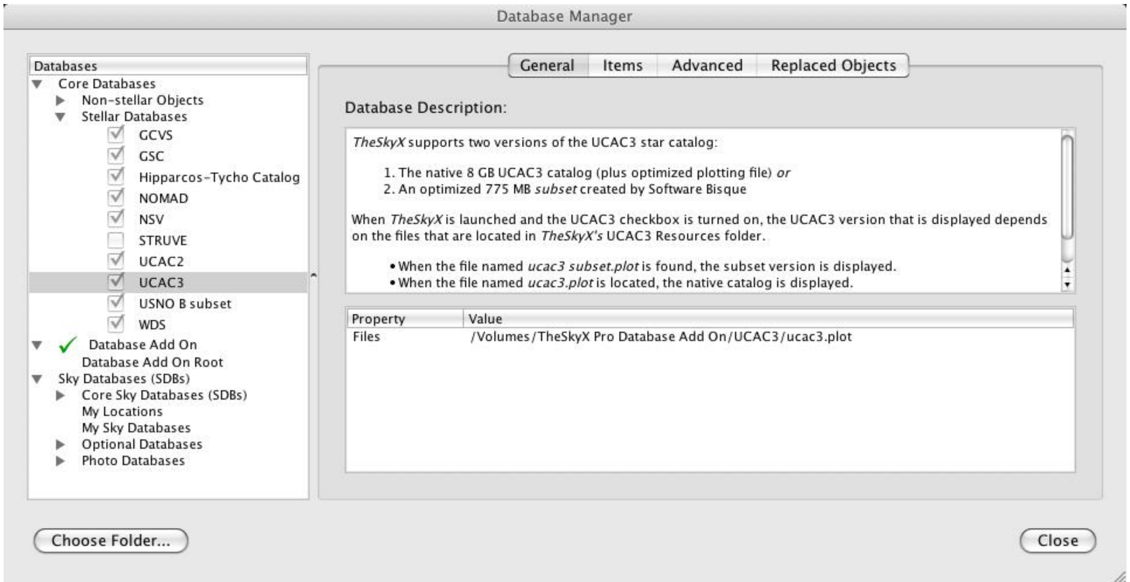


Figure 103: The Database Manager window (General tab).

To show objects in a particular database on the Sky Chart, turn on the checkbox next to its name in the ***Databases*** list.

General Tab

Selecting this tab (see Figure 103) will let you view the general information about the selected database. When a core database is selected in the ***Databases*** list, a description and the location of the database files are displayed. When a Sky Databases is selected, information such as the source text file, object types contained within the database, and the file path are listed.

Items Tab

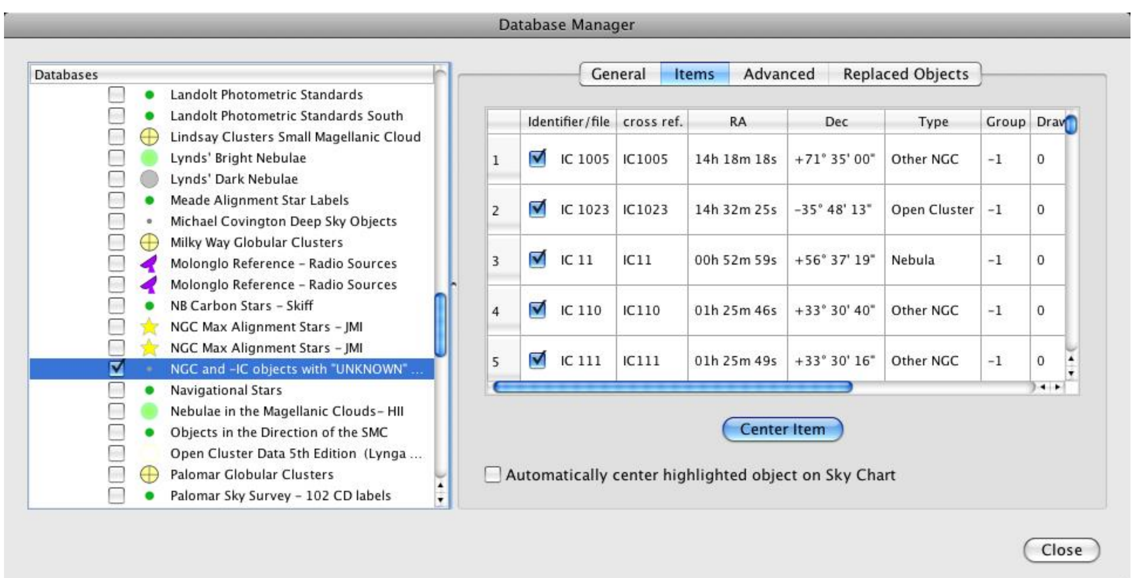


Figure 104: The Items tab on the Database Manager window.

The table lists all the objects in the database, by row, and the fields in the database, by column. Clicking the ***Center Item*** button will center the highlighted object in the Sky Chart. Alternately, you can automatically center a selected item by turning on the ***Automatically Center Highlighted Object on Sky Char*** checkbox.

Advanced Tab

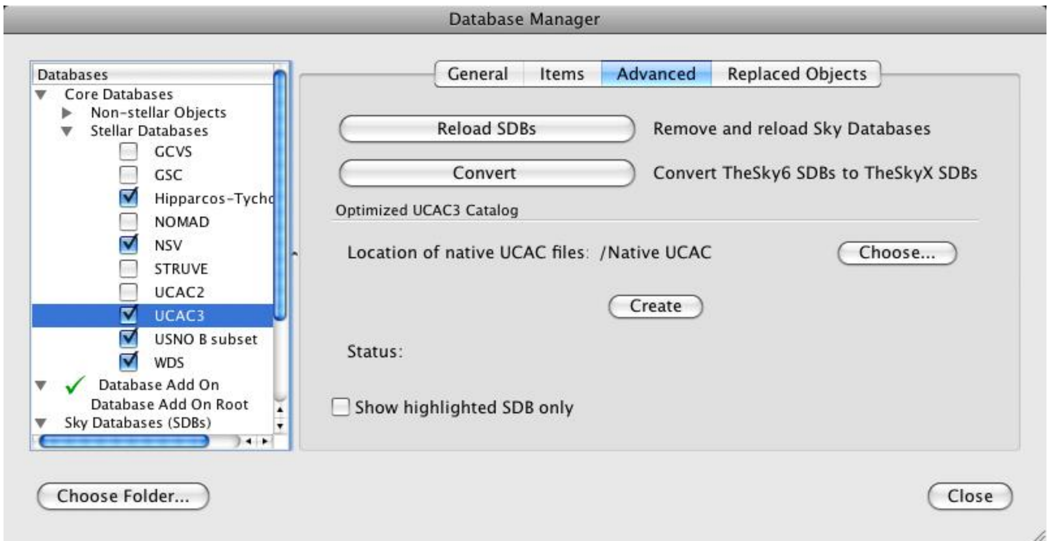


Figure 105: The Advanced tab on the Database Manager window.

Here, you can remove, then reload the Sky Databases (SDBs) by clicking the ***Reload SDBs*** button. You can also convert existing *TheSky6* SDBs to *TheSkyX*-compatible SDBX format by clicking the ***Convert*** button.

1. Copy your *TheSky6* Sky Database (.sdb) and text (.txt) files into *TheSkyX's* ***SDBs*** folder (see "Application Support Files" on page 24 for details about these files).
2. Click the ***Convert*** button, select the folder that holds your existing SDBs and associated text data (only).
3. Click the ***Open*** button to begin the conversion process.

The converted Sky Databases will appear on the ***Database Manager*** window's list of ***Databases*** under ***My Sky Databases***.

Optimized UCAC3/UCAC4 Catalogs

TheSkyX Professional Edition can show stars from the native UCAC3 and/or the native UCAC4 star catalogs. Before it can do so, you must first create a *TheSkyX Pro*-specific database file as described below.*

Choose

Click this button to specify the location of the native UCAC3 or UCAC4 databases.

Create

Click this button to create an optimized TheSkyX-specific UCAC3 or UCAC4 database file:

- *UCAC3.plot* for the native UCAC3 database.
- *UCAC4.plot* for the native UCAC4 database.

Optimized "plot" files are used by *TheSkyX Pro* to efficiently display objects and retrieve information from text-based databases. Make sure that the UCAC3 or UCAC4 folder has "write access" so that the *UCAC3.plot* or *UCAC4.plot* file, respectively, can be saved in this folder.

Creating the optimized plot files from the native databases takes several hours. To configure ***TheSkyX Pro*** to use this optimized database, select either ***UCAC3*** or ***UCAC4*** in the ***Stellar Databases*** section of the ***Databases*** list, then click the ***Choose Folder*** button and choose the folder that holds the appropriate file.

*Important notes:

- *TheSkyX Pro Database Add On* includes the optimized UCAC3 and UCAC4 plot files and they need not be generated separately. If you own the Database Add On, see "Accessing TheSkyX Pro Database Add On Catalogs" on page 525 for more information.
- Clicking a UCAC star from the Sky Chart retrieves extended information about that star directly from the text-based UCAC database. The optimized plot file is used to quickly show the position and magnitude of UCAC objects when panning and scrolling the Sky Chart.

Show Only the Highlighted SDB

When this check mark is turned on, and a ***Sky Database (SDB)*** is highlighted in the ***Databases*** list, the *only* the highlighted database is displayed on the Sky Chart (whether or not the checkbox next to the database is turned on or whether or not other Sky Databases are turned on). This option allows you to individually display Sky Databases on the Sky Chart using the up/down arrows on the keyboard. This can be helpful when trying to locate a particular SDB, or to troubleshoot whether or not your custom SDBs were compiled and are being displayed properly.

Replaced Objects Tab

To view replaced objects, click this tab. Clicking ***Refresh*** will update the list.

Custom Databases

Creating your own database of celestial objects can be a useful thing to do if you choose to carefully document your observations. *TheSkyX* lets you do this with a great amount of freedom. Let's take an overview look at the ***Create Sky Database*** command.

Creating a Sky Database

To see the ***Create Sky Database*** window, select the ***Create Sky Database*** command from the ***Input*** menu. A tabbed window then opens, with options for defining fields, behaviors, advanced operations, and compilation operation.

Define Fields Tab

From the ***Define Fields*** tab, you can select values for a number of items. If you wish to open a file containing field data, simply click ***Choose Source Text File***. If you would like to open it in Unicode, be sure to select the ***Open text file in Unicode*** checkbox.

To enter value ranges for field items, highlight a field in the window to the left. You will see its current column start and end points, if any. To enter values, you may either enter them in the ***Starting column*** and ***Ending column*** fields below, or you can click on the starting point on the graph and drag to the desired ending point. When dragging, the selected values appear to the right of the ***Set Columns*** button. You can always change the values by clicking and dragging again. Once you have entered the desired values, click the ***Set Columns*** button. The column will then be set on the graph, and a label featuring its description appears in blue.

Clicking ***Clear All*** will clear any and all data from the graph.

Behavior Tab

This tab includes options that define control the how the database interacts with the Sky Chart.

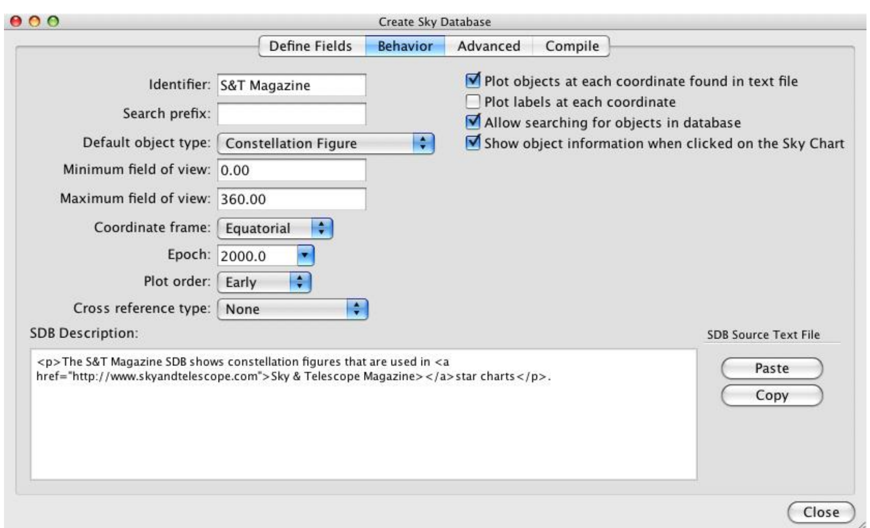


Figure 106: Behavior tab on the Create Sky Database window (Data > Create Sky Database).

Sky Database Identifier (Identifier)

Enter text that uniquely defines the database you are creating.

Search Prefix

Enter the text prefix that can be used to locate objects in the SDB when finding objects (page 48).

Default Object Type

Select the type of object (star, open cluster, etc.) that is in the source text file from this list.

Minimum Field of View

Enter a number for the smallest (narrowest) field of view on the Sky Chart to show the objects in this database.

Maximum Field of View

Enter a number for the largest (widest) field of view on the Sky Chart to show the objects in this database.

Coordinate Frame

Select the coordinate system of the objects in the source text file.

- ***Equatorial*** – Coordinates are in right ascension and declination format. Make sure to specify the correct equinox for equatorial coordinates.
- ***Horizon*** – Coordinates are in azimuth and altitude format.
- ***Topocentric*** – Coordinates are relative to the current location on the surface of Earth.

Equinox

Enter the equinox of the coordinates in the source text file.

Plot Order

When displaying databases, you may want a specific object to should appear "on top of" other objects. The Plot Order allows you to select when, relative to objects in the core database, this database will be drawn on the sky chart.

- **Early** – Show objects in the Sky Database before stars. Stars will overlay objects in the database.
- **Middle** – Show objects in the Sky Database after stars. Objects in the database will overlay stars.
- **Late** – Show objects in the Sky Database on top of all other objects.

Cross Reference Type

Select how objects in the source text file are cross referenced with objects in the core databases.

- **None** – Objects in the text file do not contain cross references to objects other databases.
- **Database –** Objects in the text file contain cross references to objects in *TheSkyX's* core databases, or other SDBs.
- **Pure** – Objects in the text file reference existing object names or catalog numbers.
- **Common Name** – Objects in the text file reference existing common object names.

SDB Description

Enter a text description for the Sky Database. The ***SDB Description*** text editor accepts text that is formatted with hypertext markup language (HTML) , so that, for example, links to external web sites can be included with the header.

Please note that the ***SDB Description*** text input is a simple *text editor*, not a *web browser*. This means, for example, when HTML is pasted into the ***SDB Description*** text box, a link to an external web page may be formatted as a hyperlink (that is, underlined in blue), but clicking on the underlined text *will not show the external link in a web browser*.

Once the SDB is compiled (see "Compile Tab" on page 223), the web links in the description can be accessed from the Description on General tab of the ***Database Manager*** (see "Managing Databases" on page 216).

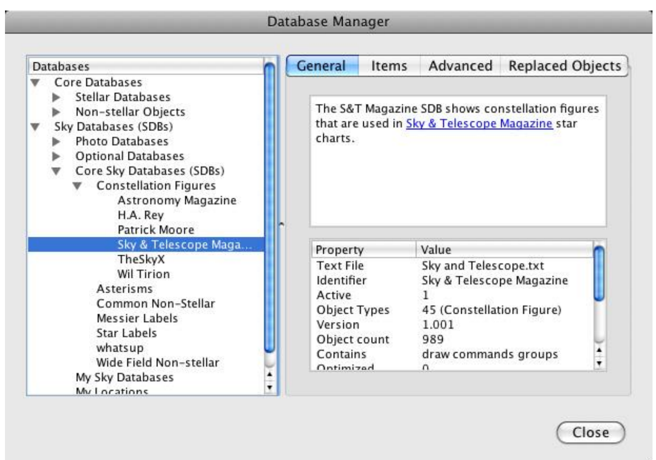


Figure 107: The General tab of the Database Manager window (page 216) showing web accessible hyperlinks in the Sky Database Description field.

Additionally, there are options that control plotting, searching, and how object information is shown in the database and/or Sky Chart.

Advanced Tab

Under ***Advanced***, you will find operators to translate text to object type, multipliers for various measurements and coordinates, folder options, and Unicode control.

To the left is the ***Translate Text to Object Type*** section. Simply type text into the fields, and select the desired object type from the drop-down menu.

Multipliers for right ascension, declination, magnitude, major and minor axes, and position angle may be entered into the fields to the upper right.

Under ***Folder Operations***, you can choose to ***compile*** a new folder from existing text files, or you may choose to ***convert*** a folder of TheSky6 database files for use in *TheSkyX*.

Additionally, you can convert a text file to Unicode and select from a list of codecs to use in the ***To Unicode*** section to the lower right.

Compile Tab

This is where you can finally compile your database, once all the criteria are set. Clicking the ***Compile*** button compiles the database, revealing the corresponding text file in the field with a star chart above. You can add a header by checking the ***Add header to text file*** box.

Once you are finished, click the ***Close*** button.

Defining Search Fields in Sky Databases

Most text-based celestial object databases include catalog numbers or other identifiers to uniquely identify each object.

TheSkyX can use these identifiers to generate a “searchable” Sky Database (SDB) . Objects in these databases can be located by typing the SDB *Search Identifier*, followed by the object’s unique identifier in the ***Search For*** text box on the Find window.

Searchable Sky Databases and the objects they contain, are also listed in the Advanced tab of the Find dialog.

The following procedure describes how to configure the Sky Database parameters so that once the SDB is created, the objects in the database can be located using the ***Find*** command on the ***Edit*** menu.

1. Select the ***Create Sky Database*** command from the ***Input*** menu.
2. On the ***Define Fields*** tab, click the ***Choose*** button near the top to the window.

3. Select the file that contains the space separated text-based celestial object database and click ***Open***. The contents of the text file appear on the right side of the ***Define Fields*** tab.
4. Specify the beginning and ending columns that hold the ***RA Hours***, ***RA Minutes***, ***RA Seconds, Dec Sign***, ***Dec Degrees***, ***Dec Minutes*** and ***Magnitude***. These are the minimum required fields for an SDB.

For example, suppose in columns 66-74 contain right ascension in decimal format. To define ***RA Hours***, select this text on the left side of the window, then enter 66 in the ***Starting Column*** text input and 74 in the ***Ending Column*** text input and then click the ***Set Columns*** button. The text file shows RA Hours in blue above these columns. (You can also drag the mouse to highlight the desired columns in the text file on the right.)

Repeat this process for each required field.

1. On the ***Behavior*** tab, click
2. Turn on the Allow Searching for Objects in Database checkbox on the Behavior tab of the Create Sky Database window.

Search Prefix

Some astronomical databases do not require a prefix to search for objects that are present in a database. For example, if the database contains common names of objects like “Polaris” or “Andromeda Galaxy”, a catalog prefix is not required.

Other catalogs identify each item by a single, unique number. For example, the NGC catalog has 7,840 items and they are numbered from 1 to 7,840. For this catalog, a *prefix* and *a number* are required to uniquely identify and locate each object in the catalog (for example, NGC 555).

In the example below, the ARP catalog of galaxies requires a Search Prefix because the search field contains only numbers from 1 to 338. Entering just the number “338” would not provide enough information to uniquely identify ARP 338.

Search Prefix Hints

- For convenience when searching, limit prefixes to about 3-5 characters.
- Do not use existing prefixes such as NGC, IC, PGC or SAO.
- If a Search Prefix is defined in an SDB, then the prefix is *required* when searching for objects in that SDB. For example, if the Search Prefix is defined as ***ARP-PG*** then the only way to locate objects in the Arp Peculiar Galaxies SDB is to enter ***ARP-PG 338***.

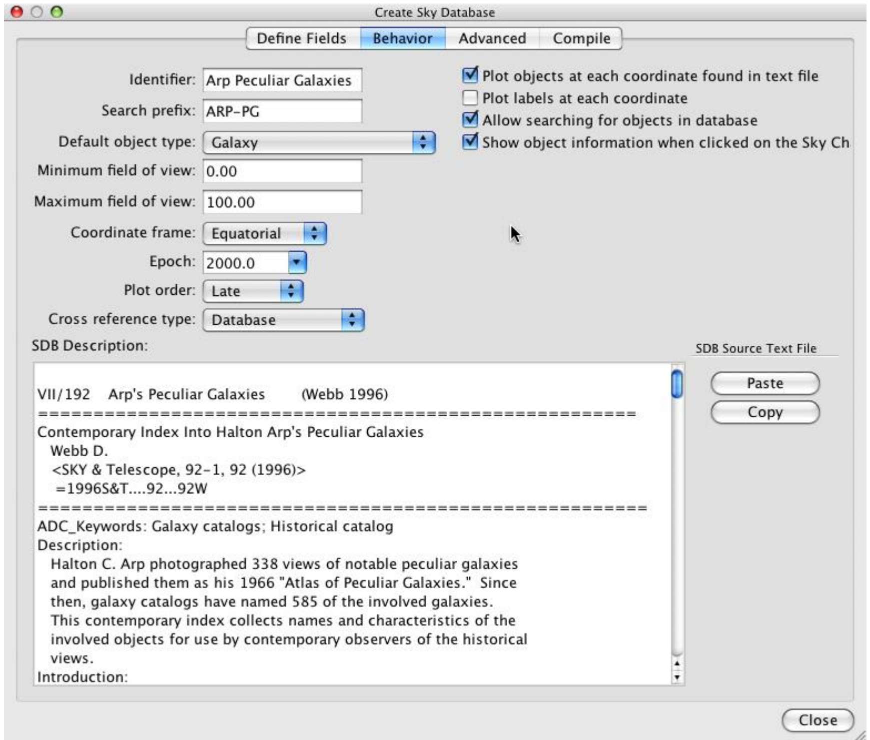


Figure 108: The Behavior tab on the Sky Database window (Sky Database command from the Input menu).

Just like other fields on the Define Fields dialog, the ***Label/Search*** field is specified by dragging over the columns (in this example, columns 1 through 3) then clicking the ***Set columns*** button. Alternatively, you can drag the columns then double-click on the ***Label/Search*** field.

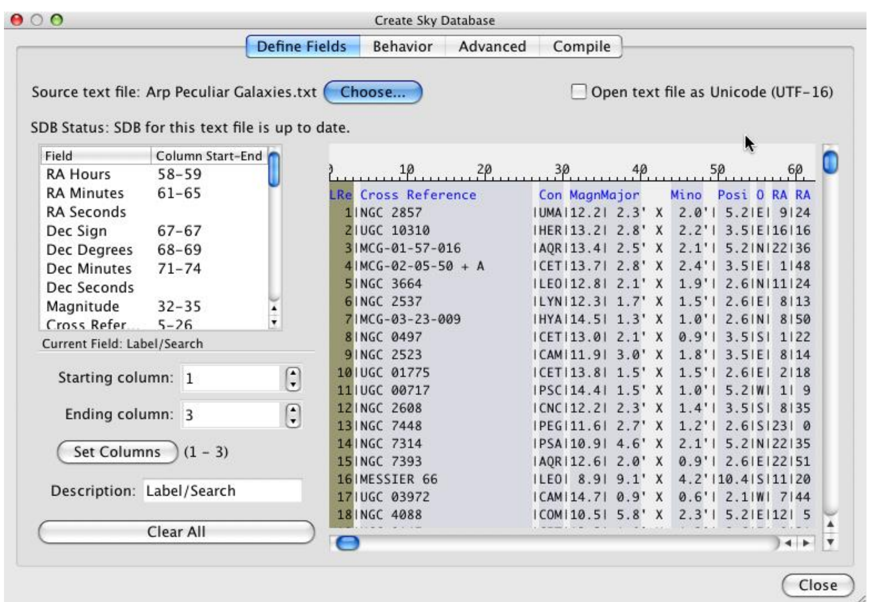


Figure 109: The Define Fields tab on the Sky Database window (Sky Database command from the Input menu).

In the ***Advanced*** tab of the ***Find*** dialog, when the database is expanded the Search Prefix will be added to the search field.

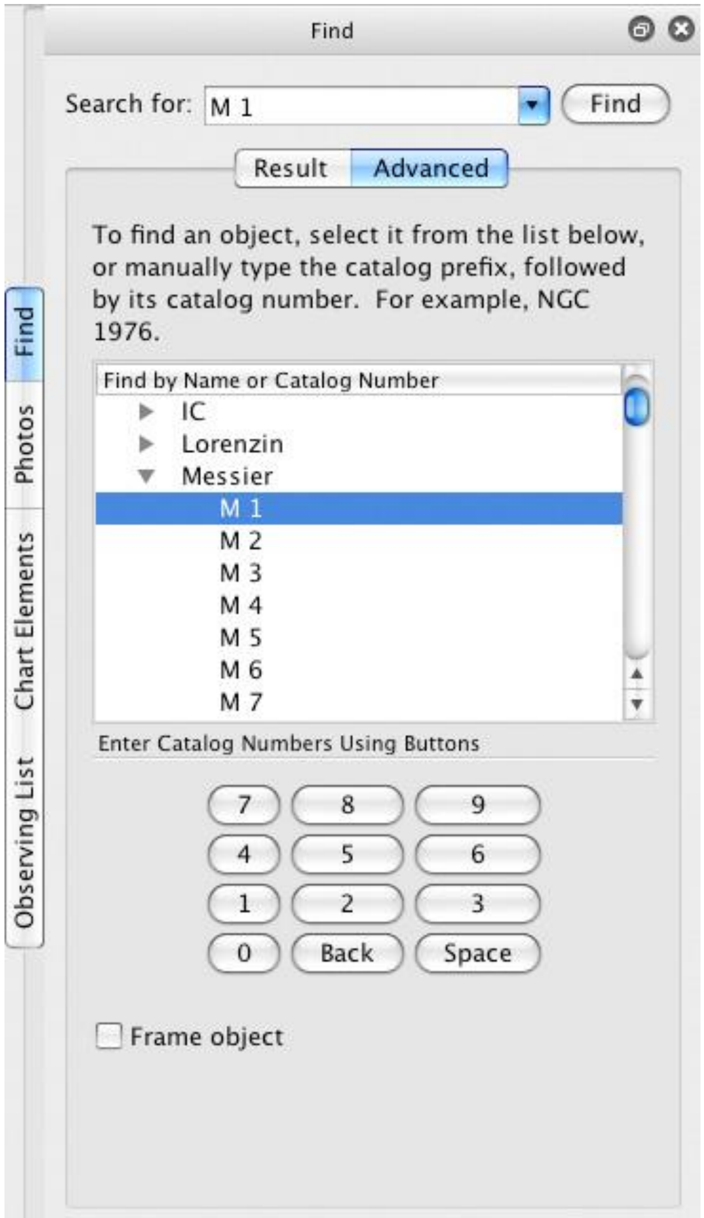


Figure 110: The Advanced tab on the Find dialog (choose the Find command on the Edit menu).

My Chart Elements

TheSkyX allows you to add your own chart elements to the Sky Chart. In so doing, *TheSkyX* gives you the best of convenience from both electronic and paper star charts.

Adding Chart Elements

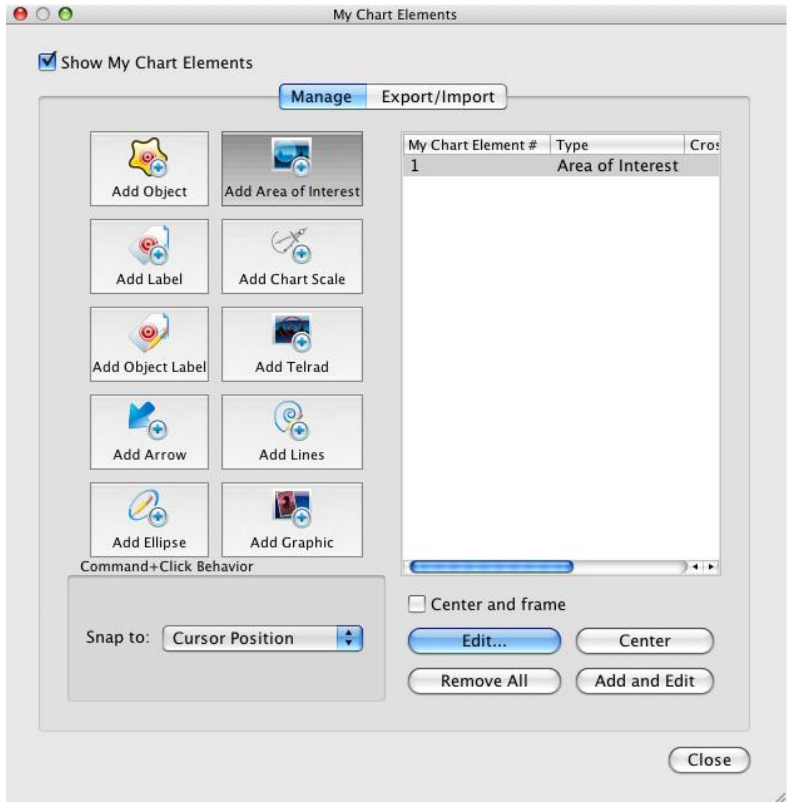


Figure 111: The *My Chart Elements* window (Input menu).

The easiest method to add a chart element to the Sky Chart:

1. Select the ***My Chart Elements*** command from the ***Input*** menu. The ***My Chart Elements*** window opens. At the top left is a checkbox, ***Show My Chart Elements***. Once you have added your own elements, turning this option on will reveal them on the Sky Chart. Notice that there are two tabs in this window, ***Manage*** and ***Import/Export***.
2. On the ***Manage*** tab, select which element to add by clicking one of the buttons on the left side of the window:
   - Add Object – Adds an object to the Sky Chart. The object can be of any type (star, cluster, galaxy, etc.) or one of your own object types (My Object Type).

- Add Label – Adds a text label to the Sky Chart. The ***Enter Label*** window will appear so that you can specify the label's text.
- ***Add Object Label*** – Adds a custom label to an existing object.
- ***Add Arrow*** – Add a reference arrow to the Sky Chart to highlight a particular object or region.
- ***Add Ellipse*** – Adds an ellipse to the Sky Chart.
- ***Add Area of Interest*** – Adds a shaded rectangular region to the Sky Chart for emphasis.
- ***Add Chart Scale*** – Adds a small graphic that shows the angular scale for the chart.
- ***Add Telrad*** – Adds a Telrad™ Finder to the Sky Chart.
- ***Add Graphic*** – Adds a photograph or Scalable Vector Graphic to the Sky Chart.

3. Position the mouse cursor over the Sky Chart, then CTRL+left-click (Windows) or ⌘+left-click (Mac) to add the Chart Element at that position.

Or, click the ***Add and Edit*** button on the My Chart Elements window. This opens a new window where you can input the necessary information about the element.

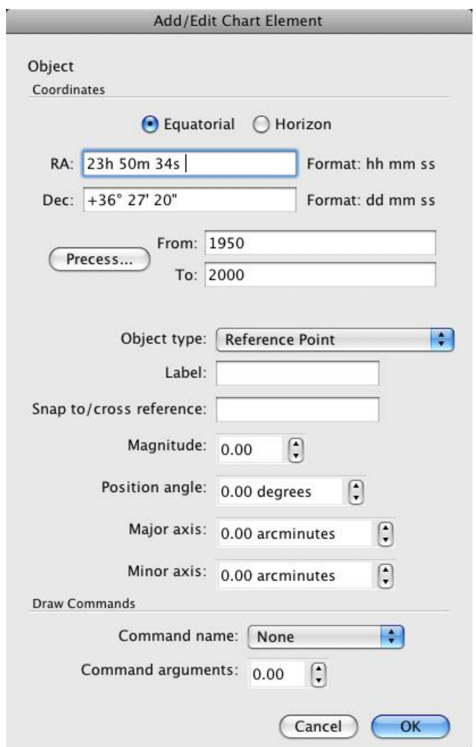


Figure 112: Add/Edit Chart Element window.

Near the top of the ***Add/Edit Chart Element*** window, you will see the coordinates section. You can choose between ***Equatorial*** or ***Horizon*** (azimuth-altitude) coordinates. Also, you can choose to precess the coordinates from one equinox to the current one to update old data. To do this, simply input equinox dates in the fields ***To*** and ***From***, and then click ***Precess***. The new coordinates will then appear in the coordinate fields above.

Note: This function works forward or backward. If you would like to precess current coordinates to a past time, you can do that too.

Once you have your coordinates entered, it is time to choose the object type. Using the pop-up menu, choose the object type for your new chart element. Remember that each of these objects is able to be toggled from various places in the Chart Elements window.

You can then enter ***Label*** text, and a ***Snap to/cross reference*** point in the appropriate fields.

The next four fields control the actual appearance of your object in the Sky Chart. ***Magnitude***, just like the magnitude of a star, controls the apparent brightness of the object in the Sky Chart (remember that the bigger the number, the dimmer the object). ***Position Angle*** controls the angular offset in degrees of your new object and the reference object, relative to the north celestial pole. Imagining your object as an ellipse, input the major and minor axis measurements in arc minutes. Remember that circles are special types of ellipses whose major and minor axes are equal.

Near the bottom of the window are the DRAW commands. You can choose the type of draw command you wish to use from the drop-down menu. You can then enter a command argument into the field below, or use the arrows to choose an appropriate argument value.

Once you click ***OK***, you will be brought back to the ***My Chart Elements*** window, and your new custom chart element appears in the object list to the right.

You can always edit the element data by clicking ***Edit***.

To center the object in the Sky Chart, click ***Center***.

Clicking ***Remove All*** will remove all My Chart Elements.

To change the CTRL+left click (Windows) or ⌘+left-click (Mac) behavior, use the drop-down menu to the lower left. You can choose to snap to the ***Cursor Position***, ***Nearest Star***, or the ***Nearest Non-stellar Object***.

When you are finished managing My Chart Elements, click ***Close***.

Export/Import My Chart Elements

Choose the ***Export/Import*** tab at the top of the ***My Chart Elements*** window. Here, you will be able to export your created chart elements, or you can import other chart elements from a text file.

Exporting Chart Elements

Follow these easy steps to export your chart elements in Sky Database (SDB) format.

1. To export a chart element, choose ***Export/Import*** tab at the top of the My Chart Elements window. The top portion of the window now shows export options.
2. Choose an appropriate identifier and enter it into the first field.
3. Then, from the ***Default Object Type*** drop-down menu, choose the desired object type. You can choose from any of the object types used in *TheSkyX*.
4. Choose the desired maximum and minimum values for the FOV (Field of View).
5. ***Coordinate Frame*** lets you choose between equatorial or horizon (azm/alt) coordinate systems.
6. Choose the appropriate equinox, plot order, and cross reference type.
7. Before exporting, be sure to take note of the checkboxes to the top right of the ***export*** section. These boxes let you toggle options for plotting objects and their labels, make these objects searchable, and to enable click identify for them.
8. Once you are ready, click the ***Export to File…*** button to export your data to a Sky Database file. Simply choose the file's destination, and click ***Save***.

Note: You can also save these data to the clipboard for later pasting.

Importing My Chart Elements

You can import any chart element(s) from a text file by using the bottom portion of the ***My Chart Elements*** window, ***Export/Import*** tab. Simply click the ***From File*** button to import an existing file. If you have chart element data copied to the clipboard, you can paste those data into *TheSkyX* by clicking the button labeled ***From Clipboard***. Additionally, you can change the working directory by clicking the ***Choose*** button.

Observing Lists

The ***Manage Observing List*** command in the ***Tools*** menu can be used to perform advanced searches or database queries to generate observing lists. The ***Advanced Query*** tab offers much more detail regarding your query of celestial objects than the simplified options on the ***What's Up Setup*** tab.

The normal procedure for creating an observing list is to define the type of objects you're after, and specify the astronomical databases to search (in the ***Object Types & Databases*** tab). Next, you can create custom filters based the *attributes* of the object types in the ***Filters*** tab. The ***Constellations*** tab allows you to refine the location further.

Once you've defined the parameters for your query, clicking the ***Run Advanced Query*** button generates an observing list on the ***Observing List*** window (***Display*** menu).

Advanced Query Setup

Defining an advanced query is as simple as clicking the ***Advanced Query*** tab to the left of the ***What's Up Setup*** tab. You will notice that the query setup area changes to a multi-tabbed window that lets you ***Open/Save Query***, choose ***Object Types & Databases***, set ***Filters***, and select ***Constellations*** and ***Other*** criteria for your query. The following is a brief discussion of each tab and the information contained there.

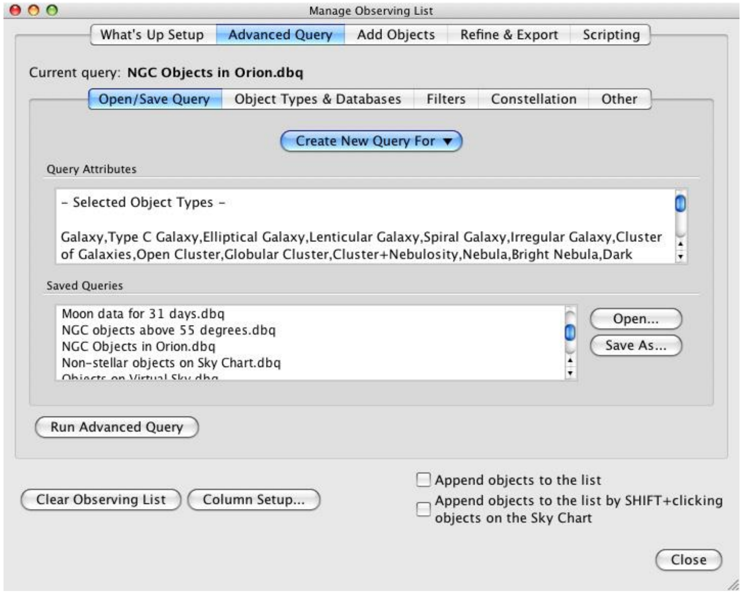


Figure 113: Advanced Query tab on the Manage Observing List window (Tools > Manage Observing List command).

Run Advanced Query

Click this button to begin searching for objects based on the specified query attributes.

Clear Observing List

Click the ***Clear Observing List*** button to remove all objects from the current observing list.

Report Setup

Click the ***Report Setup*** button to define the object parameters that appear in an observing list. For example, the list might contain only object names or it can include as many additional properties as desired.

Append Objects to the Observing List

Turn on this checkbox to generate an observing list from multiple queries. The results of each successive query are added to the end of the current observing list.

Append Objects to the Observing List by SHIFT+Clicking Objects on the Sky Chart

When this checkbox is turned on, objects can be added to the observing list by holding down the Shift key and then clicking objects on the Sky Chart.

Open/Save Query Tab

Here, you will see advanced (or ***Saved***) queries available to you. You can open queries by double-clicking on the query name in the ***Saved Queries*** list (the ***Current Query*** shows the name of the currently loaded query settings file), save current query settings by clicking the ***Save As*** button, or create new ones by clicking one of the options in the ***Create New Query For*** pop-up menu.

Figure 114: Create New Query For pop-up menu.

To Create a New Query

Click the Create New Query pop-up menu.
Select from one of the pre-defined queries to setup a query for that object type. Or click the ***Let Me Define Query Parameters*** command to clear any existing query settings and start from scratch.

Query Attributes

The ***Query Attributes*** report shows the selected object types, databases filters that will be used for the current query.

Saved Queries

The ***Saved Queries*** list shows supplied queries (files that have the database query or .DBQ file extension) and the queries that you have generated and saved. To open a query, double-click its name in the list, or click the ***Open*** button and then select it from the ***Open Database Query*** dialog.

Saving Queries (Save As)

Click the ***Save As*** button to name a query.

Object Types & Databases Tab

Here is where you select which types of objects you wish to include in your query, along with from which databases you would like to search.

It's best not to mix object types in your query. For example, it's not a good idea to create a single query for asteroids *and* spiral galaxies. These object types are distinct and need separate queries.

Filters Tab

Under this tab, you can select from a thoroughly customizable list of filter options to narrow your query parameters. All current filters can be edited or removed at any time by using the corresponding buttons found in the ***Current Filters*** section.

Constellations Tab

This tab allows you to specify a specific constellation, or group of constellations, to search.

Other Tab

This tab includes options that allow you to name your query, choose among search criteria related to the Sky Chart, set queries to run automatically at given times, and to determine imaging availability of objects sorted by the query.

Observing List Example

Let's go through the steps involved in running an advanced query. Suppose you want to create an observing list that contains all the *double stars* from the *Washington Catalog of Double Stars* that have a *spectral type* of G5 in *Orion*.

TheSkyX makes generating an observing list from this complex query relative simple.

Select the ***Manage Observing List*** command in the ***Tools*** menu.
Click the ***Advanced Query*** tab.
On the ***Advanced Query*** tab, click the ***Create New Query For*** pop-up menu.
Select the ***Double Stars*** command. Double stars from the WDS (Washington Catalog of Double Stars) database are automatically selected for you in the ***Object Types & Databases*** tab.
Click the ***Filters*** tab to define a filter that limits our search to just the G5 double stars. In the ***Attributes*** list, expand ***Double Stars***, then select ***Spectral Type*** and click the ***Create Attribute Filter*** button.

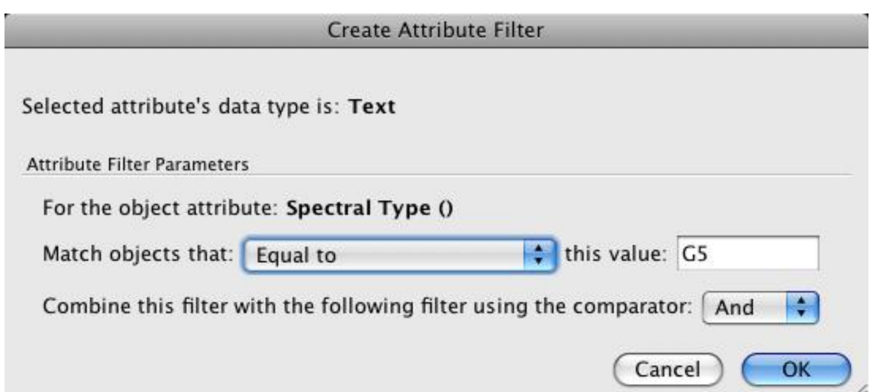


Figure 115: The Create Attribute Filter dialog.

On the ***Create Attribute Filter*** dialog, select the ***Equal To*** command from the ***Match Objects That*** pop-up menu.
Type the text ***G5*** into the ***This Value*** text input and click ***OK***.
On the ***Constellations*** tab, click the ***None*** button, then turn on the check mark next to ***Orion***.
On the ***Open/Save Query*** tab, click the ***Save As*** button, and specify the name of this query as ***G5 Double Stars in Orion***. It's always a good idea to save your work.
Click the ***Run Advanced Query*** button to run the query and create the observing list on the ***Observing List*** window (***Display*** menu).

The Observing List window now shows forty-three G5 double stars in Orion.

When you highlight an object in the Observing List, the green laser pointer will direct you to it in the Sky Chart.

The ***Show on Sky Chart*** pop-up menu affects how the object is shown in the Sky Chart. You can choose among ***Wide-field view***, ***Constellation view***, ***Small-field view***, or ***Do not show*** at all.

Clicking the ***Center*** button centers the object in the Sky Chart's field of view.

Clicking ***Copy Text*** copies the object text to the clipboard.

Print Information lets you print out the data from the list about the object.

If you would like to slew a connected telescope to the object, simply click ***Slew*** to make it so.

Observing List Window

The Observing List window lets you create, edit, and manage objects your observing lists.

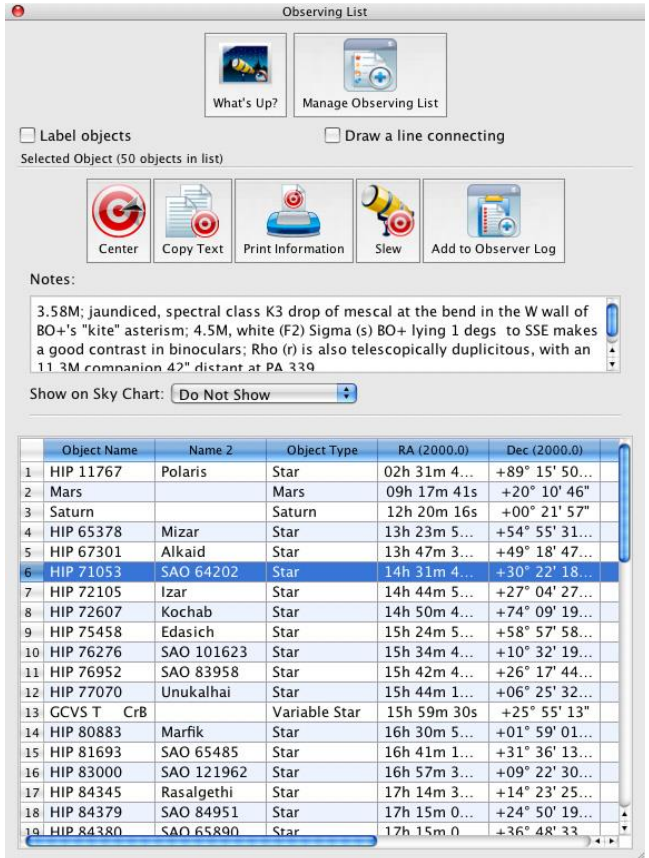


Figure 116: The Observing List window (Observing List command from the Display menu).

Observing lists can be created from *TheSkyX* in several different ways:

Manually add items. For each object in the list, double-click ***<Add>*** on the spreadsheet control, enter the name of the object and the press the Return key (Enter key on Windows).

What's Up? Click the ***What's Up?*** button located on the top left of the window to generate a list of objects (page 80).

Manually type or paste a list of object names from the Clipboard. Click the ***Manage Observing List*** button on the top of the Observing List window, then click the ***Add Objects*** tab. From here, you can type the list of object names, or paste a list of names that have been copied to the Clipboard by clicking the ***Paste Object Names*** button. When the list is complete, click the ***Add Objects to Observing List*** button to update the Observing List spreadsheet.

Create an advanced query. Click the ***Manage Observing List*** button on the top center of the window to define simple or extremely complex database queries that produce exactly the observing list you need. See "*Observing Lists*" on page 230 for details.

Labeling Observing List Objects (Label objects in observing list)

Turn this option on to display a text label next to each object in the observing list.

Draw a Line Between Observing List Objects (Draw a line connecting list objects)

Drawing a line that connects each object in the list helps visualize the path the telescope must take to view each object in the list.

Centering Objects in the List (Center)

Highlight an object in the list, then click the ***Center*** button to center this object in the Sky Chart. The chart's field of view stays the same.

Copying Object Information to the Clipboard (Copy Text)

Highlight an object in the list, then click the ***Copy Text*** button copy the object's information to the Clipboard. This text report can be pasted into any text editor.

Print Information

Click this button to print the ***Object Information Report*** for selected observing list object on the default printer.

Slew the Telescope (Slew)

Slew the telescope to the selected object.

Add Observing Notes (Add to Observer Log)

Use the ***Observing Log*** dialog to keep a track of the objects you have observed. You can even rate the object and seeing conditions, as well as add personalized notes.

Select the observed object in the list, then click the ***Add Observer Log*** button to show the ***Edit Observation*** tab of the ***Observer Log*** window.

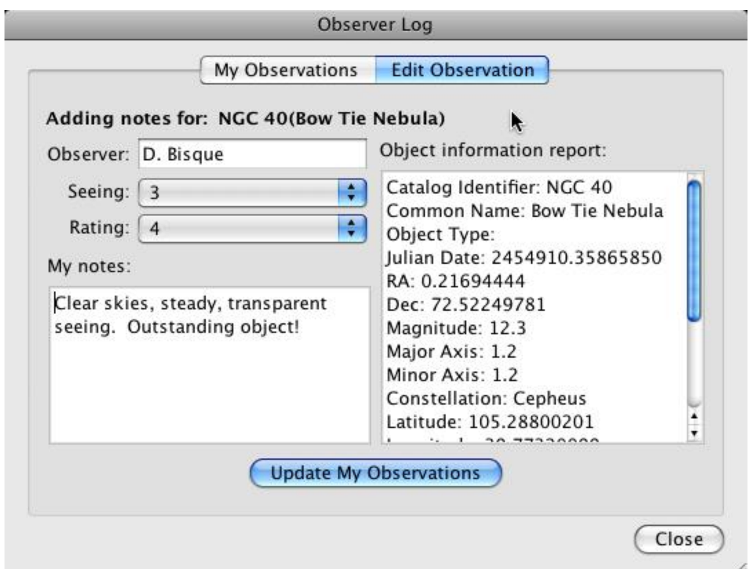


Figure 117: The Edit Observation tab on the Observing Log window (click the Add Observer Log button on the Observing List window to view this window).

Name of the Observer (Observer)

Type your name, or the list of observers' names, here.

Rate the Current Seeing Conditions (Seeing)

Atmospheric turbulence, moisture, light pollution, and many other factors influent local *astronomical seeing* conditions. Seeing conditions are typically rated on a scale from 1-5, the higher the rating, the better the seeing.

Rate the Current Object (Rating)

Similar to rating seeing, the subjective quality or appearance of the object that you're observing can also be rated. Again, a higher the number indicates a better rating.

Enter Personal Comments (My notes)

Critique the observed object by typing your notes here.

Updating the Observations Table (Update My Observations)

Click this button to add notes, ratings, and object information to the My Observations table on the My Observations tab.

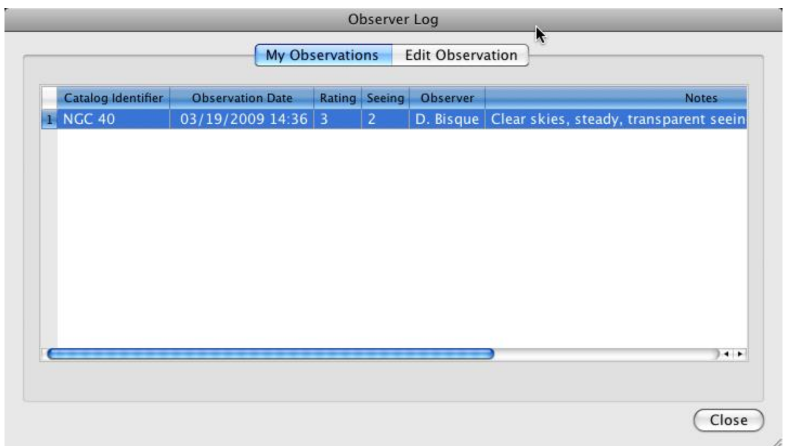


Figure 118: The *My Observations* tab on the *Observer Log* window (click the *Add Observer Log* button on the *Observing List* window to view this window).

The My Observations table shows the list of objects that you have observed. The Observing List table shows an icon next to objects to indicate they have been observed.

	Object Name	Object Type	RA (2000.0)	Dec (2000.0)
1	NGC 7822	Nebula	00h 03m 35s	+67° 09' 42"
2	NGC 129	Open Cluster	00h 30m 00s	+60° 13' 06"
3	NGC 189	Open Cluster	00h 39m 36s	+61° 04' 40"
4	NGC 146	Open Cluster	00h 33m 03s	+63° 18' 06"
5	NGC 133	Open Cluster	00h 31m 17s	+63° 21' 10"
6	NGC 103	Open Cluster	00h 25m 17s	+61° 19' 19"
7	NGC 6939	Open Cluster	20h 31m 30s	+60° 39' 43"
8	NGC 6946	Spiral Galaxy	20h 34m 52s	+60° 09' 12"
9	NGC 6951	Spiral Galaxy	20h 37m 14s	+66° 06' 21"
10	NGC 6952	Spiral Galaxy	20h 37m 14s	+66° 06' 21"
11	NGC 6869	Spiral Galaxy	20h 00m 42s	+66° 13' 41"
12	NGC 6701	Spiral Galaxy	18h 43m 13s	+60° 39' 11"
13	NGC 6796	Spiral Galaxy	19h 21m 31s	+61° 08' 42"
14	NGC 6789	Irregular Ga...	19h 16m 42s	+63° 58' 19"
15	NGC 6763	Spiral Galaxy	19h 05m 37s	+63° 56' 03"
16	NGC 6762	Spiral Galaxy	19h 05m 37s	+63° 56' 03"

Figure 119: Objects that have been observed include a checkmark next to them in the Observing List.

To remove an observation, select it and press the DELETE key.

Manage Observing List Window Orientation

The orientation and position of the controls in the Observing List stacked window changes based on the window's *aspect ratio* (that is, the ratio of the height to the width of the window).

This allows the Observing List window to float in a vertical orientation or be docked to the left or right side of the main window. The window can also float in a horizontal orientation or be docked to the bottom of the main window.

You can choose which orientation works best for your workflow and hardware (screen size, aspect ratio, resolution, number of screens, etc.).

By default, the Observing List window is docked to the left side of *TheSkyX's* main window in the vertical orientation. To undock it, first make sure it's the topmost stacked window by clicking on the ***Observing List*** tab on the left side of the window. (Click the ***Observing List*** command from the ***Display*** menu to turn it on if necessary.)

Once visible, click and drag the topmost portion (the *caption*) of the Observing List window and move it off the stacked windows.

Figure 120: Click and drag the mouse to undock or "tear off" the Observing List window.

The window can now be positioned where you want, even on a second monitor (if you're lucky enough to have two!).

Horizontal Orientation

The controls on the Observing List window automatically switch between the vertical and horizontal orientation as the window is sized.

When the window is taller than it is wide, the controls appear in a vertical orientation. When the window is wider than it is tall *and* the window is wide enough to fit the controls in a horizontal orientation, the controls are automatically repositioned.

To make the Observing List controls appear a horizontal orientation, click the lower right corner of the Observing List window (or the size control in the lower right corner on the Mac) and drag the window wider (while not making it taller). Once the window is wide enough to fit the controls horizontally, they're repositioned automatically.

When the Observing List window is in the horizontal orientation, it can also be “docked” to the bottom of the main window (see Figure 121). To dock it to the bottom of the main window, click and drag the caption to the center of the bottom of the main window. When the top of the caption is near the bottom of the main window, positions of the Sky Chart and stacked windows are adjusted to make room for the Observing List window. At this point, release the mouse to dock the window.

Observing List Orientation Notes

The Observing List window cannot be docked to the bottom of the window when the Observing List controls are in the vertical orientation.

The main window will not allow the Observing List window to be docked at the bottom if there’s not enough room for it to fit. So, maximize the main window before attempting to dock the horizontal Observing List window.

The Chart Status Window can be closed or undocked to make room, if necessary.
If all attempts at “bottom docking” fail, then close all other stacked windows. If the window refuses to be docked it means there is not enough room for it to fit.

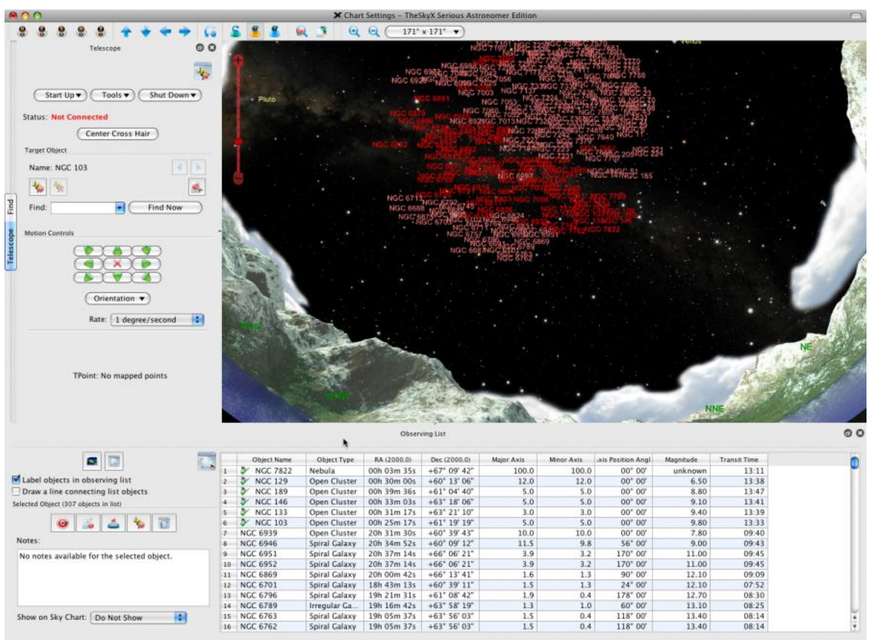


Figure 121: The Observing List controls in a horizontal orientation and docked to the bottom of the main window.

This configuration allows you to access items in the observing list while viewing the Sky Chart and still have access to the controls in the other stacked windows.

Creating Sky Chart Mosaics

PROFESSIONAL

The ***Mosaic Grid*** command on the ***Tools*** menu can be used to divide a rectangular area of the sky into smaller rectangular regions (called *tiles*), each of which has the dimensions of a selected field-of-view indicator (FOVI) or any other custom size. Once the mosaic is created, you can slew the telescope to the center of any rectangle simply by clicking on it.

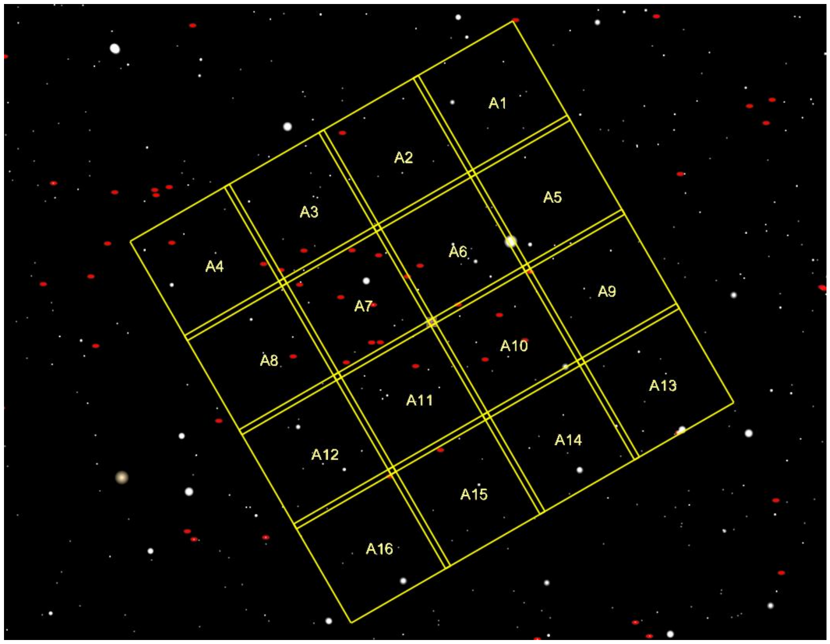


Figure 122: Sample mosaic grid on the Sky Chart.

1. Select the *Mosaic Grid* command from the *Tools* menu to show the *Mosaic Grid dialog*.

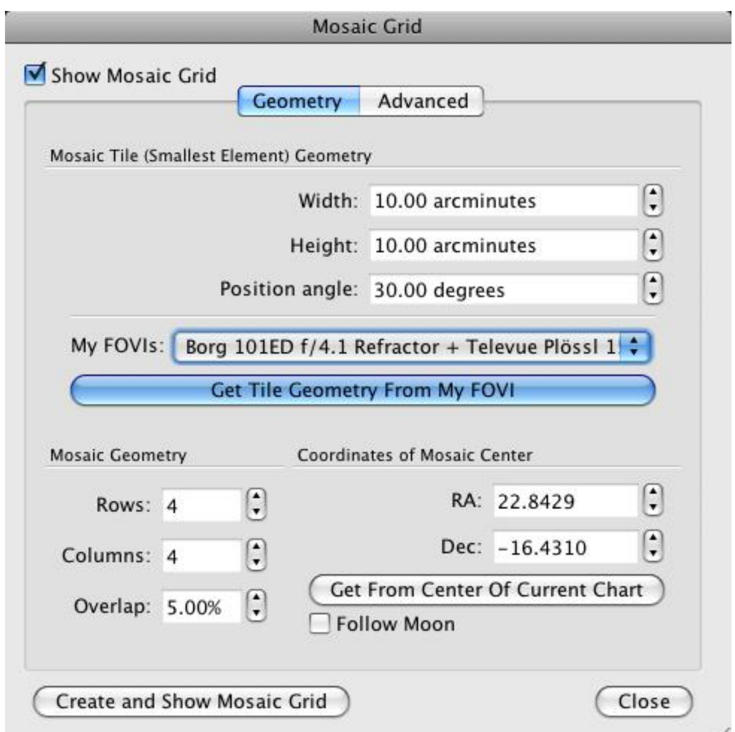


Figure 123: The Mosaic Grid window.

Mosaic Tile Geometry

Use the options on the ***Geometry*** tab to define the ***Width*** and ***Height***, in arcminutes, of each mosaic tile and each tile's rotation, or ***Position Angle***, in degrees, measured counterclockwise from North. You can optionally select a field of view indicator in the ***My FOVIs*** list.

Next, enter the number of ***Rows*** and ***Columns***, the ***Overlap*** of the *primary* mosaic grid and the grid's position on the celestial sphere, equatorial coordinates.

Turn on the ***Follow Moon*** checkbox so that *TheSkyX* will slew to the current position of the Moon, instead of a fixed equatorial coordinate.

Turn on the ***Show Mosaic Grid*** checkbox to show the mosaic grid then click the ***Create and Show Mosaic Grid*** button to center and frame the mosaic on the Sky Chart.

2. **Click the Advanced tab.** The ***Advanced*** tab can be used to duplicate the primary mosaic grid.

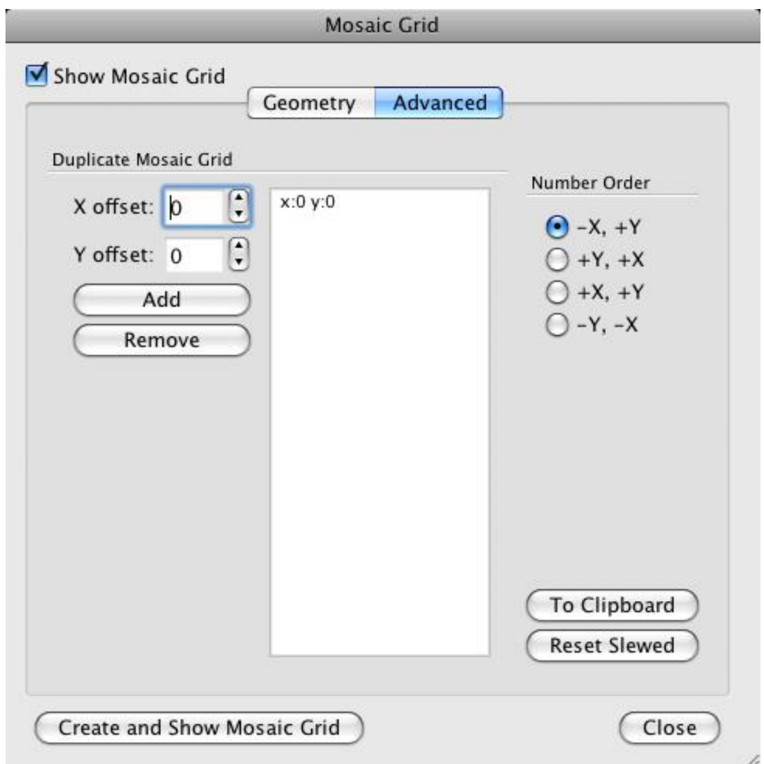


Figure 124: Advanced tab on the Mosaic Grid dialog.

Enter the horizontal (x-axis) and vertical (y-axis) offset for the new mosaic. The offset unit is defined as the "width of the primary mosaic." A value of 1 in the "X offset" will place the replicated mosaic's upper left corner next to the primary mosaic's upper right corner. (The offset is always relative to the upper left corner of the primary mosaic.)

An offset of 0, 0 is allowed and will place another mosaic on top of the primary mosaic. The mosaics centers are numbered starting at one through the total number of mosaic regions. Mosaics are ordered alphabetically.

Click the “Add” button to create the new mosaic and add the offset to the mosaic replication list.

3. Specify the numbering convention for the mosaic centers.
    - **-X, +Y** – Mosaic center numbers are incremented *right to left* by row, starting in the upper right corner of the mosaic.
    - **+Y, +X** – Mosaic center numbers are incremented *top to bottom* by column, starting in the upper right corner of the mosaic.
    - **+X, +Y** – Mosaic center numbers are incremented *left to right* by row, starting in the upper right corner of the mosaic.
    - **-Y, -X** – Mosaic center numbers are incremented *bottom to top* by column, starting in the lower left corner of the mosaic.

To Clipboard Button

Click the button to copy the equatorial coordinates of the centers of selected mosaic to the Clipboard. These coordinates can be used to generate a script that slews your telescope to each position.

Sample mosaic grid data:

```
 1  A   0   9.32121655 -29.04969590
 2  A   1   9.32119169 -28.89969638
 3  A   2   9.32116702 -28.74969737
 4  A   3   9.32114254 -28.59969785
 5  A   4   9.30977751 -29.04991248
 6  A   5   9.30976922 -28.89991265
 7  A   6   9.30976100 -28.74991333
 8  A   7   9.30975284 -28.59991349
 9  A   8   9.29833849 -29.04991248
10  A   9   9.29834678 -28.89991265
11  A  10   9.29835500 -28.74991333
12  A  11   9.29836316 -28.59991349
13  A  12   9.28689945 -29.04969590
14  A  13   9.28692431 -28.89969638
15  A  14   9.28694898 -28.74969737
16  A  15   9.28697346 -28.59969785
```

Reset Slewed

Once you have slewed your telescope to a given frame, parentheses are placed around the number in the center of the block, indicating that this frame has been imaged. If you wish to start the mosaic process over, click this button to clear all the parentheses.

Using the Mosaic Grid

Once a link with the telescope is established, click anywhere within one of the mosaic tiles, and the telescope will automatically slew to its equatorial center.

If you are viewing or photographing the Moon, turning on the ***Follow Moon*** checkbox. The telescope's drive will automatically be reset to the lunar rate. (The previous rate is restored when you remove the mosaic.)

Although each tile is numbered sequentially, you can slew to them in any order. (If *TheSkyX's* window is not maximized, or the field of view is too small, the numbers might not be displayed.) A selected frame's border changes color from magenta to red, to remind you it's been "visited." To reset each tile to its original color, click the ***Reset Slewed*** button.

If you're using the Mosaic Grid feature to take pictures, the CCD or film camera has to be aligned with the mosaic frames. You must therefore either position the camera to align it with the Sky Chart, or orient the Sky Chart to the camera. *TheSkyX* can help you. Use Image Link to align one of your CCD images with the Sky Chart, the "Image Link Information" gives the orientation of the image as an angular offset from North. You can then adjust the camera mount or the Sky Chart's orientation accordingly.

The Mosaic feature works best with equatorial telescopes. Azm/Alt telescopes suffer from field rotation, which causes the field of view to gradually rotate. The severity of this effect varies with the altitude coordinates of the area being photographed, and the length of time needed to complete the photography. A field-rotation corrector might be needed.

Image Link and Automated Astrometry

PROFESSIONAL

TheSkyX Professional Edition's Image Link™ and automated astrometry feature make it possible to overlay *Flexible Image Transport System* (FITS) photos on the Sky Chart.

Image Link creates an "inventory" of stars and other light sources on the photo, then compares patterns of stars in the photo against known star catalogs to determine the photo's *astrometric solution* (sometimes referred to as a "plate solve"). Once a match is found, the photo can exactly overlay the Sky Chart – stars and galaxies in the photo match the corresponding objects on the Sky Chart.

Image Link can be used with photos from the Digitized Sky Survey for areas of the sky of up to about 2° square, or on your photos up to about ten degree fields of view.

Your photos become part of the interactive Sky Chart. Objects in the photo can be viewed, labeled and identified, just as if they were part of the Sky Chart.

The astrometric solution can be used to precisely locate the position of variable stars, optical components of gamma ray bursts, supernovae, comets and asteroids. It can also be used to automate calibration runs using the *TPoint Add On*.

Photo Requirements

An astrometric solution can be determined for photos with the following attributes.

- A photo that adheres to the Flexible Image Transport System standard.
- A minimum of eight distinct stars in the photo.
- A field of view of *ten degrees* or smaller. For photos with relatively narrow fields of view (5-20 *arcminutes*), Software Bisque recommends using one of the larger star catalogs from *TheSkyX Professional Edition Database Add On* (page 520).
- The approximate equatorial coordinates of the photo must be known or otherwise available.

    - FITS photos acquired with the *Camera Add On* are saved with the telescope's right ascension and declination and the Sky Chart is adjusted to this position when the photo is opened from the ***Image Link*** window.
    - If the photo was not acquired with the *Camera Add On*, or does not include the photo's coordinates in the FITS header, then, in order to perform a successful Image Link, the Sky Chart must be manually oriented to match the approximate position and field of view of the photo.

- The approximate image scale of the photo, in arcseconds per pixel, must be known. If you know the details of the optical system and detector, the scale can be obtained from the Field of View Indicator Report (page 93). The photo's image scale is also displayed in the ***Status*** window after a successful Image Link is performed.

Let's use a FITS photo from the Digitized Sky Survey to demonstrate how Image Link and automated astrometry work together.

1. On the ***Find*** tab, enter ***M81*** and then click the ***Frame*** button. This sets the field of view to about 40 arcminutes and frames M81 on the Sky Chart.
2. Select the ***Digitized Sky Survey*** command from the ***Tools*** menu.
3. On the ***Setup*** tab, turn on the ***Web*** option to retrieve Digitized Sky Survey photos from the web.
4. On the ***Create Photo*** tab, click the ***Create*** button in the ***Show in FITS Viewer*** section. The photo is downloaded from the web and displayed in the ***FITS Viewer*** window.

5. On the ***FITS Viewer*** window, click the ***To Image Link*** command in the ***Photo*** pop-up menu. The photo is now displayed in the ***Image Link*** window. You'll normally open your FITS photos that are acquired from a CCD or digital camera by clicking the ***Open FITS*** button on the ***Image Link*** window.
6. Click the ***Find Astrometric Solution*** button.

The ***Astrometric Solution*** tab on the ***Image Link*** window shows the equatorial coordinates of the photo, the scale, position angle and the list of stars used in the solution.

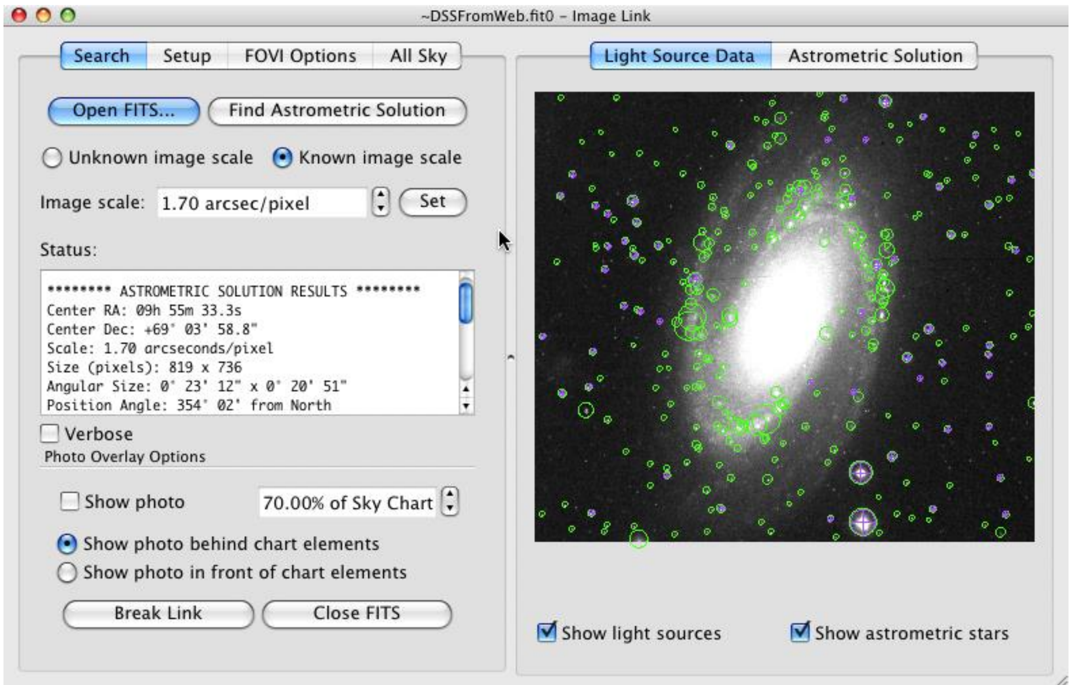


Figure 125: The Astrometric Solution tab of the Image Link window.

The photo of M81 also appears on the Sky Chart at the appropriate location. Turn on the ***Show Photo In Front of Chart Elements*** option to show the photo "on top of" the other chart elements.

Figure 126: M81 “linked” to the Sky Chart.

The default Image Link settings can be used to perform astrometric solutions on photos acquired from a wide range of optical systems. If an Image Link fails, check the following settings on the ***Setup*** tab of the ***Image Link*** window.

Search Tab

Image Link’s ***Search*** tab is used to open one or more FITS photos, configure the image scale, initiate the Image Link or astrometric solution, show the progress of the Image Link and define how the photo is displayed on the Sky Chart.

Open FITS

Click this button to display the ***Open FITS*** widow and select a FITS photo to Image Link. Multiple photos can be selected and are Image Linked in succession. The results of each photo’s Image Link are displayed in the ***Status*** text box.

When opening a FITS photo, if the FITS header contains the photo’s equatorial coordinates (specifically, the OBJCTRA and OBJCTDEC keywords), or World Coordinate System (WCS) information, the center of the Sky Chart is automatically adjusted to match these coordinates. The Sky Chart’s field of view is also changed to approximately match the photo’s field of view (based on the value of the image scale).

- When *TheSkyX* is used to control the telescope, the FITS header in photos acquired with the *Camera Add On* use the current position of the telescope for the OBJCTRA and OBJCTDEC keywords.
- If the position of the Sky Chart does not change when a FITS is opened, the photo’s coordinates cannot be determined from the FITS header. In this

case, you'll need to manually center the Sky Chart on the approximate right ascension and declination of the photo to find the astrometric solution.

Find Astrometric Solution

After opening a FITS photo, and configuring the ***Image Scale***, click this button to start searching for the astrometric solution.

Abort

The text on the ***Find Astrometric Solution*** button changes to ***Abort*** while Image Link is searching for the astrometric solution. Click it to end the search.

Unknown Scale

When the ***Unknown Scale*** option is turned on, *TheSkyX must know the approximate image scale of the photo*. Image Link will fail otherwise. Make sure that the ***Image Scale (Best Guess)*** value is "close to" the actual scale (plus or minus two arcseconds per pixel).

Image Link uses the ***Image Scale (Best Guess)*** as a *starting point* to find the astrometric solution of the photo. If a solution is not found using this value, larger and smaller image scale values (based on the ***Scale Tolerance*** on the ***Setup*** tab) are used.

Use the ***Unknown Scale*** option if you do not know the image scale of your optical system. After the astrometric solution is found, turn on the ***Know Scale*** option and click the ***Set*** button to use the image scale that was computed from the astrometric solution.

Known Scale

When the ***Known Scale*** option is turned on, enter the actual image scale of the photo to plus or minus 0.5 arcseconds per pixel. In contrast to the ***Unknown Scale*** option, the ***Known Scale*** does not perform an iterative search, so Image Link will always fail when the wrong ***Known Scale*** is used.

Status

This text box provides diagnostic feedback of the search for the astrometric solution. When a solution is found, the following information is displayed:

- Right ascension and declination of the photo's center.
- Image scale, in arcseconds per pixel.
- Height and width, in pixels.
- Angular size.
- Position angle, measured counterclockwise from north.
- Shows the total root mean square of the residual errors in the astrometric solution, and the RMS error in each axis.
- The number of cataloged stars used in the solution.
- The full-width, half maximum (FWHM) of the stars in the x- and y-axis.

For example, the solution for M81 displays the following results:

```
******** ASTROMETRIC SOLUTION RESULTS ********
Center RA: 09h 55m 22.8s
Center Dec: +69° 02' 49.7"
Scale: 1.70 arcseconds/pixel
Size (pixels): 963 x 670
Angular Size: 0° 27' 17" x 0° 18' 59"
Position Angle: 353° 59' from North
RMS: 0.93 (X: 0.71 Y: 0.59)
Number of Stars Used in Solution: 91 (98%)
FWHM: 2.74 pixels, 4.65 arcseconds
**********************************************

Image Link Succeeded.
```

Verbose

Turn this checkbox on to show extra information about the status of the search.

Photo Overlay Options

When Image Link finds the astrometric solution, the Sky Chart is adjusted to exactly match the field of view and the orientation of the photo (even mirrored, if necessary). How the photo appears on the Sky Chart is configurable using the ***Photo Overlay Options***.

Show Photo

Turn on this checkbox to show the Image Link photo on the Sky Chart.

Percentage of Sky Chart

This value defines the relative angular size of the photo compared to the Sky Chart's field of view after a successful Image Link. For example, a value of 75% means the Sky Chart's field of view is adjusted so that the resulting Image Link photo overlay occupies 75 percent of the Sky Chart.

Show Photo In Front of Chart Elements

Turn this option on to place the Image Link photo "on top of" the objects and symbols on the Sky Chart. This hides the simulated stars and other elements on the chart.

Show Photo Behind Chart Elements

Turn this option on to place the Image Link photo "behind" objects and symbols on the Sky Chart. This option reveals stars and other elements on the chart on the photo.

Break Link

When a photo's astrometric solution is found, the photo is pinned or "image linked" to the Sky Chart so the photo becomes part of the chart. Click this button to break the Image Link so that the photo is displayed in the center of the window and does not move when the position or field of view of the Sky Chart is changed.

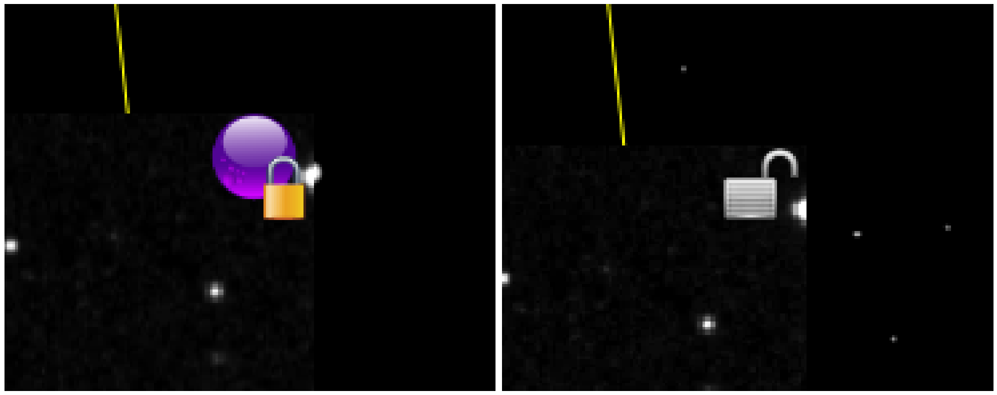


Figure 127: The graphic on the left is displayed after a successful Image Link is found. The graphic on the right indicates the Image Link has been turned off.

Close FITS

Click this button to break the Image Link and remove the FITS photo from the Image Link window.

Light Source Data Tab

The Light Source Data tab on the right side of the Image Link window shows a preview of the currently open FITS photo.

Show Light Sources

Turn this checkbox on to show the inventory of stars and other light sources on the photo after the ***Find Astrometric Solution*** button is clicked. Light sources are shown with green circles.

Show Astrometric Stars

Turn this checkbox on to show purple circles that represent the known cataloged stars used in the astrometric solution.

Astrometric Solution Tab

The table on the ***Astrometric Solution*** tab shows the details of the astrometric solution.

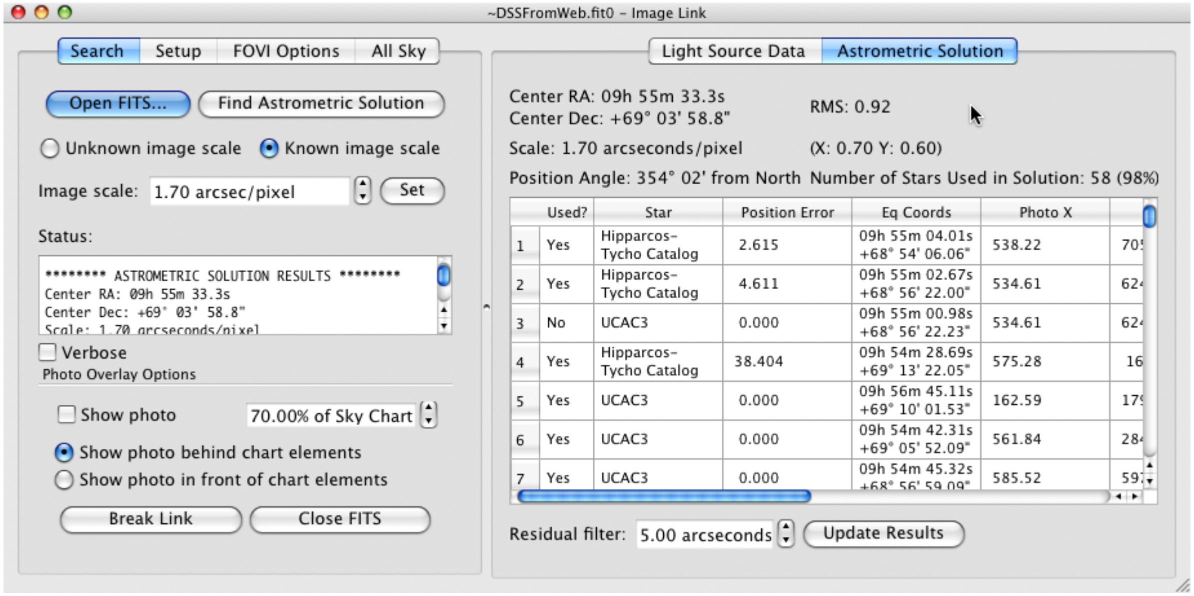


Figure 128: The Astrometric Solution tab.

Center RA and Dec

Shows the Equinox 2000 coordinates of the center of the photo.

Scale

Shows the image scale of the photo, in arcseconds per pixel.

Position Angle

Shows the photo's position angle, measured counterclockwise from north.

RMS

Shows the total root mean square of the residual errors in the astrometric solution, and the RMS error in each axis immediately below.

Number of Stars Used In Solution

Shows the number of cataloged stars that we used in the astrometric solution.

Each row in the table represents a known or cataloged star that was used in the astrometric solution. The table below describes each column in the report.

Column Name	**Description**
Used?	The word Yes in this column indicates this star was used in the solution. No means the star was rejected because the *residual error* was greater than the ***Residual Filter*** value.
Star	The astronomical catalog of the known star.
Position Error	The error in the position of the cataloged star's coordinates.
Eq Coords	The Equinox 2000 coordinates of the cataloged star.
Photo X	The x-axis position of the cataloged star on the photo.

Column Name	Description
Photo Y	The y-axis position of the cataloged star on the photo.
Residual	The amount by which the position of the star in the photo differs from the cataloged position.

Residual Filter

Enter the value of the maximum residual error that is permissible to use a given star in the astrometric solution.

Update Results

Click this button to update the astrometric solution table based on the value of the ***Residual Filter***.

Troubleshooting Image Link Failure

If the solution fails, and you're sure the scale is correct, the next step is to review and configure the ***Source Extraction Setup*** parameters. *Source Extractor* is photo analysis tool that catalogs the sources of light (that is, stars, extended objects like nebulas, asteroids, etc.) in photos.

If your wide-field photo contains too many light sources (photos in the Milky Way, for example), or has a poor signal to noise ratio (too short of an exposure), you'll want to try altering two *Source Extractor* parameters accordingly to achieve a successful astrometric solution. In other words, if there are too many light sources, increase the ***Detection Threshold*** so that fewer stars are used on the astrometric solution. If there is an insufficient number light sources, decrease the ***Detection Threshold*** until a sufficient number is found.

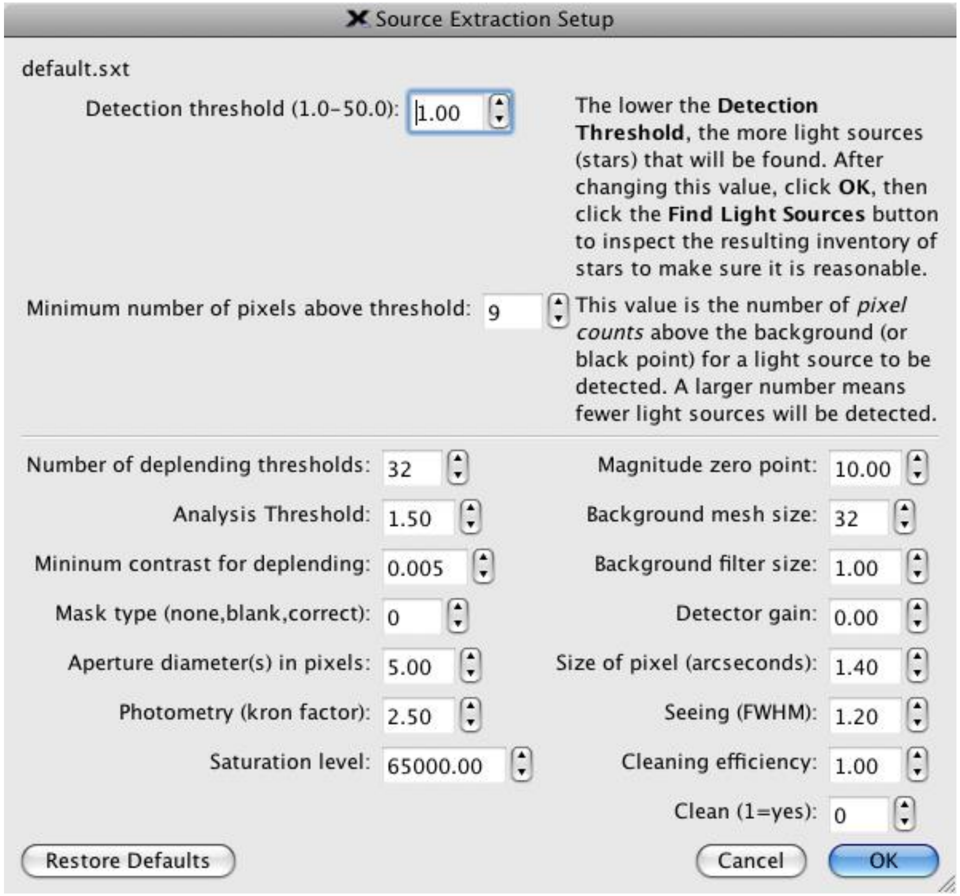


Figure 129: The Source Extraction Setup dialog.

Typically, the ***Detection Threshold*** is the only setting that needs to be adjusted to allow a successful astrometric solution.

The ***Detection Threshold*** can range from 1.0 up to 50.0. Smaller values detect more light sources in the photo. If the ***Detection Threshold*** too small, then potentially too many light sources, or light sources that are actually noise in the photo are detected, and will cause the astrometric solution to fail.

If an astrometric solution fails for a particular photo, or for all the photos obtained your imaging system, then altering the ***Detection Threshold*** is usually the solution.

If changing the ***Detection Threshold*** over a range of values fails to find a solution, the next, not normally necessary, step is to change is the ***Minimum Number of Pixels Above Threshold***.

The ***Minimum Number of Pixels Above Threshold*** is the number of “pixel counts” above the background (or black point) that a light source must be to be detected. Increase this value by increments of 5 or so until the astrometric solution is found.

Advanced users can read *Source Extractor for Dummies* by Dr. Benne W. Holwerda of the Space Telescope Science Institute for a technical explanation of each source extraction parameter (and more).

Here are a few examples of how modifying the ***Detection Threshold*** parameter can affect the astrometric solution.

Example 1

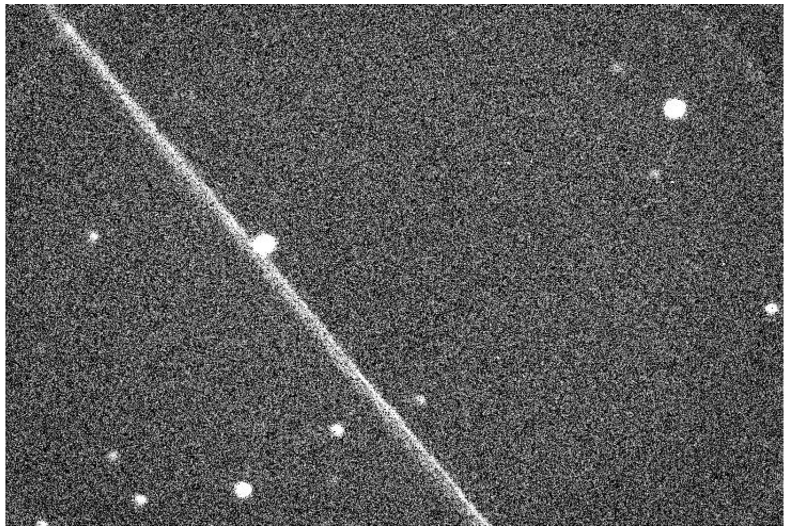


Figure 130: Photo with satellite trail.

The above photo has a satellite passing through it. Setting the ***Detection Threshold*** to 1, and then clicking the ***Light Sources*** button on the ***Image Link Setup*** tab shows the light sources in the photo.

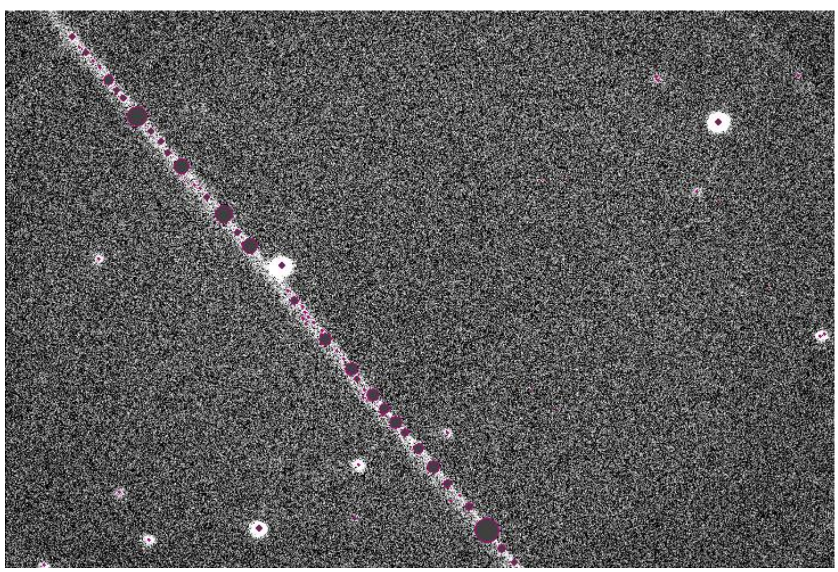


Figure 131: A "poor" inventory of light sources.

What's wrong here? When the ***Detection Threshold*** at set to 1, the streak is *misidentified* as a series of non-existent light sources. These "stars" are then used in the astrometric solution, and, Image Link fails because these light sources do not actually exist.

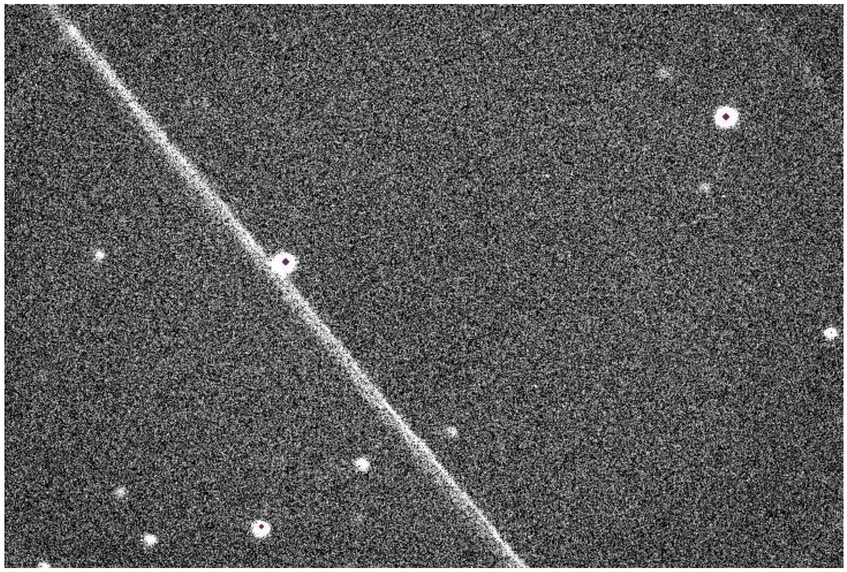


Figure 132: "Correct" inventory.

Changing the ***Detection Threshold*** parameter from 5 to 10, shows no stars detected in the "streak" and only true "stars" are identified.

Note: Even though an astrometric solution can be found using this photo, it is a very poor photo for many reasons. It has very bad signal to noise ratio (the dynamic range is 65 counts out of a possible 65535), and it is also "deficient" in stars (about 6 are "inventoried"). A longer exposure is *highly* recommended for photos like this.

Example 2

This photo also reveals the importance of the ***Detection Threshold*** setting.

Figure 133: Sample image.

The above photo contains relatively good signal and has many “well-defined” stars. However, notice how the nebulosity in the upper left affects the inventory using different ***Detection Threshold*** values.

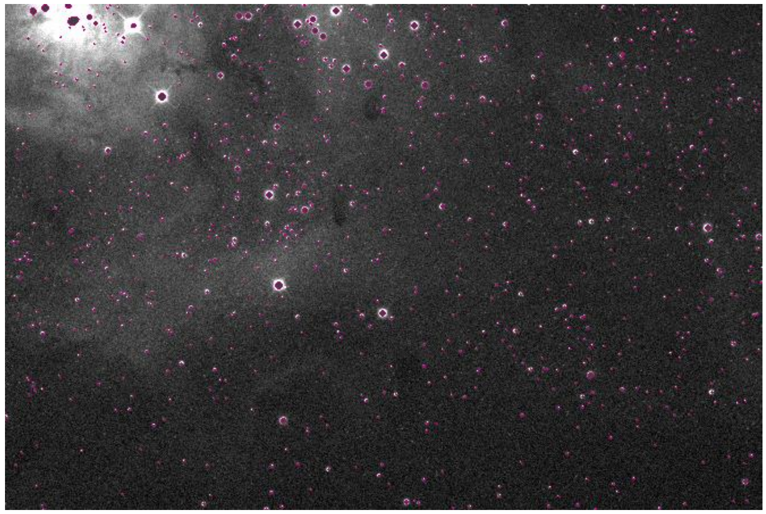


Figure 134: Note the incorrectly identified "stars" in the upper left corner.

A Detection Threshold setting of 6 identifies stars in the nebula that do not exist, and causes the astrometric solution to fail.

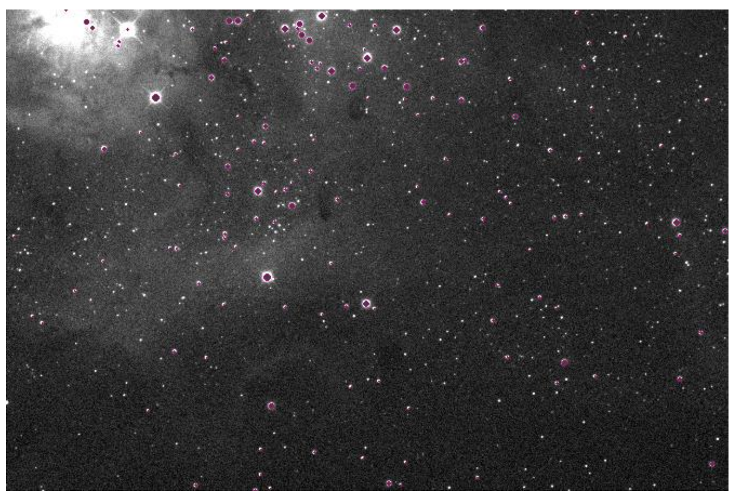


Figure 135: Changing the detection threshold correctly identifies stars in the nebula.

A ***Detection Threshold*** setting of 30 correctly identifies the stars in the nebula; The solution will now succeed.

Example 3

Figure 136: Poor signal-to-noise ratio and poor focus make this a very poor candidate for an astrometric solution.

At first glance, image in Figure 136 may appear to be a good candidate. Upon closer inspection, the image “falls apart”…

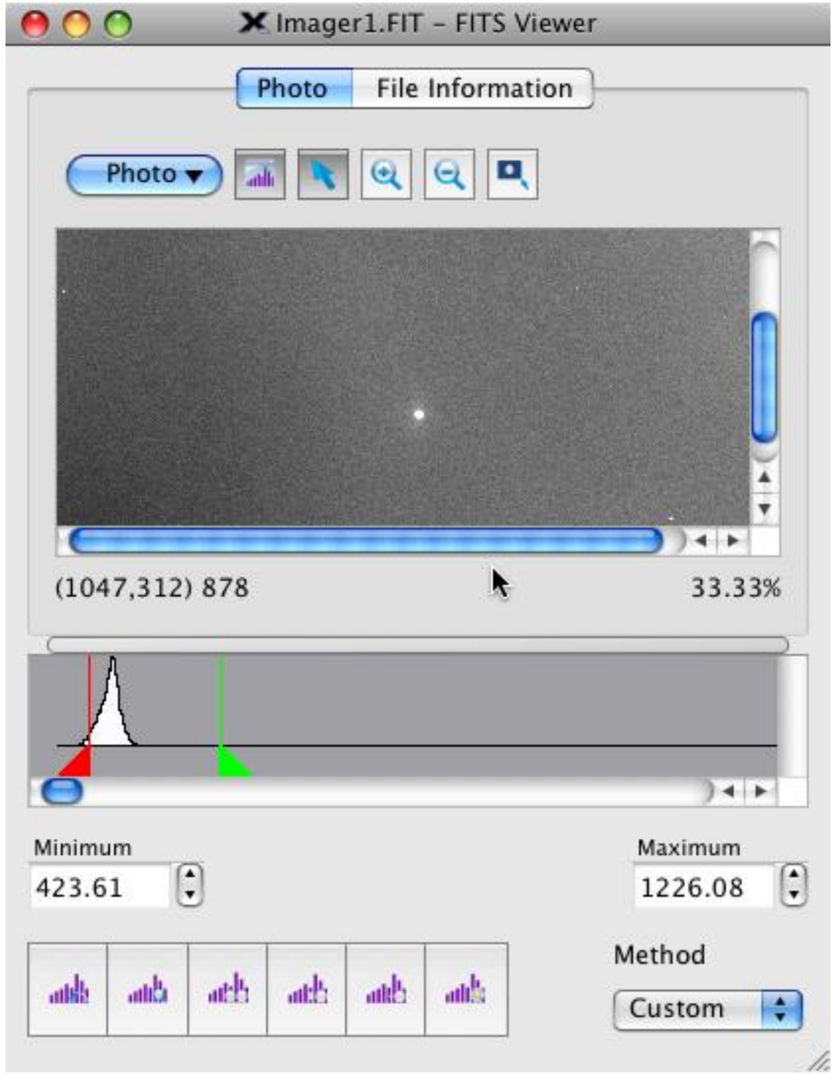


Figure 137: Histogram

The histogram shows that there is very little actual *signal*. The default background and range settings differ by a few hundreds counts using camera that has a much larger dynamic range (16-bit, or a total of 65,355 counts). The exposure time should be increased to ensure better a signal-to-noise ratio.

Figure 138: Same image after adjusting the range or "white point"

After increasing the range (that is, increasing the “white point” in the image), another very important deficiency is revealed, specifically that the image is way out of focus. Notice the donut-looking stars.

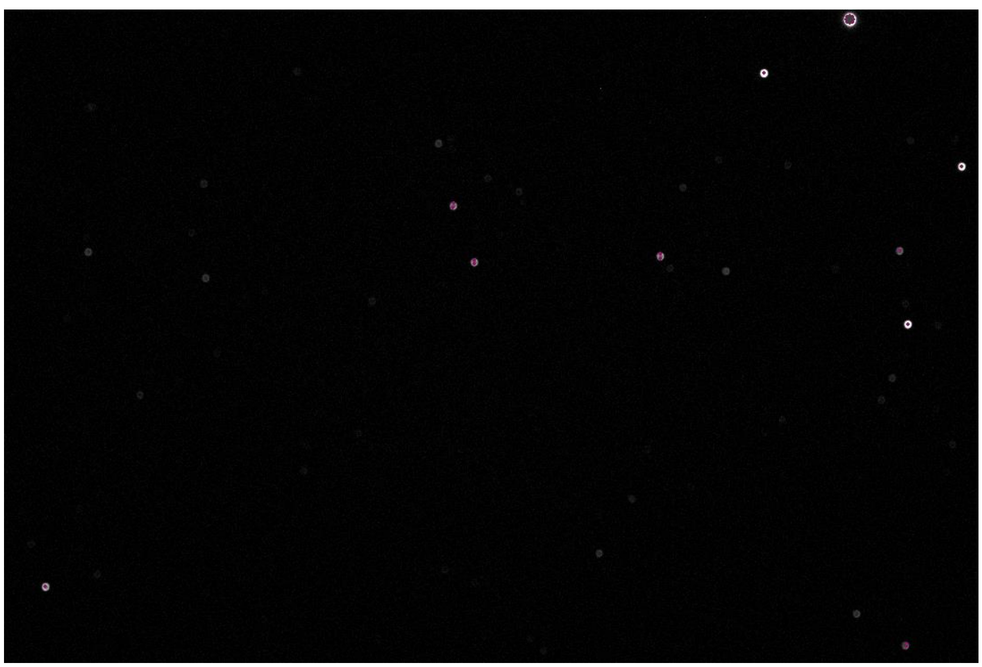


Figure 139: Multiple light sources (indicated by two red dots) are detected for individual “out of focus” stars.

The ***Show Inventory*** command, using a detection threshold of 10, reveals that several of the out of focus stars are identified as two separate light sources! If multiple light sources are detected for a single star, then the astrometric solution will almost certainly fail.

FOVI Options

A Field of View Indicator can be generated automatically from the Image Linked photo.

Current Image Link Photo

Use these options to generate a FOVI from the Image Link photo.

FOVI Description

Enter the description of the FOVI that will appear beneath it on the Sky Chart.

Create FOVI from Scale and Position Angle

Click this button to generate a FOVI based on the Image Link photo, and add the FOVI to the list of My FOVIs (page 93).

Synchronize Rotator Angle to Position Angle

Click this button to synchronize the rotator's current angle to the position of the Image Linked photo.

All Sky Image Link

PROFESSIONAL

NASA uses the phrase "lost in space" to describe a technique that satellites use to determine their orientation in orbit. In short, the satellite takes a photo and then compares star patterns in the photo with known star catalogs to determine the photo's (and thus the satellite's) position.

All Sky Image Link uses a similar process to find the astrometric solution of virtually photo taken anywhere in the sky.

All Sky Image Link Requirements

- The minimum field of view for the smaller dimension of the photo is 10 arcminutes.
- The maximum field of view for the larger dimension of the photo is 180 arcminutes, or 3 degrees.
- The image scale of the photo must be known, in arcseconds per pixel. All Sky Image Link can search a range of image scales when the image scale of the photo is not known, however, this increases the time required to match the star patterns in the photo with the equivalent star field.

Using All Sky Image Link

All Sky Image Link operates performs similar functionality as Image Link (see "Image Link and Automated Astrometry" on page 243). Image Link requires an approximate or "best guess" image scale and the approximate equatorial coordinates of the photo so that is can search a small region of the sky to locate a pattern match between the stars in the photo and the actual stars. All Sky Image Link searches the *entire celestial sphere* to match the star patterns in your photo.

All Sky Image Link Database

In order to perform an All Sky Image Link, the 1.8 GB “All Sky Image Link Database” named *10-180.allsky* must be present on the computer. This database contains millions of known star patterns for fields of view between 10 and 180 arcminutes.

Installing the All Sky Image Link Database

Due to its large size, the All Sky Image Link Database is distributed as a separate download. The procedure below describes how to download and save this file to your computer.

1. Click the ***Image Link*** command from the ***Tools*** menu.
2. On the ***All Sky*** tab, click the ***Download the All Sky Image Link Database*** link at the top of the window to download and save the All Sky Image Link Database archive, named 10-180.zip. Note that you must be signed in to the Software Bisque web page, and have a registered *TheSkyX Professional Edition* serial number with an active subscription to access this resource. Download access will be denied otherwise.
3. Unzip or extract the file named 10-180.allsky from 10-180,zip and save it to the ***Astrometry*** folder in the “Application Support Files” folder (see page 24 for details about the location of this folder on your operating system).

Once the All Sky Image Link Database has been copied to your computer, you are ready to perform an All Sky Image Link.

1. Choose the ***Image Link*** command from the ***Tools*** menu.
2. Click the ***Open FITS*** button on the ***All Sky tab*** of the ***Image Link*** window.
3. Navigate to the folder on your computer where the photo resides, highlight it, and then click the ***Open*** button.
4. Configure the All Sky Image Link options described below, and click the ***Find All Sky Image Link***.

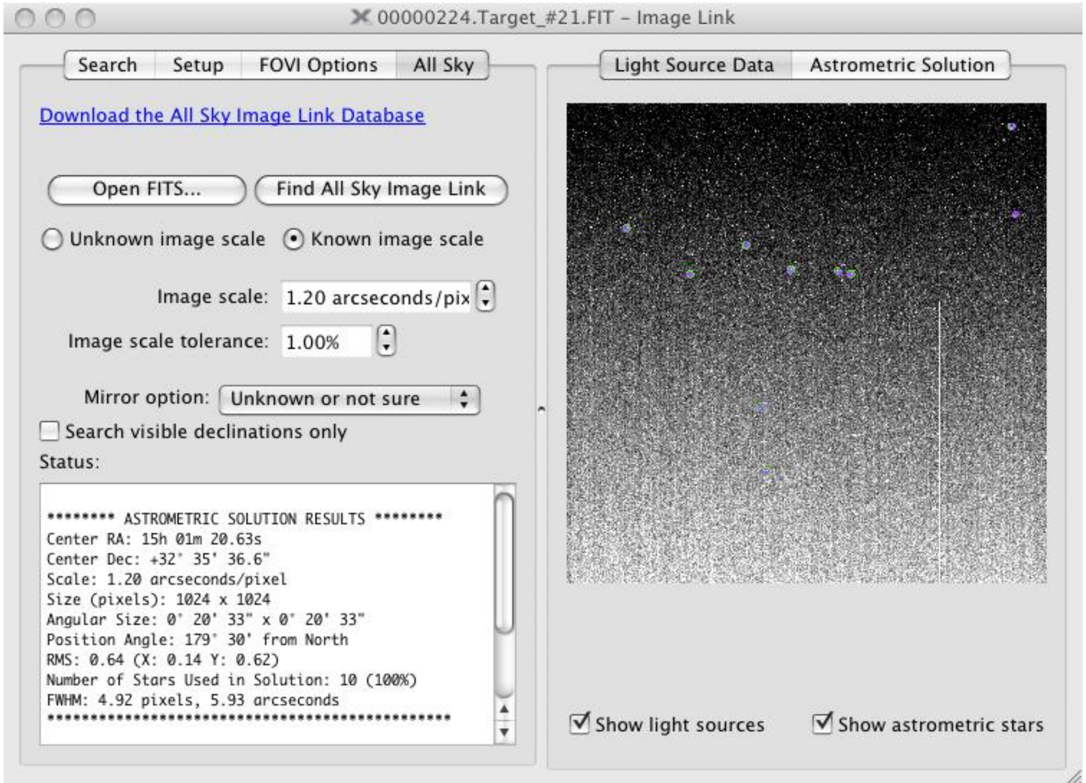


Figure 140: Successful All Sky Image Link using a photo with a limited star field.

Download the All Sky Image Link Database

Click this link to open a browser on the All Sky Image Link Database download page. The URL to this page is: http://www.bisque.com/allskydownload. You must be signed in to the Software Bisque web page, and have a registered *TheSkyX Professional Edition* serial number with an active subscription to access this resource.

Open FITS

Click this button to open the FITS photo on which to perform an All Sky Image Link.

Find All Sky Image Link

Click this button to begin the all sky search. The text changes to ***Abort*** after this button is clicked so that the process can be stopped.

Unknown Image Scale

Turn this option on if you do not know the image scale, in arcseconds per pixel, for the photo.

Minimum/Maximum Scale

When the ***Unknown Image Scale*** option is selected, enter the range of image scales to use during the all sky image link search. All Sky Image Link starts with the lower image scale, performs an all sky search, and when no match is found, increments the image scale and continues this process, up to the maximum image scale, or until a match is found.

The above process can be very time consuming, so please be patient. Once the image scale has been found for your photo (and optical configuration), we recommend using the ***Known Image Scale*** option going forward.

Known Image Scale

Turn this option on when you know the image scale for the photo.

Image Scale

Enter the image scale for the photo, in arcseconds per pixel.

Tolerance

For best results, the image scale of the photo should be accurate to with a few hundredths of its actual value. In practice, determining image scale this accurately without Image Link can be difficult. Setting a larger ***Tolerance***, specified as a percentage of the photo's image scale, can help find matches using an approximate image scale.

Mirror Option

Choose the appropriate option for your telescope. The time required to find a matching star patterns in photos with the patterns of cataloged stars can be greatly reduced if you know whether or not the photos generated by your optical system are mirrored.

Photo is Not Mirrored

Choose this option if photos produced by your optical system (telescope, camera, focal reducer, etc.) are not mirrored.

Photo is Mirrored

Choose this option if photos produced by your optical system (telescope, camera, focal reducer, etc.) are mirrored.

Unknown or Not Sure

Choose this option if you are unsure or do not know the details of the optical system that was used to produce the photo.

Search Visible Declinations Only

When this checkbox is turned on, All Sky Image Link determines the lowest visible declination based on TheSkyX's current latitude settings (page 31), and then only searches at or above this declination to speed up all sky searches.

Status

This text box provides status of the search and reports the astrometric solution results when successful (see Figure 140).

Show Light Sources

Turn this checkbox on to show the inventory of stars and other light sources on the photo after the ***Find All Sky Image Link*** button is clicked. Light sources are shown as green circles.

Show Astrometric Stars

Turn this checkbox on to show purple circles that represent the known cataloged stars used in the astrometric solution.

Telescope Control

TheSkyX can control many go to and computer-aided (or “push to”) telescope mounts.

NEVER attempt to observe the Sun through your telescope! Without a specially designed solar filter, viewing the Sun – for even a fraction of a second – will cause instant, irreversible eye damage. When observing during the day, do not point the telescope near the Sun. Do not use *TheSkyX Professional Edition’s* automatic slew feature to find objects during the day.

Children should *never* use a telescope during the daytime without strict adult supervision.

Telescopes with Optical Encoders (Push To)

If your telescope is equipped with optical encoders, *TheSkyX* can show and track its position with the aid of a “serial interface box”. The encoders read the rotation of the telescope’s axes, and return numbers that represent how much they moved. The following serial interface boxes are compatible with *TheSkyX*.

- AB Engineering
- BBox (Software Bisque)
- NGC-MAX (JMI)
- NGC Sky Commander (Lumicon)
- Sky Commander (SkyComm Engineering)
- Sky Wizard 3 (Lumicon)
- Sky Tour (Tele Vue)
- SkyQuest IntelliScope Computerized Object Locator (Orion Telescopes & Binoculars)

Jim’s Mobile, Inc. (www.jimsmobile.com) is a good source to purchase software-guided telescope (SGT) hardware.

Telescopes with Go To Control

TheSkyX comes with native telescope drivers that can send positioning and other commands to the following “go to” telescope systems.

- Astro-Physics GTO mounts (all models)
- Celestron™ Advanced Series (all models)
- Celestron™ NexStar (all models)
- Celestron™ CG Series (all models)
- Celestron™ CGE Series (all models)
- Celestron™ CPS Series (all models)
- Celestron™ GT Series
- Celestron™ SLT Series (all models)
- Celestron™ NexStar i Series (all models)
- Celestron™ *Ultima 2000*™ telescopes*
- Gemini Telescope Positioning System (Losmandy and MI-250)
- iOptron™ SmartStar™ Series
- Meade™ *LX200*™ (Classic) Telescopes
- Meade™ *LX200*™ 16-inch (Classic) Telescopes
- Meade™ Autostar (classic) telescopes
- Meade™ Autostar II (LX200 GPS) Telescopes and Mounts
- Meade™ Autostar III Telescopes and Mounts
- Orion® Telescopes & Binoculars Atlas™ EQ-G Equatorial Mounts and Sirius™ EQ-G Equatorial Mounts
- SkyWatcher mounts using the SynScan Controller
- StellarCAT™ Computer Assisted Telescope Innovations
- Takahashi™ Temma mounts (all go to models)
- Vixen™ Sphinx™ and Sphinx Deluxe mounts

* Software Bisque considers the Celestron Ultima 2000 telescope a "legacy mount" since so few of these telescopes are still in use. While TheSkyX includes a driver for the Ultima 2000, we no longer provide technical support when using TheSkyX to control this mount. Sorry for any inconvenience.

In addition, *TheSkyX* can simulate a telescope link. You can experiment without actually having a telescope connected.

Whether your telescope has optical encoders, or computer control, the Sky Chart tracks the telescope's position. In addition, *TheSkyX* can command "go to" telescope systems. Select an object from *TheSkyX'*s database and it will point the telescope at it.

All systems using optical encoders are set up the same way and are explained below in a single section. Computer-controlled telescopes are each set up slightly differently.

X2 and Third Party Telescope Drivers

TheSkyX Professional Edition and *TheSkyX Serious Astronomer Edition* can control telescopes using third-party telescope drivers with the X2 Driver Standard (see "Appendix G: TheSkyX Pro Device Driver Architecture" on page 543).

Setting the Correct Time

Computer-controlled drive systems typically have an internal clock that must be set with high accuracy. (Encoder-based systems do not need as high degree of accuracy.) The best method for keeping accurate time on your computer is to use an Internet time server. Most modern operating systems include time synchronization as part of their Date & Time settings.

Night Vision Mode

Selecting Night Vision Mode command from the Display menu (or clicking the Night Vision button) redraws the display in red to minimize loss of dark adaptation.

On the Mac, turning on Night Vision Mode will show the entire desktop, and all other applications that are running, red. Turning off Night Vision Mode, or exiting *TheSkyX* restores the screen colors.

Under Windows, by default, turning on Night Vision Mode reddens only *TheSkyX's main window*. In order to change the desktop colors, you must configure *TheSkyX* to use a Windows Theme. See the "Night Vision Setup (Display Menu)" below for details.

Night Vision Setup (Display Menu)

TheSkyX on Windows allows you to change screen elements or both screen elements and the Windows theme to red. (You can learn more about Windows Themes by searching Windows help.) Each method has advantages and disadvantages. Together they can provide an effective way to minimize screen brightness that should satisfy even the most discriminating astronomer.

The Night Vision Setup dialog (Figure 141) lets you configure how colors are changed when entering and exiting Night Vision Mode.

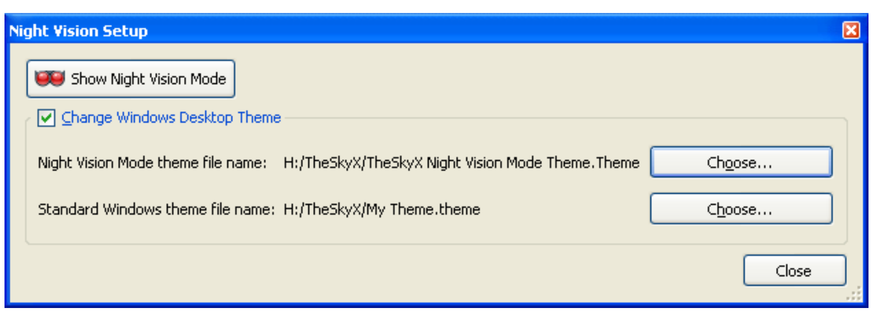


Figure 141: Night Vision Setup dialog (Display menu, Windows OS only).

When the ***Change Windows Desktop Theme*** checkbox is off and the Night Vision Mode button clicked on, the colors of the *TheSkyX's* screen elements change to red.

Note that when the ***Change Windows Desktop Theme*** checkbox is turned off, the options to set theme names are disabled.

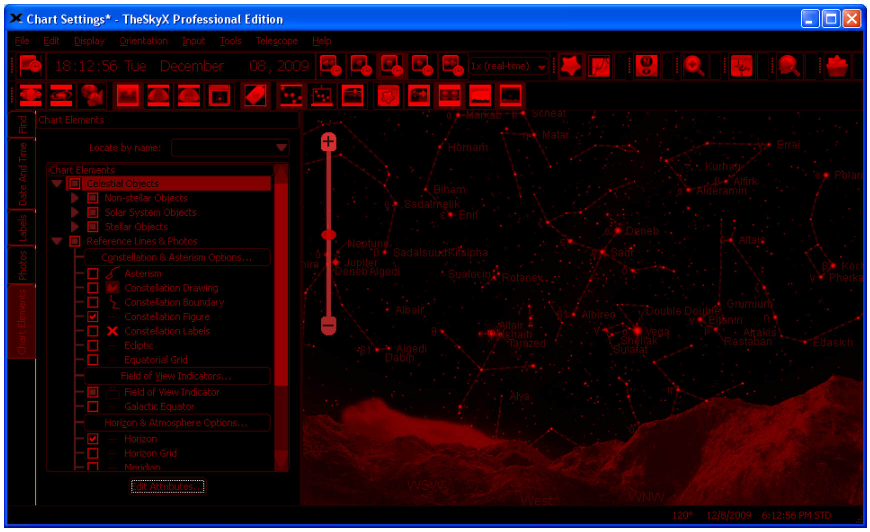


Figure 142: Sample Night Vision Mode Screen that does not use the Windows Desktop Theme.

When the ***Change Windows Desktop Theme*** checkbox is on and the ***Night Vision Mode*** button is clicked on, the selected ***Night Vision Mode Theme File Name*** is loaded.

Themes are changed automatically under Windows 7 and 8. Under Windows XP and Windows Vista, the Control Panel's Display Properties application appears, and you must select OK or the Apply button to actually apply the new theme.

Night Vision Mode Theme File Name

Click the ***Choose*** button to select the theme file name to load when Night Vision Mode is turned *on*.

Standard Windows Theme File Name

Click the ***Choose*** button to select the theme file name to load when Night Vision Mode is turned *off*.

Before you can choose a theme file name, you save one to your hard drive.

Saving a Theme File (Windows 7 and 8)

1. Click ***Start > Control Panel***.
2. Click the Change the Theme link under Appearance and Personalization.
3. Under the ***Change the Visuals and Sounds on your Computer*** window, select the desired theme. The easiest way to save a theme file under Windows 7 is to modify an existing theme, then save it. (There's no other obvious way just save a "supplied" theme.) For example, after selecting a theme to use, click the Window Color icon at the bottom of this window and then modify the color's intensity before clicking the ***Save Changes*** button. The now "modified" theme appears in ***My Themes***.
4. Right-click the modified theme, then click the ***Save Theme for Sharing*** command.

5. Enter a name for the “theme pack file” (.themepack), such as ***My Theme***, and then click ***OK***. The Windows 7 default location to save themes is the ***Libraries > Documents*** folder. Remember this folder name.

Windows 7 Starter Edition and Themes

If you are using a Netbook computer, chances are it runs *Window 7 Starter Edition*. Windows themes on this “streamlined” operating system are very limited and cannot be saved to a file, or restored from a file. These limitations make *TheSkyX’s* Night Vision Mode less than ideal. To best preserve dark adaptation when using Windows 7 Starter Edition, we recommend covering the computer screen with a sheet of red velum, which is available at most hobby stores.

Saving a Theme File (Windows Vista)

1. Click Start > Control Panel.
2. Click the Appearance and Personalization link.
3. Under Personalization, click Change the Theme.
4. Enter a name for the “theme file” (.theme), such as ***My Theme***, and then click ***OK***. The Windows XP/Vista default location to save themes is the ***Libraries > Documents*** folder. Remember this folder name.

Saving a Theme File (Windows XP)

1. Click Start > Control Panel > Display.
2. On the ***Themes*** tab of the ***Display Properties*** window, click the ***Save As*** button.
3. Enter a name for the “theme file” (.theme), such as ***My Theme***, and then click ***OK***. The Windows XP/Vista default location to save themes is the ***Libraries > Documents*** folder. Remember this folder name.

Once you’ve saved the theme file, to select it in Night Vision Setup dialog, click the ***Choose*** button next to the ***Standard Windows Theme File Name***, then navigate to the folder where the file resides, and double-click the theme pack name. *TheSkyX* will now load this theme when exiting Night Vision Mode.

Setting Up and Using Push To Telescope Systems

Other than the encoders and their interface box, the extra hardware required includes a standard serial (RS232) cable to connect the interface to your computer and a USB to serial adaptor. The serial cable is usually supplied with the encoder system; USB to serial adaptors can be purchased at almost any computer store. Make the appropriate connections from the encoders to the interface box, and the box to your computer.

Configuring the Hardware

You are now ready to configure the hardware.

Select the ***Telescope Setup*** command from the ***Telescope*** menu. The Telescope Setup dialog is displayed.

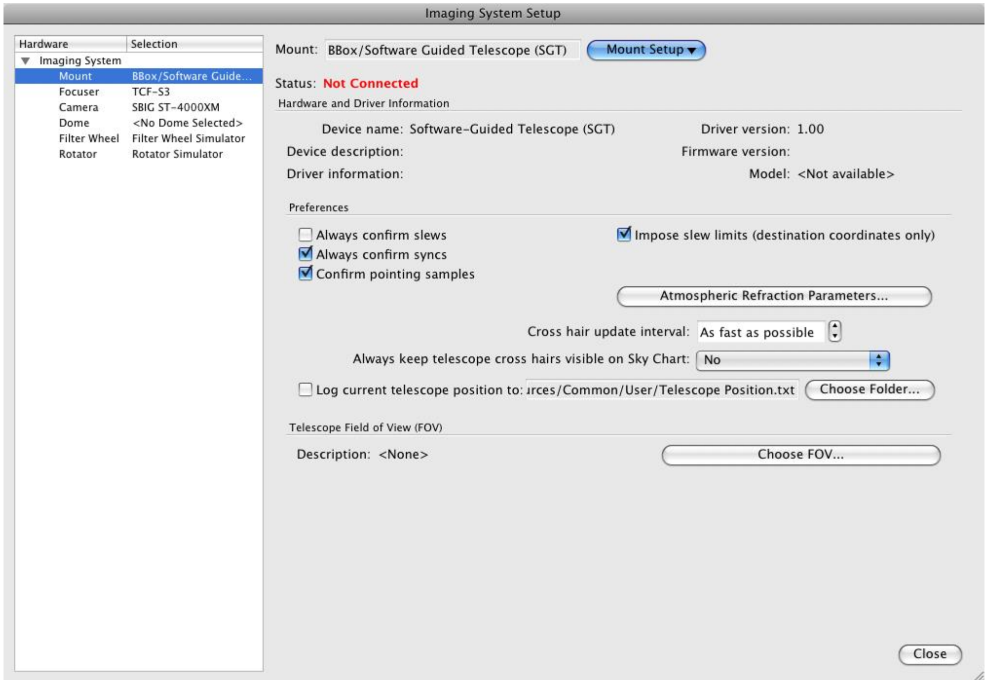


Figure 143: The Telescope Setup dialog.

1. **From the *Mount* pop-up, click the *Select Mount* button.** On the ***Select Mount*** window, select **SGT.** Or select the name of your serial interface box, if it's listed then click ***OK***.
2. **Click *Settings***. The Telescope Settings dialog appears.

Figure 144: The SGT Settings dialog.

Click the ***Serial Port*** button to select the serial port to which the interface is connected. All telescope serial interface boxes use RS232 serial communication.

Since most modern computers are not equipped with a serial port, you'll most likely need to purchase a USB to serial adaptor to convert a USB port into a serial port. Follow the manufacturer's instructions for installing the software drivers for this hardware. On the Mac, choose the port that contains the manufacturer of your USB to serial adaptor's name. On Windows, use the Device Manager to determine the communications port number (COM number) for the adaptor, and enter "COMN", when "N" is the number of the port reported by the Device Manager.

3. Select your telescope model from the Telescope pop-up menu. If it isn't listed, choose the CUSTOM option. The number of encoder tics per revolution for the selected telescope is displayed in the ***Encoders*** text boxes to the right. If your telescope isn't listed, don't worry. Just manually enter the correct values in the Encoders edit boxes. If you don't know these values, contact the manufacturer.
4. Enter the *same values* in the ***Tics/Rev*** text boxes. The RA and Dec values are sometimes different. Don't switch them. If you own version 1.7 through 1.99 of the BBox, or version 2.93 through 3.49 of NGC-MAX, enter 32768 for both axes.
5. Set the ***Clockwise/Counterclockwise*** options for Azimuth and Altitude Direction. If you aren't sure which way the encoders are supposed to be mounted, contact the manufacturer. Or continue with the setup, and see which way the cross hairs move when you link the telescope and computer. If the cross hairs move in the wrong direction, you've selected the wrong direction.
6. Click the ***Configure Device*** button. This step applies only if you own a BBox, version 1.7 (or later). If not, skip to the next step. The BBox is automatically configured for the selected number of encoder tics. If you get the message "Cannot configure BBox," try again. If you still cannot configure the box, please refer to the "Troubleshooting" section on page 310. This step need be done only once, as the interface box stores the configuration in non-volatile memory.
7. Click ***Close*** to save the configuration.

Aligning the Encoders

TheSkyX is now configured to communicate with the encoders. The next step is to align the encoders by aiming the telescope at specific stars. This gives *TheSkyX* the information it needs to calculate where the telescope is pointing.

Any two stars that are visible from your location can be used during the alignment procedure.

1. After your telescope is setup, select the ***Connect*** command from the ***Telescope*** menu to show the SGT Alignment dialog.

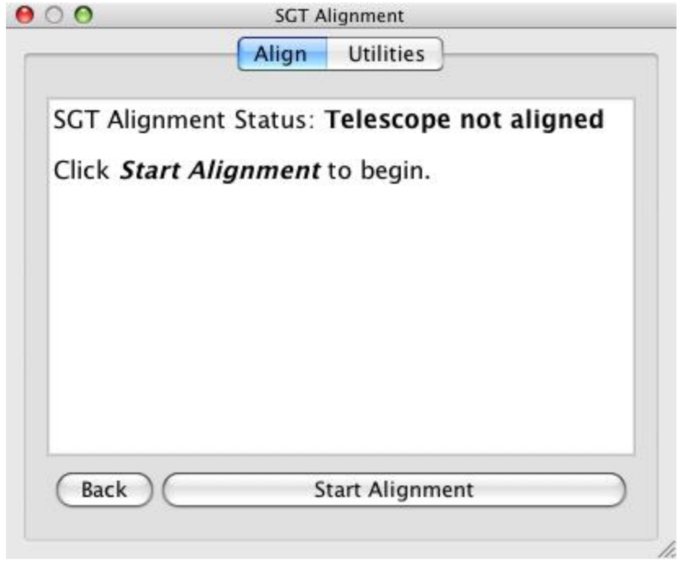


Figure 145: The SGT Alignment dialog.

2. **Click the *Start Alignment* button**. If your telescope is mounted equatorially (that is, the RA axis is pointing to the celestial pole), point it at 90° declination by default. Choose a different declination (or azimuth) from the Point Scope At pop-up menu if your telescope cannot be pointed at 90°.
3. **If your telescope has an azimuth/altitude mounting, point it at 90° *altitude***. Specifically, you're looking for the telescope position where rotation in right ascension (or azimuth) causes no rotation in declination (or altitude). The default angle is 90°.
4. **Point the telescope at the first alignment star**. The default first-alignment star is Polaris. To use a different star, use the Find command to locate the star (or just click on it in the Sky Chart). Then click Align On in the Telescope sheet of Object Information dialog.
5. **Point the telescope at the second alignment star.** The default second-alignment star is Capella. To use a different star, use the Find command to locate the star (or just click on it in the Sky Chart). Then click Align On in the Object Information dialog. The difference between the actual angular separation of the alignment stars and the angle measured by the encoders is displayed. A difference of zero indicates a "perfect" alignment. Experience shows that a difference of 1 degree or less is acceptable. If the difference is substantially greater, you should try pointing to two different stars.
6. **Click *Accept Alignment***. The alignment is complete. You should see cross hairs in the Sky Chart, marking the approximate center of the field of view of the telescope.

As you move the telescope, the cross hairs move to show where the telescope is pointing. As the cross hairs reach the edge of the screen, the Sky Chart automatically scrolls to keep the cross hairs visible.

The ***Connect*** button on the toolbar is "down" to show the telescope link is active.

Selecting Alignment Stars

If you choose different alignment stars, don't pick closely spaced ones. Generally speaking, the greater the angular separation of the alignment stars (in both right ascension and declination), the more errors inherent to the system are "averaged out" across the sky.

Realignment with Each Use

TheSkyX has no provision for saving alignment settings because you must align the telescope each time you use it, *even when observing from the same location*.

Mount and Status

When ***Mount*** is highlighted in the ***Imaging System*** list, the name of the selected mount driver is displayed on the top, right side of the ***Imaging System*** window. The ***Status*** of the connection is shown below it. Common status messages include the following. Green-colored text indicates normal operation; red indicates either no communication, or a communication failure.

Status Text	Description
Not Connected	The red text indicates there is no connection between *TheSkyX* and the mount. To connect to the mount: Choose your mount from ***Mount List*** window on the ***Mount Setup*** pop-up menu from the ***Telescope Setup*** window Choose the communication port by clicking the ***Settings*** command on the ***Mount Setup*** pop-up menu Click the ***Connect*** command from the ***Telescope*** menu, or the ***Connect Mount*** command from the ***Start Up*** pop-up menu on the ***Telescope*** window to connect to the mount. See the step-by-step setup instructions below for your specific mount.
Connecting	This message is displayed while *TheSkyX* attempts to establish communication with the mount. If connection fails, double check: The mount is powered on. The communication cable is plugged into the correct port on the mount and computer. When using the device's RS232 communications port (serial port), make sure the USB to Serial Adaptor driver for your operating system are installed. Under Windows, check the Device Manager to ensure the driver is recognized and functioning properly.

Status Text	Description
	Click the ***Settings*** button on the ***Telescope Setup*** window to make sure *TheSkyX's* Telescope settings are correct. Make sure the cable (RS232 or USB cable) is not frayed, damaged or otherwise compromised.
Disconnecting	This message appears while *TheSkyX* terminates communication with the mount.
Not Homed	The green ***Not Homed*** status message means *TheSkyX* is successfully communicating with the mount's control system, but the mount has not been homed. Click the ***Find Home*** command from the ***Start Up*** pop-up menu on the ***Telescope*** window slew the mount begin the homing process.
Finding Home	This message appears while the mount is searching for the homing sensors.
Not Synced	Synchronization is the procedure where the optical tube assembly is pointed to a position on the celestial sphere (typically a bright star) and the mount is synchronized to this specific equatorial coordinate. See "Software Synchronization" on page 295 for more information. To perform a synchronization from *TheSkyX*, identify the bright star on the Sky Chart, center this star in the telescope's field of view, then click the ***Synchronize*** button on the ***Synchronize*** window. (To display the Synchronize window, click the ***Synchronize*** command from the ***Start Up*** pop-up menu on the ***Telescope*** window.) Provided *TheSkyX's* location, date, time, time zone and Daylight Saving Option is configured correctly, and the correct star is identified on the Sky Chart, and the telescope is actually pointing to the identified star, the mount is now oriented with the celestial sphere so that when you tell the mount to "slew to this RA/Dec" it will actually slew to the correct position. The Paramount ME and Paramount MX control systems are *position-based*, so that, when this message appears, the mount knows nothing about its orientation with respect to the celestial sphere. You must perform a software synchronization before controlling the Paramount from *TheSkyX Professional Edition*.
Tracking at	The mount's right ascension axis is rotating at the same rate as the

Status Text	Description
Sidereal Rate	stars, so that there will be no apparent motion in the eyepiece. This “steady state” message appears when the mount is tracking at the sidereal rate (and not a custom tracking rate).
Tracking at Custom Rates	The mount has been configured to track at a rate other than the sidereal rate. See “Set Track Rates” on page 306 for details about configuring custom rates.
Slewing to Target	This message appears after clicking the ***Slew*** button (or right-clicking an object on the Sky Chart that is above the horizon and selecting the ***Slew*** command) and while the mount slews to the target object. See “Slewing to Objects” in TheSkyX Pro User Guide for details. Click the ***Abort*** button on the ***Telescope*** window to stop the slew.
Joysticking	This message appears when the Paramount’s joystick (Paramount ME) or hand paddle controller (Paramount MX) is being used to slew the mount.
Parking	The mount can be slewed and “parked” to a custom position at the end of each observing session. Please carefully read the Defining the Park Position and Park Position Rules for more information. This message is displayed while the mount slews to the park position.
Parked	When the mount reaches the Park Position, tracking is turned off. Once the mount is parked, make sure to disconnect from the mount to terminate the observing session.
Tracking Satellite	This message is displayed while the mount is tracking a satellite (the right ascension and declination tracking rates are configured for a the satellite that is being tracked). Click the ***Abort*** button to terminate this process.
Connection Lost or Poor Communications	After multiple retries, when *TheSkyX* cannot reliably send/or receive commands to/from the telescope, the connection is terminated.

Mount and Driver Information

After selecting your mount, the Imaging System Setup dialog lists the mount's driver-specific information. (The telescope driver is the software that "talks" to the mount's control system.)

Device Name

Displays the name of the mount or control system.

Device Description

Displays a short description of the selected mount.

Driver Information

Displays a short description about the telescope driver.

Driver Version

Displays the software version of the telescope driver.

Firmware Information

When available, the mount or control system *firmware* version is displayed. Remember, firmware is the internal software that is used by the control system and is different than the telescope driver version.

Model

When available, the model of the mount is displayed.

Telescope-Related Software Preferences

The Imaging System dialog provides the following additional preferences for both encoder and "go to" interfaces.

Always Confirm Slews

When this option is turned on, after initiating a slew command (page 298), you must confirm whether or not you actually want to slew the telescope before the mount begins slewing.

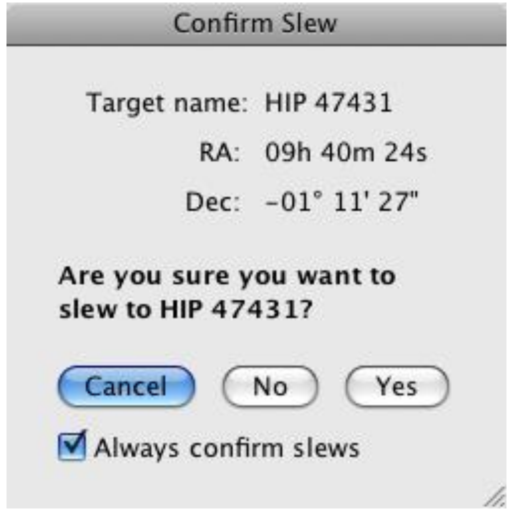


Figure 146: The Confirm Slew dialog.

Turn off the ***Always Confirm Slews*** option on the ***Confirm Slew*** window or on the ***Telescope Setup*** window so that confirmation is not required.

Always Confirm Syncs

When this option is turned on, after initiating a software synchronization (page 295), you must confirm whether or not you actually want to sync the telescope.

Figure 147: The Confirm Sync window.

Turn off the ***Always Confirm Slews*** option on the ***Confirm Slew*** window or on the ***Telescope Setup*** window so that confirmation is not required.

Confirm Pointing Samples

When this option is turned on, after adding a new pointing sample, you must confirm whether or not you actually want to do so.

Figure 148: The Confirm Pointing Sample window.

Turn off the ***Always Confirm Pointing Samples*** option on the ***Confirm Pointing Sample*** window or on the ***Telescope Setup*** window so that confirmation is not required.

Impose Slew Limits (Destination Coordinates Only)

Turn this option on to have *TheSkyX* try to stop slews to slew limit regions (page 285).

Atmospheric Refraction Parameters

Click the ***Atmospheric Refraction Parameters*** button to set the temperature, pressure and other weather-related parameters that can change telescope pointing (specifically, refraction calculations) from night to night. Note that these parameters can usually be left unchanged for most observers. For those using TPoint and the TPoint Super Model to achieve sub-10 arcsecond pointing, setting these parameters each night will help maintain superb pointing each night.

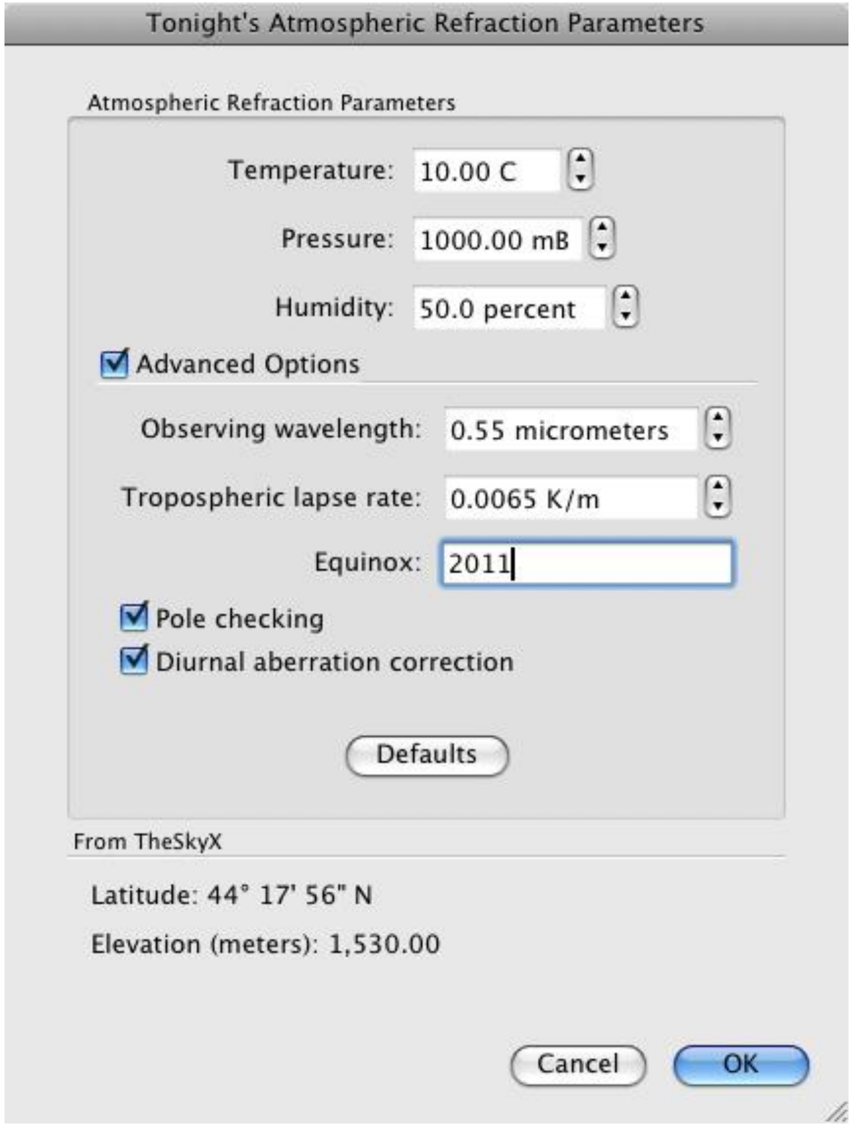


Figure 149: Tonight's Atmospheric Refraction Parameters window.

Temperature

Enter tonight's ambient temperature.

Pressure

Enter the barometric pressure, in mB.

Humidity

Enter the relative humidity, as a percentage.

Observing Wavelength

Enter the wavelength of light that is being observed. Yes, the atmosphere affects different wavelengths.

Tropospheric Lapse Rate

In degrees K/m, default 0.01. The default value can be used in nearly all circumstances.

Equinox

Enter the equinox of the telescope coordinates. This is only required if the recorded telescope positions are "mean" positions (If *TheSkyX* is used to collect the data, leave this blank). Only one equinox (typically, it is B1950 or J2000) may be specified, and this applies to all pointing samples.

Pole Checking

Pole checking rejects pointing samples in places that may cause problems – very close to the celestial pole, for instance. This option should be checked unless specific circumstances require turning pole checking off.

Diurnal Aberration Correction

The correction for diurnal aberration (maximum 0.3") should be disabled if the telescope control system itself omits it.

Defaults

Click this button to restore the default atmospheric refraction settings.

From TheSkyX

The current latitude and elevation (in meters) settings from TheSkyX's Location dialog (page 31).

Cross Hair Update Interval

Enter the length of time, in milliseconds, that the coordinates of the telescope cross hairs are updated. The default setting is ***As Fast As Possible***; if you cannot establish communication with your mount, or encounter communication failures, it may be that your mount cannot keep up with *TheSkyX's* requests. If this is the case, try increasing the interval to 500 ms or higher.

Always Keep Telescope Cross Hairs Visible on Sky Chart

The telescope cross hairs can be forced to remain visible on the Sky Chart so that you can more easily track its position. The other options in this list include:

- **No** – This option allows the telescope cross hairs to move independently from the Sky Chart. Use the ***Center Cross Hairs*** button to adjust position of the Sky Chart based on the telescope's current position.
- **Yes** – The telescope cross hairs remain visible on the Sky Chart. If the telescope is slewed, or the Sky Chart's position is changed, the Sky Chart is automatically updated to center the cross hairs.
- **Yes, Centered** – The telescope cross hairs are pinned to the center of the Sky Chart.
- **No, Suspend Connection** – The telescope link is temporarily suspended; the telescope cross hairs are no longer displayed, and Sky Chart's field of view can be changed. Selecting another option in the list causes activates the link and updates the Sky Chart if necessary.

Telescope Field of View (FOV)

Click the ***Choose*** button to choose the Field of View Indicator (page 93) for your imaging system.

Using the Software-Guided Link

The cross hairs in the Sky Chart will now "follow" the telescope. This is true whether you move the telescope by hand, or let its motor drive turn it. Be sure you've clicked the ***Computer Clock*** button. The Sky Chart will then update automatically. If you select a specific date and time, the Sky Chart does not update; however, the Sky Chart may not match what you see through the telescope.

Terminating the Link

On the Telescope menu, click the ***Connect*** command. Or, select ***Disconnect Telescope*** in the ***Shut Down*** pop-up menu on the ***Telescope*** window.

Finding a Particular Object

TheSkyX can help you position the telescope on a particular object.

1. Use the ***Find*** command on the ***Edit*** menu to locate the object.
2. **Click the *Guide To Current Object* button**. It is located on the Utilities tab of the SGT Alignment window. This will show the Guide To controls on the Sky Chart. When the telescope is pointing relatively near the target object, its position is represented by cross hairs on the RA/Azimuth and Dec/Altitude axis circles. When an axis is far from the object, a red and green line are shown instead. The red line rotates as the telescope is moved. The green line remains stationary. Your goal is to move the telescope until the red line is drawn on top of the green line. At this point, the lines fade away. Slowing move the telescope axis until the cross hair is over the center green circle.

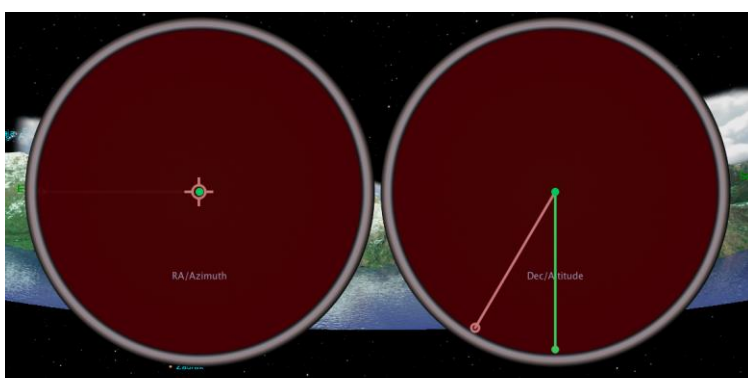


Figure 150: The SGT Guide To controls.

3. **Starting with the RA/Az axis**, move the telescope until the cross hairs are centered in the circle. Lock the RA/Az axis.

Repeat the last step for the Dec/Alt axis.

The Sky Chart's cross hairs are now over the desired object. When you look through the telescope, the object should be near the center of the field. If Impose Slew Limits are enabled, *TheSkyX* warns you if you try to move the telescope into a limit-line region.

Setting Up and Using your Go To Telescope

TheSkyX can drive many popular commercial telescopes. Most telescopes that *TheSkyX* controls are *serial devices* (one exception is Vixen SX mounts; it uses an Ethernet connection). In order for a telescope that uses serial communications to "communicate" with the computer (and *TheSkyX*), the computer must have a *serial port*.

Unfortunately, serial ports have been replaced by USB ports on virtually every newer model computer. This means the physical USB hardware, as well as the USB protocol, is not compatible with older serial devices. Fortunately, there is a solution…

USB to Serial Adaptors

The most common method to connect a personal computer that has a USB port to a telescope that uses serial (RS232) communication, is to use purchase a *USB to serial adaptor*.
This hardware device "converts" one of the computer's USB ports into a virtual serial port that understands serial communication used by the telescope.

The most common way to do this is to use a USB to Serial Adaptor so that one of the computer's USB ports can accept RS232 commands. (Bluetooth or serial to Ethernet hardware devices are other, less common, and typically more expensive alternatives.)

USB to serial adaptors are relatively inexpensive and can be purchased at almost any computer store.

- Before purchasing the USB to serial adaptor, make sure the adaptor is compatible with your computer's operating system. For example, some USB to serial adaptors are not compatible with Mac OS X Snow Leopard.
- Carefully follow the manufacturer's setup instructions for your operating system. Remember, the USB to serial adaptor hardware requires that you install a separate software driver before it can be used to communicate with a telescope.

Mac OS X Snow Leopard and USB to Serial Adaptors

When you plug a USB to Serial Adaptor into a computer that is running Mac OS Snow Leopard, a message appears that a new network device has been connected, and prompts you to set it up (via the Network options in System Preferences).

Configuring the USB to Serial Adaptor as a network device will not allow TheSkyX to control a telescope that uses RS232 serial communication.

In order for *TheSkyX* to control a telescope that uses serial communications on Mac OS X, an OS X compatible USB to serial adaptor driver must be installed first.

Contact the manufacturer of your USB to Serial Adaptor hardware device, or visit the manufacturer's Downloads page to obtain this driver.

After installing the Mac OS X-compatible USB to Serial Adaptor driver, you need to select it from *TheSkyX's* ***Telescope > Telescope Setup > Settings*** window.

You'll also need a telescope cable that connects your computer to USB to serial adaptor. Cables for Meade and Celestron products can be purchased from the Software Bisque Store.

We strongly recommend that you read the telescope's owner manual carefully, and become thoroughly familiar with the telescope's operation, before using *TheSkyX* to control it.

Configuring the Telescope Interface

TheSkyX must be configured so your computer can communicate with the telescope. The following general procedure applies to most "go to" telescopes.

1. Turn off the telescope.
2. **Using the appropriate telescope cable, connect the serial port on the telescope to an unused serial port.** If your computer does not have a serial port, you'll need to use a [USB to serial adaptor]().
3. Turn on the telescope.
4. Select the *Telescope Setup* command from the *Telescope* menu to show the *Imaging System Setup* window.

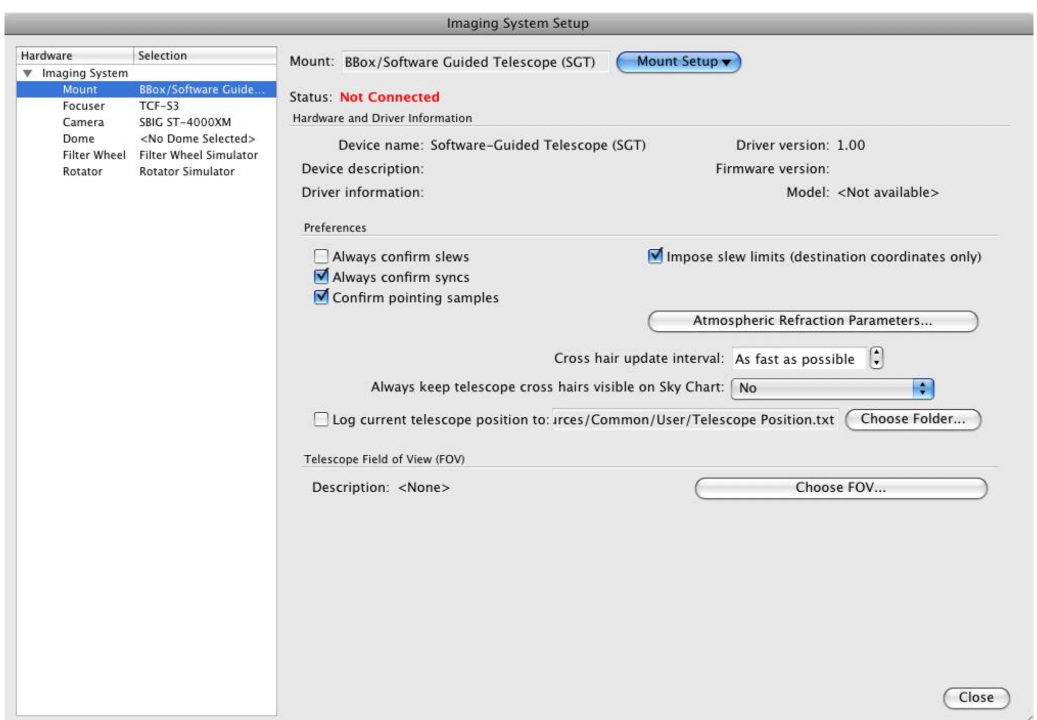


Figure 151: The default Imaging System Setup window.

5. Highlight ***Mount*** from the ***Imaging System*** tree on the left.
6. From the ***Mount Setup*** drop down menu, click the ***Choose*** command to select your telescope model and click ***OK***.

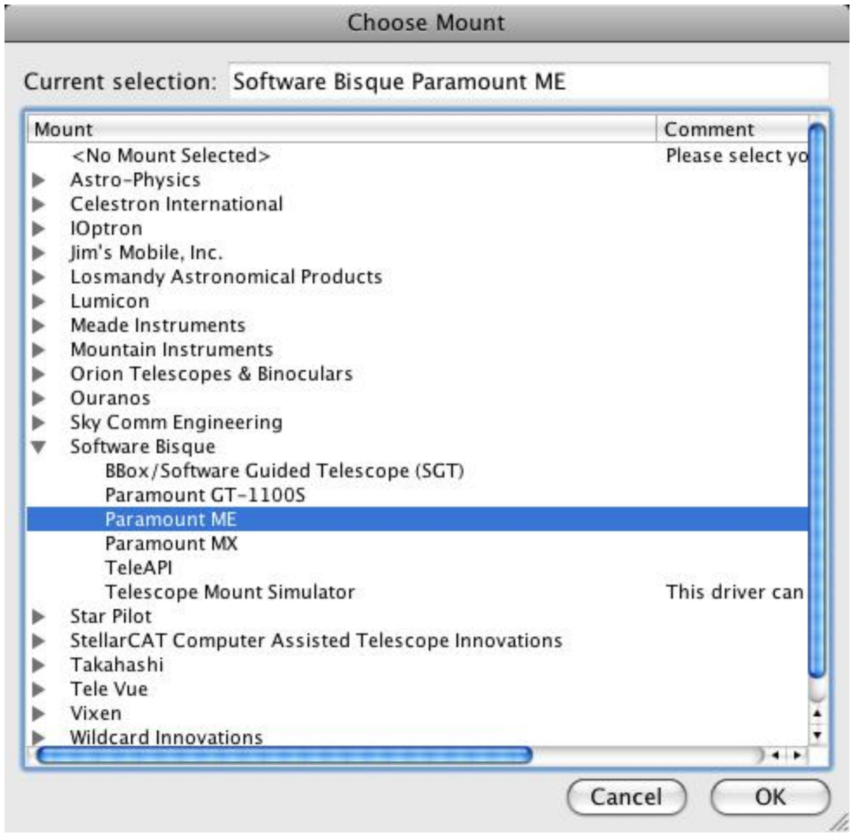


Figure 152: Select your mount from the list of supported telescopes.

7. From the ***Mount Setup*** drop down menu, click the ***Settings*** command. On the Mac, the Serial Device Settings dialog allows you to specify the USB to serial adaptor that your telescope cable is connected to.

Under Windows, in the COM Port text input, type the letters "COM" followed by the number of the port that the Device Manager reports for the device.

Windows Serial Port Notes

- Only standard serial ports or USB to serial adaptors that are not being used by any other device should be used.
- Use Windows Device Manager to determine the COM port number for your serial ports, or USB to serial adaptor.

Linking To and Synchronizing the Telescope

Most "go to" drive systems must be properly configured before *TheSkyX* can control them. You can do this "by hand," using the telescope's hand paddle. Or, you can do it from within *TheSkyX* by performing a process called synchronization.

(Note that Celestron telescopes using firmware version 4.1 and earlier cannot be synchronized from *TheSkyX* and must be aligned using the hand paddle before *TheSkyX* can control it.)

Important Notes:

- The local date, time, time zone, Daylight Saving Time and terrestrial coordinates must be entered into the telescope's hand paddle. If the telescope is connected to your computer, you might find it easier to use *TheSkyX* to initialize the telescope's hand paddle with these values. If your telescope can be initialized by *TheSkyX*, click the ***Location, Date, Time*** command from the ***Tools*** pop-up menu on the ***Telescope*** window to do so (page 290).
- The telescope must be aligned with the celestial sphere. Follow the manufacturer's instructions for aligning the telescope with the night sky.

See "Software Synchronization" on page 295 for details how to synchronize your mount with *TheSkyX*.

Telescope Setup Options

After choosing your telescope, the ***Imaging System Setup*** window displays mount and driver specific information, and allows you to specify your telescope preferences.

Telescope Limits

Controlling the slewing limits of your telescope is a snap with *TheSkyX's* telescope limits command. There, you can set lower altitude and upper altitude and declination limits. To open the ***Telescope Limits*** dialog, select the ***Telescope Limits*** command from the ***Telescope*** menu.

Upper Limits

When you first open the Telescope Limits dialog, you will first be given an opportunity to set the ***Upper Limits*** of your telescope's slewing control. Use the data fields to enter maximum values for declination and altitude slewing and to choose whether the telescope limits are plotted on the Sky Chart.

Lower Altitude Limit

Choose the ***Lower Altitude Limit*** tab to set minimum altitude limits for your telescope setup. In the top portion of the dialog window, you will see a graph upon which you can click and drag the mouse pointer to draw a set of altitude limit data for given azimuth values.

You can also choose to ***Open*** a pre-existing horizon file, and, once you have set altitude limits, you can save a horizon file for later use by clicking ***Save As***.

Clicking ***Set To*** allows you to set altitude limits according to a number of values, such as a given set altitude, or to match the current horizon image. For more on horizon images, see ***Horizon & Atmosphere Options***.

You can also import the telescope's current Az/Alt position into the dialog by clicking ***Get Telescope Az/Alt***.

Here, too, you choose to have *TheSkyX* plot the set limits onto the Sky Chart by clicking ***Show limits on Sky Chart***.

Once you are satisfied with the input limit data, click ***OK*** to commit. If you decide not to use these data, click ***Cancel***.

TPoint Add On

The TPoint Add On is optional telescope pointing analysis software that allows you to analyze the errors inherent in your particular telescope system to drastically improve its pointing performance. Both *TheSkyX Serious Astronomer Edition* and *TheSkyX Professional Edition* supply a 90 day trial version of *TPoint*. The *TPoint Add On* can be accessed from the ***Tools*** menu.

Like many aspects of your imaging system, there is a learning curve to master calibrating telescope pointing. Fortunately, *TheSkyX* makes using *TPoint Add On* easier and you should be able to complete a calibration run on the first night to start analyzing and improving your telescope's pointing right away. There is a comprehensive user guide for *TPoint* available by selecting ***Help > TPoint Add On User Guide***.

Telescope Controls

The ***Telescope*** window holds the most commonly used telescope controls. Select the ***Telescope*** command from the ***Display*** menu to show it.

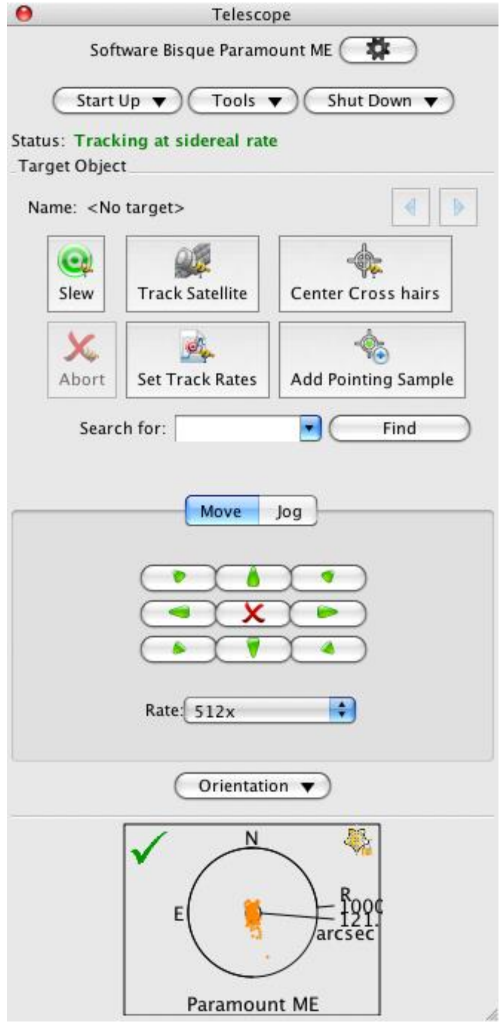


Figure 153: The Telescope window.

Not all telescope mounts have the same feature set; the ***Telescope*** window shows the most commonly used mount controls. Note that the commands in the ***Start Up***, ***Tools*** and ***Shut Down*** pop-up menus may change for each mount.

Manufacturer-specific telescope control features can be accessed from the appropriate *<Telescope Name>* command in the ***Display*** menu. For example, the control system specific commands for the Gemini are located on the ***Gemini*** window.

Telescope Initialization

The ***Start Up*** pop-up menu on the ***Telescope*** window shows mount-specific commands that are used to connect to, synchronize, unpark or find the mount's home position, when applicable.

Connect Telescope Command

This command is identical to selecting the ***Connect*** command from the ***Telescope*** menu. See "Linking To and Synchronizing the Telescope" for more information about this command.

Find Home Command

Sends the mount to its home position.

Synchronize Command

Use this command to tell *TheSkyX* where the telescope is currently pointing. See “Software Synchronization” for more information about this command.

Telescope Setup Command

Shows the ***Telescope Setup*** dialog. See “Configuring the Telescope Interface” for more information about setting up your mount.

Once communication with the telescope is established, the ***Telescope*** window can be used to find objects, monitor the status of the communications between the mount and the computer, initialize the mount’s hand paddle or controller with *TheSkyX’s* location, date, time, and time zone values, methodically slew the telescope outward to search for a nearby star and more.

Telescope Tools

The ***Tools*** pop-up menu contains the less-commonly used telescope control features.

Turn Sidereal Tracking On/Off

Use the ***Turn Sidereal Tracking On*** and ***Turn Sidereal Tracking Off*** commands to enable or disable sidereal tracking on mounts that support this feature.

Slew To Coordinates

Use this command to enter a specific right ascension and declination or altitude and azimuth coordinate. See the “Slewing to a Specific Coordinate” on page 299 for more information.

Slew Prior

Use this command to slew the telescope to its previous coordinates. For example, if you slew to M42, then to the Pleiades, selecting the ***Slew Prior*** command will return the mount to M42. Slews must have been initiated by *TheSkyX* for this command to work. In other words, using the telescope hand paddle to slew to an object, then attempting to slew to the previous object will not work.

Star Search

The Star Search feature slews the telescope in a spiral pattern of increasing size to help locate an object in the eyepiece. Choose the ***Star Search*** command from the ***Tools*** pop-up on the ***Telescope*** window to show the ***Star Search*** window.

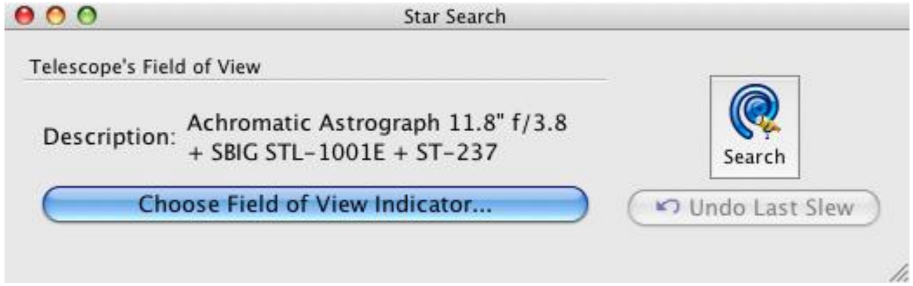


Figure 154: The Star Search dialog (Tools menu on the Telescope window).

Begin Spiral Search (Star Search button)

Clicking this button begins slewing the telescope in a "spiral" pattern, based on the size of the selected Field of View Indicator.

Defining the Size of the Spiral (Telescope's Field of View)

The angular distance between slews when the telescope "spirals" outward can be configured to match the telescope's field of view. Click the ***Select From Field of View Indicators*** button to tell *TheSkyX* the specifics of your optical system.

Communications Log

The ***Communications Log*** command (***Tools*** pop-up menu on the ***Telescope*** widow) shows the serial or network communications between *TheSkyX* and the telescope.

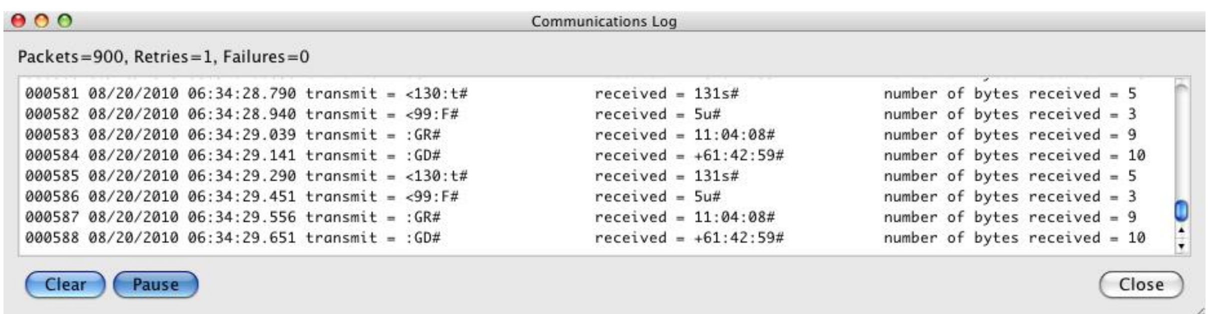


Figure 155: The Communications Log window.

The report contains six columns.

- **Packet Count** – The total number of packets or commands sent to the telescope, including retries and failures.
- **Date and Time** – The date and time the packet was sent.
- **Transmit** – The telescope-specific command that was sent to the telescope. Please refer the telescope protocol specifications for your telescope to decipher what each command means.

- **Received** – The response received from the telescope.
- **Number of Bytes Received** – The number of individual characters received.

This information can be useful when troubleshooting telescope connection problems.

Packets, Retries, Failures

The number of ***Packets*** represents the individual commands that have been transmitted to the telescope. If the telescope does not respond to a command, TheSkyX resends or ***Retries*** to send the command three times. Failures mean the telescope did not respond to a particular command. Multiple failures usually indicate that there is a configuration, cabling or other hardware problem. To begin troubleshooting, check that the telescope is turned on, the serial cable plus the USB to serial cable is properly plugged in to the computer and the telescope's communication port.

Clear

Click the ***Clear*** button to clear the current report.

Pause

Click the ***Pause*** button to temporarily stop the communications log report from being updated. Note that communications with telescope continue when this button is pressed down.

Location, Date, Time

Astro-Physics, Gemini, Celestron and Meade mounts allow *TheSkyX* to configure the control system's location, date, time and time zone information, rather than having to set them manually using the hand paddle. Choose the ***Location, Date, Time*** command from the ***Tools*** pop-up on the ***Telescope*** window to show the ***Telescope Location, Date, Time*** window.

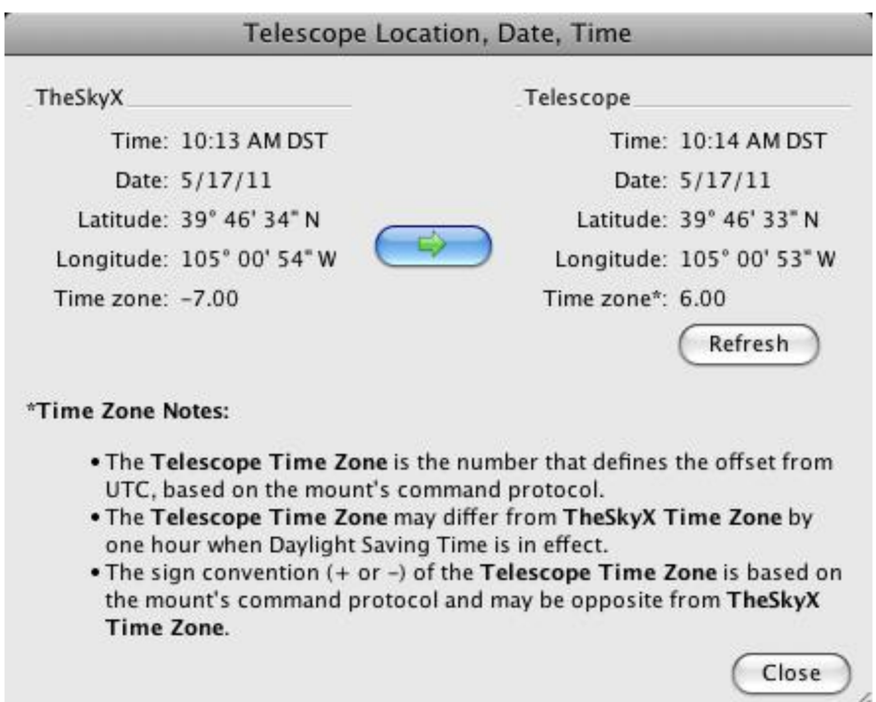


Figure 156: The Telescope Location, Date, Time dialog (Tools menu on the Telescope window).

In order for the telescope to be commanded to the correct coordinates, the telescope must use the same parameters as *TheSkyX*.

Refresh Button

Click the ***Refresh*** button to get the telescope's current settings.

Right Arrow Button

Click the green right arrow button to configure the hand paddle's settings to match *TheSkyX's* current time, date, latitude, longitude and time zone settings.

TheSkyX's settings may not *exactly* match the telescope's settings for the following reasons.

Parameter	**Reason for Difference**
Time	The time display is not updated continuously on this window, so the seconds may differ.
Latitude and Longitude	The telescope protocol may not allow arcsecond accuracy for latitude and longitude. The telescope's coordinate convention may differ from *TheSkyX's* convention. For example, the Astro-Physics longitude is displayed from 0–360°; *TheSkyX* measures longitude from 0–180° East or West of GMT.
Time Zone	*TheSkyX* uses a different time zone sign convention as compared to the telescope protocol, so the sign of *TheSkyX's* time zone is opposite from the telescope. *TheSkyX* sets the telescope's time zone to the nearest whole number. When Daylight Saving Time is in effect, the telescope protocol must be configured to use a one hour offset from the actual time zone. This convention means *TheSkyX's* time zone will differ from the telescope by one hour.

These differences are normal and expected and ensure the telescope is properly configured for *TheSkyX* control.

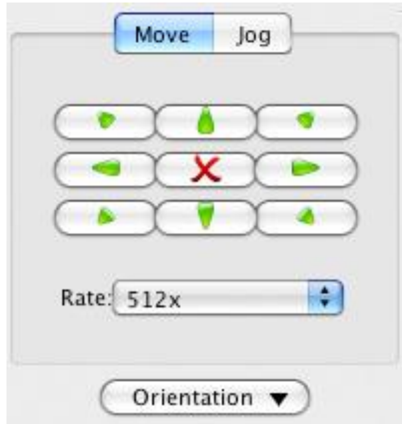


Figure 157: The Move tab on the Telescope window.

Bisque TCS

The *Paramount ME* and *Paramount MX Robotic Telescope Systems* (page 328) use the Bisque Telescope Control System (Bisque TCS) for dual axis motion control. The ***Bisque TCS*** command provides access to control system specific features. See the Paramount MX User Guide for details about this command.

Virtual Telescope

The ***Virtual Mount*** window simulates the orientation and motion of your mount, and can be especially helpful for remote operation. As the actual mount is commanded to slew, the virtual mount follows.

The current simulated mounts include:

- Astro-Physics Mach1 GTO
- Software Bisque Paramount ME
- Software Bisque Paramount MX

The simulated telescope on the simulated mount is a Newtonian optical tube assembly shown in Figure 158. We hope to add other simulated mounts and telescopes in future versions of *TheSkyX*.

Choose the ***Virtual Observatory*** command from the ***Tools*** pop-up on the ***Telescope*** window to show the ***Virtual Observatory*** window.

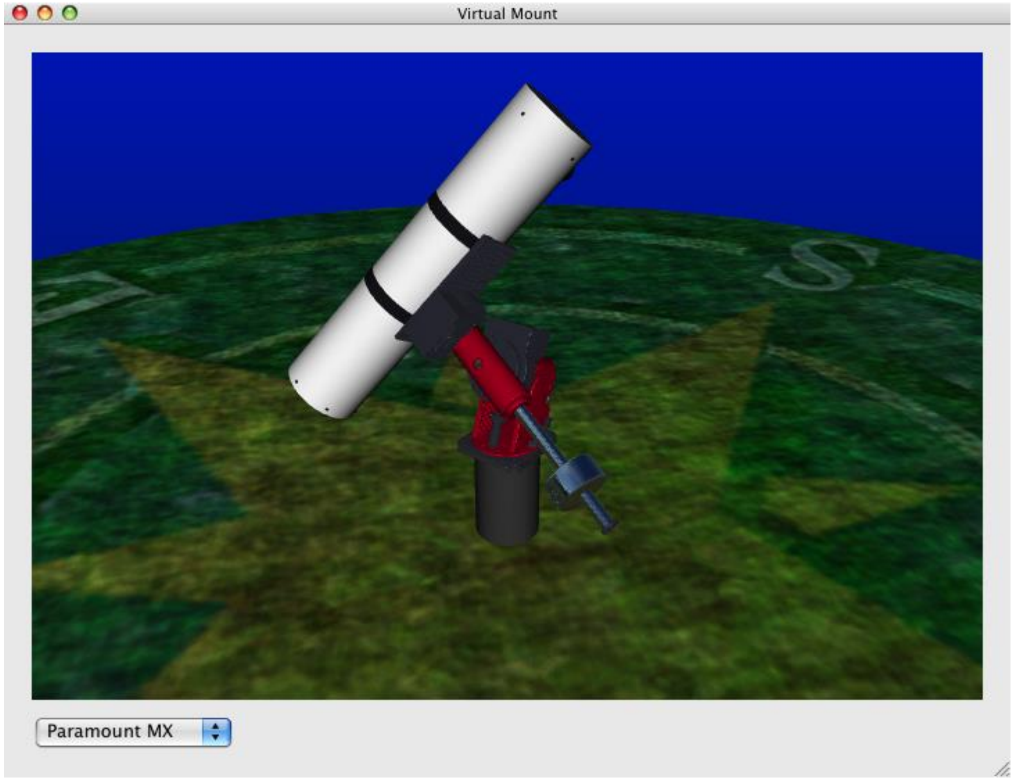


Figure 158: The Paramount MX in the Home Position.

Right-click and drag on the Virtual Mount window to change the point of view. Place the mouse cursor over this window and use the mouse scroll wheel to zoom in and out.

The pop-up menu on the bottom of the Virtual Mount window allows you to select the simulated telescope mount.

Move and Jog Controls

Use the controls on the ***Move*** and ***Jog*** tabs to manually slew or move, by discrete increments, the telescope.

Move Tab

Click and hold the ***Move*** arrow buttons on the ***Telescope*** window to direct the telescope in a specific direction. The ***Rate*** pop-up menu controls the speed of the slew. The ***Rate*** options in this list change depending on the currently selected mount.

The ***Move*** window offers eight different direction controls: north, east, south, west, and the "diagonal" directions in between. Diagonal direction buttons are hidden for mounts that do not support dual-axis moves.

Jog Tab

Use these arrow buttons to slew the telescope by the angular distance shown in the ***Distance*** list, and using and equatorial (***RA/Dec***) or horizon (***Azm/Alt***) coordinates.

Orientation Options

The direction a particular button moves the mount is configurable. This is useful, for example, when the optical tube on a German equatorial mount changes sides from East to West, the relative motion of the telescope in the right ascension axis is reversed. Changing the orientation for the right ascension axis makes the buttons work "as expected" for the opposite side of the mount.

- ***Normal*** sends the standard commands to the mount for moving in this direction.
- ***Swap Axes*** changes the left/right direction buttons to up/down, and up/down to left/right.
- ***Flip Left/Right*** swaps the left and right buttons. Left moves right, and right moves left.
- ***Flip Up/Down*** swaps the up and down buttons. Up moves down and down moves up.

Alice, welcome to Wonderland.

Shut Down Procedure

At the end of the night, you'll want to make sure to park the telescope so it will be in the correct orientation to close the observatory roof. Note that some telescope control systems do not have the ability to park the telescope. For these telescopes, *TheSkyX* uses a "built-in" park feature that slews the mount to the park position (a fixed altitude/azimuth coordinate) that you define and turns off the mount's sidereal tracking. When communication with the mount is established again, *TheSkyX* can unpark the mount and initialize the mount's control system.

Set Park Position

Use this command to specify the altitude and azimuth coordinates to slew the mount before parking. The current position of the telescope cross hairs is used as the park position.

Clear Park Position

Use this command to delete the previously defined park position. After clearing the park position, a new one must be defined with the ***Set Park Position*** command before the telescope can be parked.

Park

The Park command slews the telescope to the park position, and then turns the mount's sidereal tracking off (where possible).

Unpark

For mounts that do not support parking (see above), once parked, the ***Unpark*** command must be issued to end the "periodically rewind the mount's position because it is still tracking" loop.

Disconnect Telescope

Terminates communication with the mount, same selecting the Connect command from the Telescope menu when there is a connection. See "Linking To and Synchronizing the Telescope" for more information about this command.

Focuser

Controls the focus and focus speed of a pulse focuser that is connected to the telescope's focuser port. This feature is especially useful when viewing CCD images on a monitor while focusing.

Software Synchronization

Synchronizing (or "syncing" for short) a mount with *TheSkyX* initializes the mount's control system to an equatorial position on the celestial sphere. Mount synchronization may be performed using the mount's hand paddle, if one is available, or through *software synchronization*.

To synchronize a mount using TheSkyX:

1. For telescopes that employ an external hand paddle that can control the mount independently, make sure that *TheSkyX's* location, date, time, time zone and Daylight Saving Time settings (DSO) match the telescope's hand paddle settings. See "Entering Your Location" on page 31 for information about how to configure *TheSkyX* for your location on earth. See "Location, Date, Time" on page 290 for details how to use *TheSkyX* to configure the mount's site and time settings.

If your mount does not have a hand paddle, or the ***Location, Date, Time*** command is not available for your telescope, consult the owner's manual for your mount for details how to initialize the control system before using *TheSkyX* to control it.

2. From TheSkyX, manually center a known star in the telescope's eyepiece (or other detector) using the mount's hand controller or *TheSkyX's* telescope move control commands (see "Move and Jog Controls" on page 293).
3. Find or identify this star in *TheSkyX Professional Edition*. (See "Finding and Identifying Celestial Objects" on page 48).
4. Choose the ***Synchronize*** command from the ***Start Up*** pop-up menu on the ***Telescope*** window.
5. Click the ***Synchronize*** button.

The following procedure applies if your telescope can be synchronized through software like *TheSkyX*. Some control systems do not support software synchronization and must be configured to operate "standalone" first. If your telescope mount does not support software synchronization, following the manufacturer's initialization instructions now. *TheSkyX* can control the mount only after it has been initialized using the hand paddle.

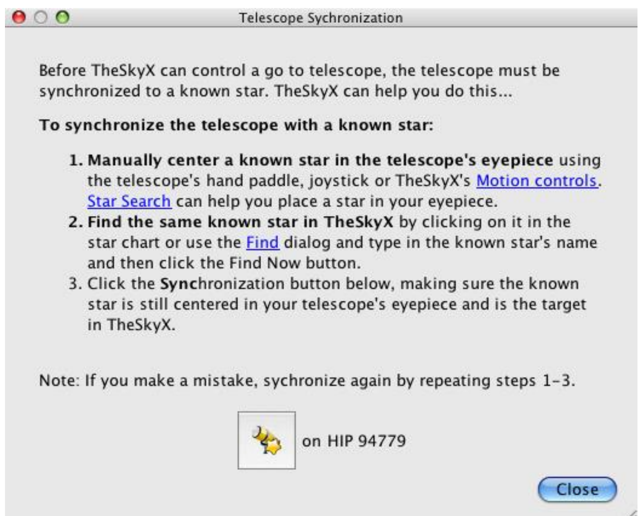


Figure 159: The Telescope Synchronization window (*Synchronize* command in the Start Up pop-up menu on the *Telescope* window).

1. Select the ***Connect*** command from the ***Telescope*** menu. Cross hairs appear on the Sky Chart, showing the position the telescope "thinks" it is pointing.
2. If you haven't set the telescope's time and coordinates, do so now (page 290). Use the ***Telescope*** window's ***Synchronize*** command in the ***Start Up*** pop-up menu to do so.
3. Position the center of the telescope's field on a known star. Don't use a planet, nebula, or galaxy. Star coordinates are more accurate, and a star is a true "point source."
4. Click on that star in the Sky Chart or use the Find command to locate it.
5. Select ***Synchronize*** command in the ***Start Up*** pop-up menu on the Telescope window.
6. On the ***Telescope Synchronization*** dialog, click the ***Sync*** button.

The Sky Chart's cross hairs should jump to and overlay the star that was used for synchronization, or be centered on the star used during the hand paddle initialization.
The telescope is now aligned on, or synchronized with, the target object and can be controlled by *TheSkyX*. See "Slewing to a Specific Object or Target" on page 298 to get started slewing the telescope.

A Faster Way to Synchronize

Use the ***Sync*** command to perform a synchronization on the current target object. This command bypasses the ***Synchronization*** dialog.

The ***Sync*** action should not be performed unless you are absolutely sure of the consequences.

- Once a permanently mounted Paramount-class mount is polar aligned and a working TPoint model established, further synchronization should not be necessary. A "bad" synchronization can cause the mount to lose its orientation with the celestial sphere.
- Telescopes that employ TPoint should only be synchronized before pointing calibration data is acquired. Subsequent observing sessions should recalibrate the model rather than re-synchronize the mount. See the *TPoint Add On User Guide* for more information about recalibration.
- If there is no TPoint model, then you may wish to "single-click" synchronize the mount multiple times during a single observing session to minimize pointing errors in a small area of the sky.

To add the ***Sync*** command to a toolbar:

1. On the ***Preferences*** window, click the ***Toolbars*** icon (page 164).
2. Click the ***Customize*** button to show the Customize Toolbars window.
3. Select the toolbar to add an action.
4. Select the ***Sync*** command from the ***Actions*** list, under ***All Other Commands***.
5. Click the right arrow to add this action to the selected toolbar.
6. Click ***OK***.
7. Click ***Close***.

The single-click ***Sync*** command is now accessible on the selected toolbar.

Image Link and Sync

If you are familiar with *TheSky6 Professional Edition*, you may have used the ***Image Link and Sync*** feature, where the coordinates of a photo determined by Image Link are used to synchronize the telescope. *TheSkyX Professional Edition* can do the same.

Synchronizing on an Image Linked Photo

1. Use the ***Image Link*** command to overlay a photo on the Sky Chart and determine its precise astrometric coordinates (page 243).
2. Click on the Sky Chart anywhere "inside" the boundaries of the linked photo. One of the ***Related Search Results*** on ***Details*** tab of the ***Find*** dialog is ***Linked Photo***.
3. Select the ***Linked Photo*** text to select it as the current target.
4. Synchronize the telescope on this target (page 295).

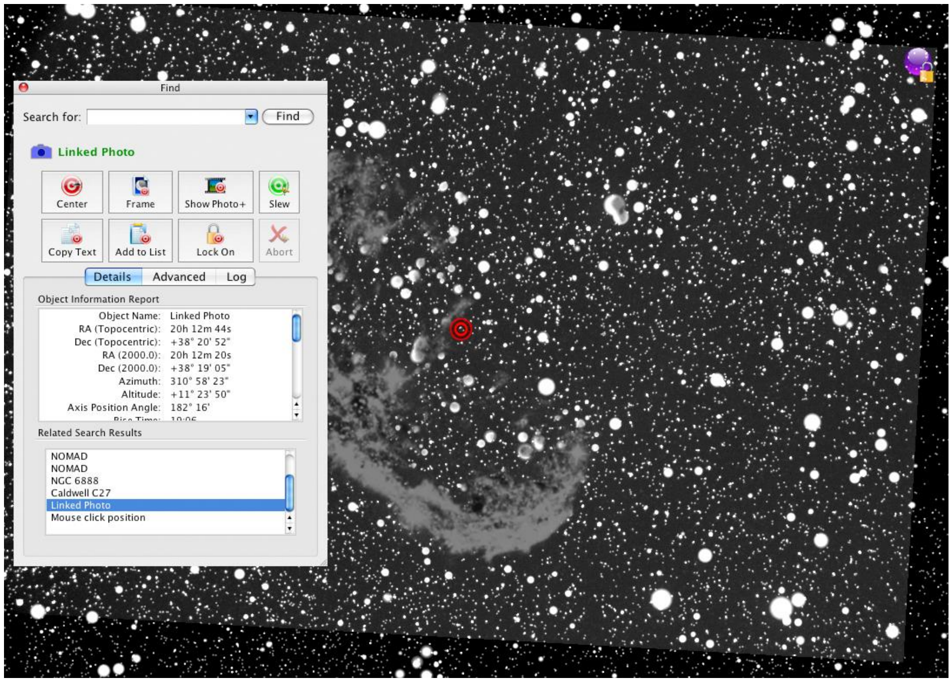


Figure 160: Clicking on an Image Link photo will display the *Linked Photo* in the Find dialog.

Slewing to a Specific Object or Target

1. Click on the object in the Sky Chart. If the desired object is not visible on the current chart, click the ***Find*** command from the ***Edit*** menu, enter the object's name (***Crab Nebula***, for example) or its catalog number (***M1***) into the ***Search For*** text input and click the ***Find*** button.
2. Click the ***Slew*** button. One is located on the ***Telescope***, ***Find*** and the ***Observing List*** windows and on the ***Telescope*** toolbar.

The ***Search For*** text input and ***Find*** button are also available on the ***Telescope*** window.

There's another way slew the telescope…

1. Right-click an object in the Sky Chart.
2. Select the ***Slew*** command from the Sky Chart's pop-up menu.

Slewing to a Specific Coordinate

Use the ***Slew To Coordinates*** command from the ***Tools*** menu on the ***Telescope*** window to display the ***Enter Coordinates*** tab of the ***Navigate*** window. From here, enter the right ascension, declination or azimuth, altitude coordinates, then click the ***Slew To RA/Dec*** or ***Slew To Az/Alt*** button, respectively.

Slewing to the Prior Target

Use the ***Slew Prior*** command to slew the telescope to the previous target. This command is not accessible on the ***Telescope*** window, but can be added as a button to any tool bar. See "Customizing Toolbars" on page 164 for details about adding buttons to toolbars.

Slewing to an Image Link Target

Closed Loop Slew

PROFESSIONAL

Imagine, while observing objects visually with your go to telescope, slewing the telescope to star cluster (the "target") in a different part of the sky. Chances are, the telescope's inherent pointing inaccuracies mean the cluster will not fall "dead center" in the eyepiece. At this point, you will most likely grab the telescope's hand paddle to manually find and center the object in the eyepiece before enjoying the view.

A *Closed Loop Slew* automates this target centering process using the astrometric position of a photo acquired with a camera, instead of the human eye. Image Link (page 243) replaces the observer's interaction with the telescope to automatically center target object. The result of a closed loop slew is that, using a single button click, a go to telescope with a camera attached can be slewed to any target, or equatorial coordinate, and the object will fall squarely in the center of the frame.

This feature can be used, for example, to precisely slew the telescope to a specific star so that it falls a spectrographic slit each night. Or, to precisely slew the mount to the center of a previously acquired photograph.

How does Closed Loop Slew work?

The Closed Loop Slew command incorporates automated telescope control, automated Image Links and automated camera control to ensure the target object is centered.

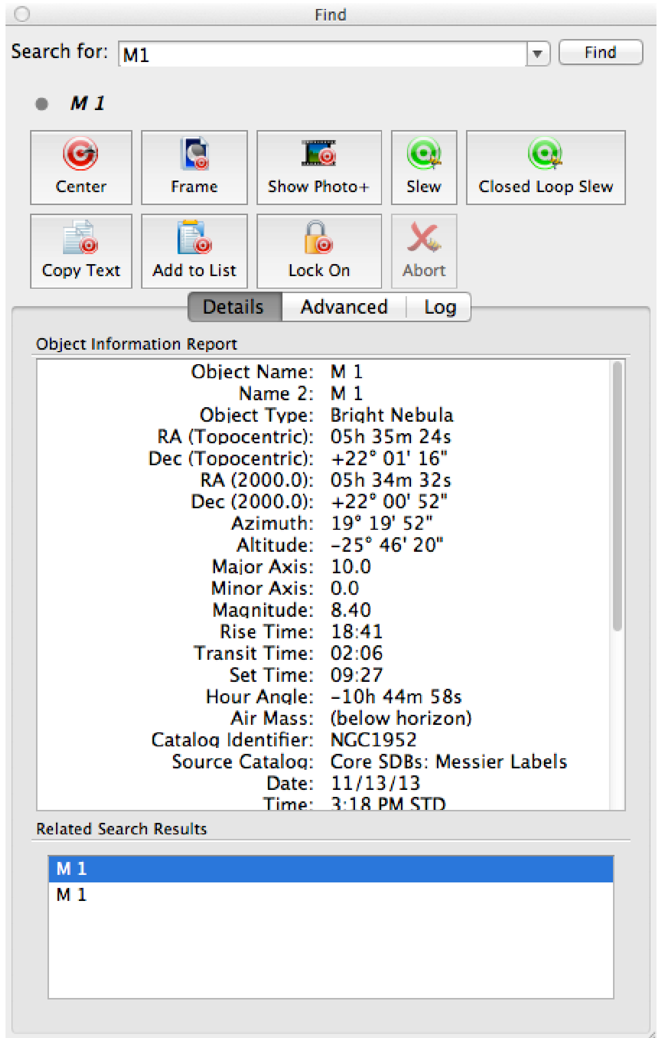


Figure 161: The Closed Loop Slew button on the Find window.

Figure 162 shows what happens “behind the scenes” when the ***Closed Loop Slew*** button is clicked.

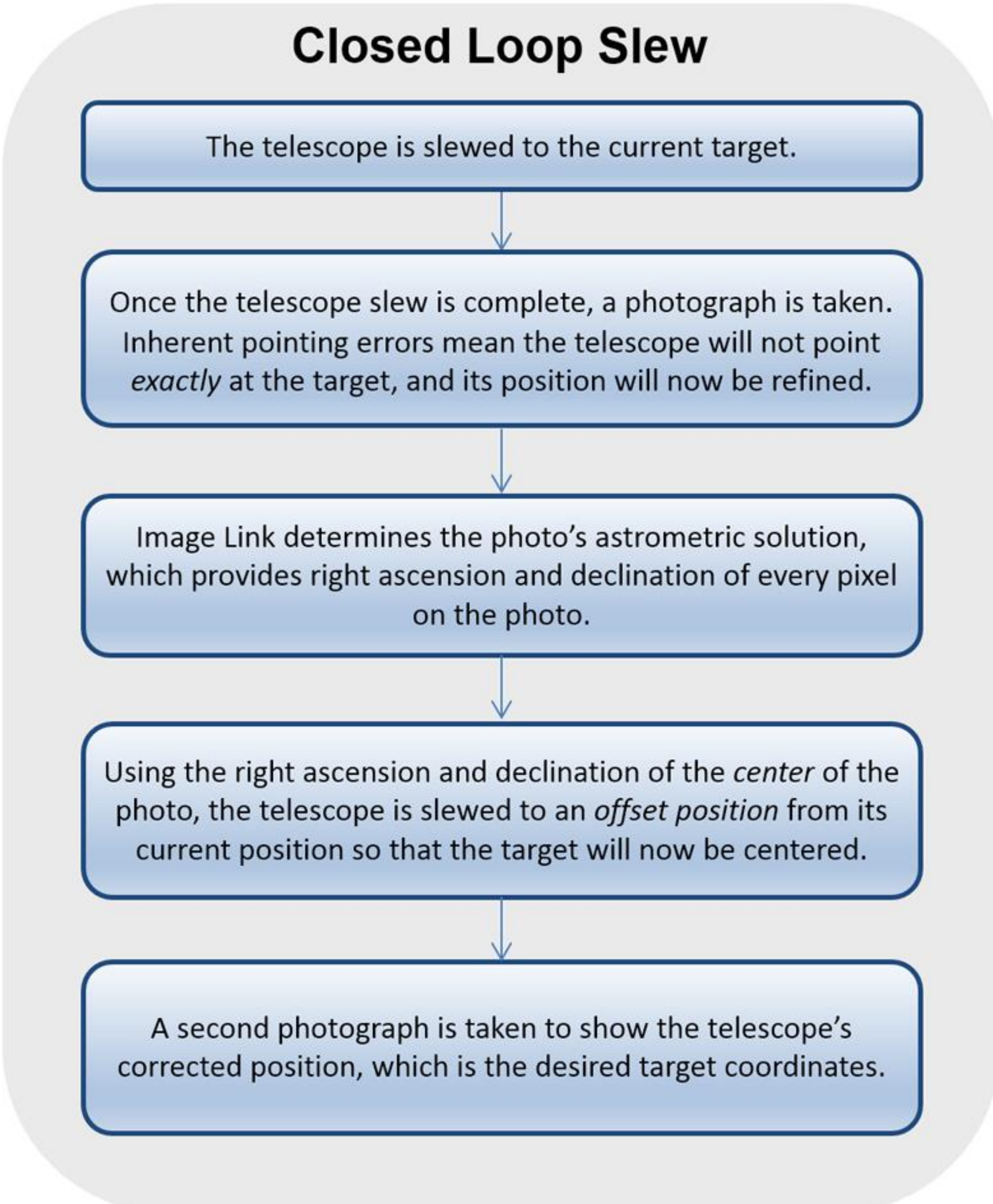


Figure 162: Flow chart showing each step of a Closed Loop Slew.

Acquiring multiple photos, and determining the astrometric solution *necessarily* requires more time than the typical "open loop slew", however, the result of a Closed Loop Slew means the target object should be centered on the photo to within a few arcseconds of the target's right ascension and declination coordinates.

Closed Loop Slew Setup

Use the ***Setup*** tab on the ***Automated Pointing Calibration Run*** window to configure the following Closed Loop Slew parameters:

- ***Exposure Time***

- ***Image Scale***
- ***Position Angle***
- ***Search Area***
- ***Retries Near Each Target***
- ***Source Extraction Setup***

The ***Automated Pointing Run*** window can be viewed by clicking the ***TPoint Add On*** command from the ***Telescope*** menu, then clicking the ***Automated Calibration*** button on the ***Calibration Run*** tab.

All other camera-specific settings used when acquire photos from the imaging camera during a Closed Loop Slew (including bin mode, image calibration, etc.) can be configured from the ***Camera*** tab (page 340). Closed Loop Slews *do not* use the autoguider settings.

When the camera's binning (page 352) is changed, the value of the ***Image Scale*** on the Automated Pointing Calibration Run window must be changed accordingly.

For example, if the image scale produced by the optical system at 1x1 binning is 1 arcsecond per pixel, and the binning is changed to 2x2, then the value in the ***Image Scale*** text box must be changed to 2 arcseconds per pixel. Failure to do so will cause the Closed Loop Slew's Image Link to fail.

Performing a Closed Loop Slew

Once *TheSkyX Professional Edition* has been configured for your mount (page 282) and imaging camera (page 347), click the ***Closed Loop Slew*** button to connect to the mount and the camera, then slew to the telescope to the target (using the Closed Loop Slew process described above).

Tracking Spacecraft

TheSkyX Professional Edition can slew the telescope to, and track spacecraft. The first step is to locate the satellite to track (by clicking its symbol on the Sky Chart or using the ***Find*** command), then click the ***Track Satellites*** button on the ***Telescope*** window (which is otherwise hidden). If the satellite is currently above the horizon, mount is slewed to intercept the satellite's path, then the mount's tracking rates are set to match satellite's rates. If the satellite is currently below the horizon, *TheSkyX* waits until it is visible (specifically, above the local horizon) then begins the *slew to and track satellite* process.

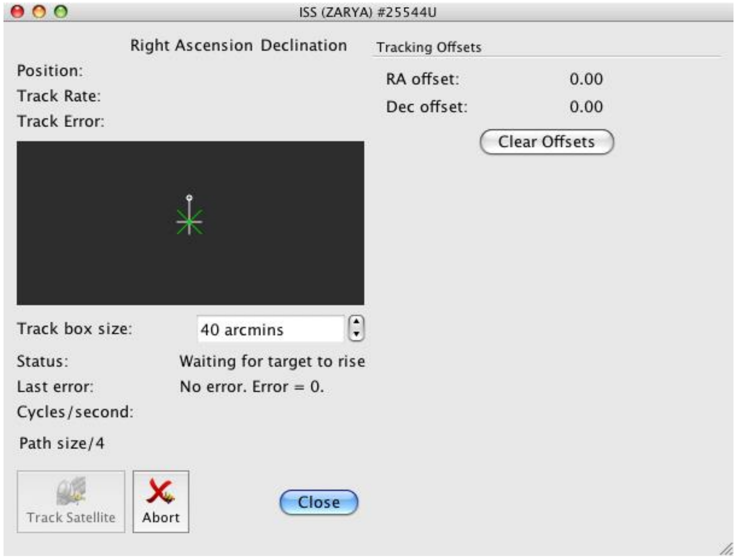


Figure 163: The Track Satellite window while waiting for the satellite to rise.

Figure 163 shows the ***Track Satellite*** window while waiting for the satellite to rise. (See the ***Status*** message.)

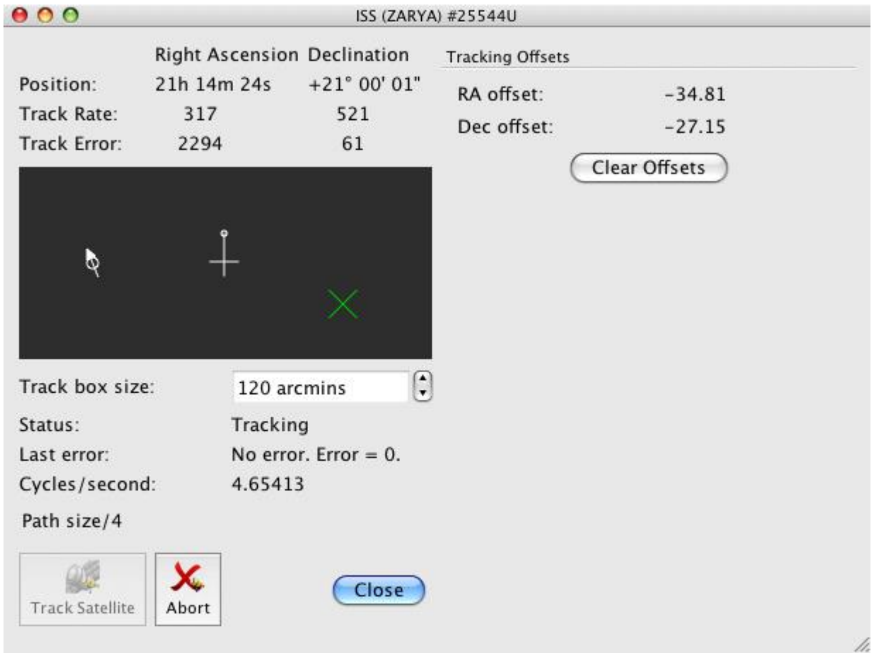


Figure 164: Tracking initiated, but not yet "stable".

When then satellite appears above the *theoretical* local horizon, the mount slews to the satellite and begins tracking it. The satellite's ***Position***, relative ***Track Rate*** and ***Track Error*** in ***Right Ascension*** and ***Declination*** are displayed at the top of the window.

The black region represents the background sky. The white circle represents the satellite, the white arrow drawn through this circle shows the magnitude of the satellite's tracking rate and its current trajectory. The gray cross hairs show the center of the field. The green X represents the current ***Tracking Offset*** that is applied to the mount's position.

Optimal tracking is achieved when satellite is centered in the field. Mechanical errors and uncertainty in the satellite two-line elements may cause the satellite to fall away from the center. To adjust the position of the satellite, click in the black region away from the satellite's current position. The green X shows this new offset, and, when the correct offset is applied, the satellite will slowly move to the center of the field.

A larger number in the ***Track Box Size*** text box allows a larger maximum tracking offset. Click the ***Clear Offsets*** button to set the offset to zero in each axis.

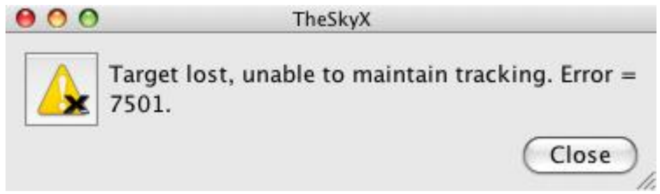


Figure 165: This message appears when the satellite can no longer be tracked.

Satellite Tracking Add On Controls

Each control on the Satellite Tracking window is described below.

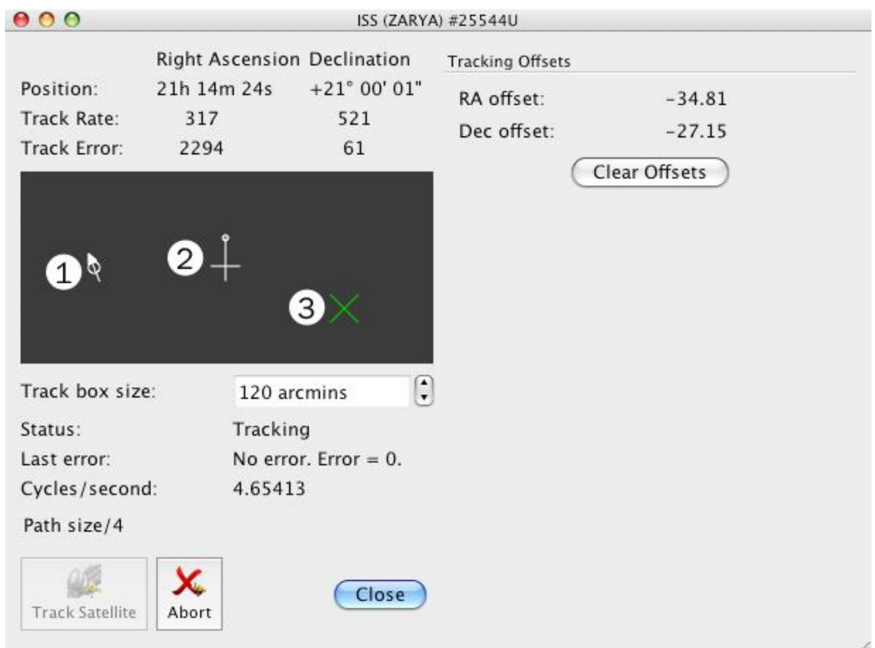


Figure 166: The Satellite Tracking window's graphical controls.

Figure 166 shows numbers next to each graphical element, and each is described below:

1. The white arrow shows the relative position of the satellite in the field of view and points in the direction of the satellite's motion.
2. Click and drag the small circle at the end of the cross in the center of the graphic to rotate the field (so that the satellite path can be oriented to match the video or detector).

3. Click anywhere inside the black region (which represents a "satellite tracking field of view" or track box) to apply an offset to the telescope's current tracking position, which is represented by a large green "X".

Advanced satellite tracking capabilities for Paramount-class mounts are available in the optional *Advanced Satellite Tracking Add On*; contact Software Bisque for details.

Position (RA/Dec)

Shows the right ascension and declination coordinates of the telescope.

Track Rate (RA/Dec)

Shows an internal tracking rate for the satellite.

Track Error (RA/Dec)

Shows the magnitude of the tracking error in each axis. The minimum "acceptable" average tracking error that is allows to start tracking can be configured from the ***Satellite Tracking*** options in the ***Advanced*** preferences window (page 185).

Tracking Offsets (RA/Dec)

Shows the offsets in right ascension and declination, in arcminutes that are applied to the satellite's position during tracking. The offset is represented by the green X graphic. To change the offset, click the mouse within the black region.

Clear Offsets

Click this button to set the tracking offsets to zero.

Track Box Size

Enter the relative size of the satellite tracking box. The size of the track box can be adjusted to match the field of view of the optical system. The track box size can be up to two (2) arcminutes, so that relatively large "position offsets" to the telescope's current track position can be introduced by clicking on the track box graphic.

Status Message (Status Text Box)

Shows the current state of satellite tracking.

- ***Idle*** – No satellite tracking.
- ***Begin*** – TheSkyX has initiated satellite tracking.
- ***Start Slew*** – Telescope slewing is about to start.
- ***Waiting for Target to Rise*** – *TheSkyX* is monitoring the satellites position, and will begin tracking when it rises.
- ***Slewing to Target*** – Telescope is being slewed to the satellite.
- ***Settling*** – The position of the telescope is being adjusted to match the satellite's position.
- ***Tracking*** – The mount is successfully tracking the satellite.

Last Error Message (Last Error Text Box)

Shows the most recent error message to occur.

Update Frequency (Cycles Per Second)

Shows the frequency at which the satellite's position is being updated.

Track Satellite Button

Click this button to start tracking the selected satellite.

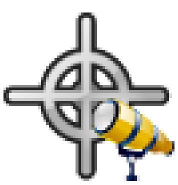
Abort Button

Click this button to stop tracking the satellite.

Satellite Tracking Notes:

- *TheSkyX Professional Edition* does not use a "leap frog" or "successive slews" method to track satellites. Instead, *TheSkyX* sets the mount's *tracking rate* in both RA and Dec to match the current satellites current tracking rate.
- Many commercial mounts do not allow tracking rates to be configured in both RA and Dec axis, so these mounts cannot be used to track satellites with *TheSkyX*.
- For mounts that can set dual axis tracking rates, many still do not have the required dynamic range to track very slow or very fast moving satellites. Trying to use a mount that does not have configurable tracking rates from zero to several degrees per second may not result in satisfactory results.
- *TheSkyX Professional Edition's* satellite tracking has been optimized for, and extensively tested with both the Paramount ME and Paramount MX mounts and works quite well to accomplish this task. The Paramount control system allows tracking rates to be configured for both the RA and Dec axes and can track virtually any satellite (or any object that tracks at any rate from 0.0 arcseconds per second up to several degrees per second).

Center Cross Hairs



Click this button to center the telescope cross hairs on the Sky Chart.

Set Track Rates

Solar system objects, including the Sun, Moon, planets, comets and asteroids each move at rates that can vary greatly compared to sidereal rate.

- Important Note: In order to track objects at non-sidereal rates using *TheSkyX*, the mount's control system must be able to set tracking rates for both the right ascension axis and declination axis based on the computed rates of the object.
- See "Tracking " on page 302 for details about tracking satellites with *TheSkyX*. Many commercial mounts either cannot set the tracking rates in both axes, or do not have sufficient dynamic range to track relatively slow moving or relatively fast moving objects.

To configure the mount to track at the non-sidereal rate for one of these objects:

1. Locate the object on the Sky Chart (using either the ***Find*** command or by clicking the object on the Sky Chart).
2. Click the ***Slew*** button to slew the telescope to the object. This step is optional, but, if the object is a "faster mover", it's better to position the telescope close to its current position first.
3. Click the ***Set Track Rates*** button on the ***Telescope*** window. The ***Confirm Set Track Rate*** dialog shows the current right ascension and declination rates for the selected target, in arcseconds/second.

Figure 167: The Confirm Set Track Rate for solar system objects.

Clicking the ***Yes*** button sets the mount's right ascension and declination tracking rates.

Important Note

Slewing to a star automatically resets the right ascension's axis to the sidereal rate and sets the declination rate to 0.0.

Figure 168: Set tracking rate to the sidereal rate.

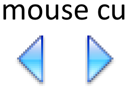
Clicking the ***Set Track Rate*** button when the target object is a star shows 0.0 for both the right ascension and declination tracking rates, which, although perhaps confusing, is *TheSkyX's* convention. The right ascension tracking rate is *relative to the sidereal rate*, so, setting a tracking rate of 0.0 in right ascension means "track at the sidereal rate". As expected, the declination axis' tracking rate is set to 0.0.

Add Pointing Sample

Click this button to add a TPoint Add On pointing calibration sample to calibration data. See "TPoint Add On" on page 286 for details about telescope modeling using the *TPoint Add On* software.

Search for Targets

Enter the name of a target object into the ***Search For*** text box then click the ***Find*** button. Or, click the mouse on the Sky Chart to select the target. If there is more than one object near the mouse cursor, click the forward or backward buttons to scroll through them.



Using the Telescope Simulator

The telescope simulator allows you to simulate the process of connecting to, synchronizing and slewing a go to telescope without actually connecting to any hardware. This can be useful to become familiar with how to operate a telescope from *TheSkyX* or practice an observing session during daylight.

1. Select the ***Telescope Setup*** command from the ***Telescope*** menu.
2. In the Telescope Setup dialog, click the ***Select Mount*** button.
3. Choose Telescope Mount Simulator option from the Simulator list.

4. Click ***OK***.
5. Click the ***Connect*** button on the Telescope Setup dialog to establish a virtual connection to the simulated telescope mount.

Terminating the Telescope Link

Select the ***Connect*** command ***Telescope*** menu to end the session.

Using the Telescope Simulator

The telescope simulator allows you to simulate the process of connecting to, synchronizing and slewing a go to telescope without actually connecting to any hardware. This can be useful to become familiar with how to operate a telescope from *TheSkyX* or practice an observing session during daylight.

1. Select the ***Telescope Setup*** command from the ***Telescope*** menu.
2. In the Telescope Setup dialog, click the ***Select Mount*** button.
3. Choose Telescope Mount Simulator option from the Simulator list.
4. Click ***OK***.
5. Click the ***Connect*** button on the Telescope Setup dialog to establish a virtual connection to the simulated telescope mount.

Digital Setting Circles

TheSkyX's Digital Settings Circles window displays a status report that contains, for example, the telescope's RA/Dec coordinates. The text size is also configurable so that it can be more easily read at a distance.

This feature is available with both encoder-based systems and telescopes having full computer control.

To use it, select the ***Digital Setting Circles*** command from the ***Telescope*** menu.

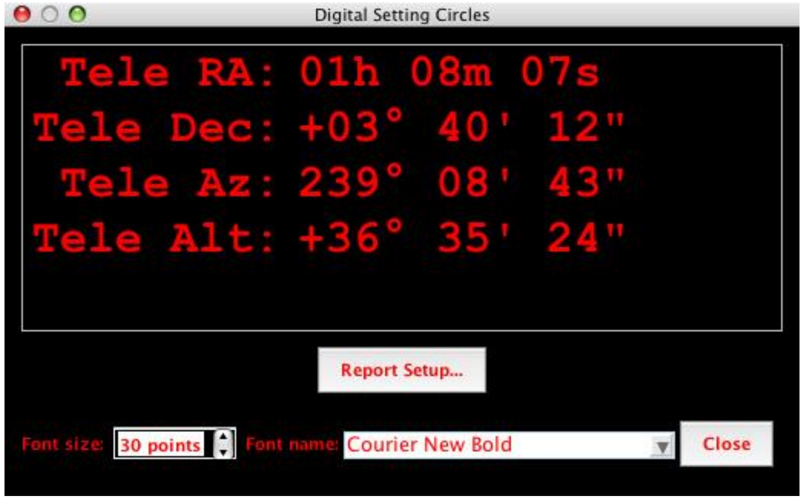


Figure 169: Digital Setting Circles window.

Configuring the Digital Settings Circles Report (Report Setup button)

By default, the report shows universal time (UT) and local sidereal time (LST). Click the Report Setup button to show the Digital Setting Circles report in the Preference dialog.

Select the attributes you wish to display in the report, and then click Close.

Telescope Troubleshooting

Physically connecting a hardware device to computer software is not always a simple task. Things can, and often do, go wrong. Below is a checklist of items to consider before contacting the Software Bisque support desk.

- Both the software and the hardware must be correctly configured. Communication ports, cables, connectors and telescope control systems all must be plugged in, turned on, connected properly using the correct telescope interface cable and initialized before attempting to be "linked" to the computer.
- Connection cables must be wired correctly. *TheSkyX* uses "bi-directional" serial communication with most devices. This means that the connecting cable must be wired properly to send *and* receive commands. You can verify that a serial cable is functioning by measuring resistance between pins 2, 3 and 5 on each end of the telescope cable.
- The communication port must be operational. If you are using a USB to serial adaptor, make sure that you have the latest software drivers installed for the device.
- The proper telescope firmware (that is, the software that is run by the telescope's control system) must be correct before *TheSkyX* can control the telescope. Contact the manufacturer to obtain firmware updates.

Astro-Physics GTO German Equatorial Mounts

Figure 170: Astro-Physics GEM (© Astro-Physics)

AP GTO Minimum System Requirements

TheSkyX can control any mount that employs the Astro-Physics GTO control system running firmware version G or later (including the GTOCP1, GTOCP2 and GTOCP3). If you have an older version of the firmware, contact Astro-Physics for details about upgrading. *TheSkyX* will successfully connect to and control earlier firmware versions (for example, Software Bisque has successfully tested *TheSkyX* using the GTO model controller with firmware version D from May 2001 with the GTO model controller). However, we *strongly recommend* using the latest firmware version.

Hardware Requirements

- Astro-Physics GTO German Equatorial control system with firmware G or later.
- A standard RS232 serial cable. Serial cables can be purchased from most any computer store.
- A USB to serial adaptor.

Step-by-Step AP GTO Setup Procedure

1. Using a standard DB9 M/F RS232 serial cable, connect the male end of the cable to the port labeled COM1 on the GTO Control Panel and the female end to the USB to serial adaptor.
2. Click the ***Telescope Setup*** command from the ***Telescope*** menu.
3. Select ***Mount*** in the ***Imaging System*** list on the left side of the ***Imaging System Setup*** window.
4. On the ***Choose Mount*** window, select your model telescope and click ***OK***. If the *exact* model of your telescope is not listed, don't worry; just select a similar model telescope. The underlying serial communication protocol is the same for similar models.

5. Click the ***Settings*** command on the ***Mount Setup*** pop-up menu and then select the correct ***COM*** port (Windows) or the correct ***Serial Device*** (Mac).
6. On the ***Imaging System Setup*** window, turn on the desired preferences and then click ***Close***.
7. Select the ***Connect*** command from the ***Telescope*** menu.

The telescope cross hair will now display the current coordinates of the telescope. If the mount has not been parked, or has not been initialized with the location, date and time from another application, the coordinates of the telescope will be RA: 0h 0' 0" Dec: 90° 0' 0".

AP mounts are automatically initialized using *TheSkyX's* time, date, location and Daylight Saving Time adjusted time zone, the mount's tracking is started, and the control system is configured to use the more accurate long format mode when sending and receiving equatorial coordinates to and from the mount.

Synchronization vs. Recalibration

Synchronizing a GEM when the telescope is pointing to a position in the sky that is on the same side of the pier as the telescope (for example, when the telescope is on the east side of the pier and is pointing to a star on the east side of the meridian) can result in unexpected behavior and possibly damage your equipment. Please carefully read the most recent version of the Astro-Physics Keypad Manual for details how to use synchronization and recalibration.

The Astro-Physics command protocol provides two different methods that planetarium software like *TheSkyX* can use to initialize the mount's control system.

- The Calibrate mount or Sync command (*:CM#* is sent to the control system) defines both the equatorial coordinates of the telescope and on which "side of the pier" the optical tube assembly resides.

  The normal or expected orientation of a GEM is when the optical tube assembly is on one side of the pier (for example, the east side of the pier) and points to a position on the ***opposite*** side of the pier (in the west). Always make sure the mount is this normal orientation before using the synchronization command.

  If you are unsure about which side of the pier the control system "thinks" the telescope is on, click the ***Get Current Settings*** button under ***Hand Paddle Status*** on the ***Miscellaneous*** tab of the ***Astro-Physics*** window.

- The Re-calibrate or Re-Cal command (*:CMR#* is sent to the control system) is used to update the control system with the telescope's current position only, and does not define the telescope's side of pier. Astro-Physics highly recommends using the command instead of using the Synchronization command.

When Astro-Physics mounts are controlled by *TheSkyX*, by default, *TheSkyX* uses the Astro-Physics command protocol's Recalibration command instead of the Calibration command. See page 295 for details about *TheSkyX's* telescope ***Synchronization*** command.

If you need to use the Astro-Physics Calibrate command to initialize the telescope's position and side of pier information, turn off the ***Convert Sync to Re-Cal (highly recommended)*** checkbox on the Astro-Physics window. Don't forget to turn this checkbox back on once the calibration has been performed.

Astro-Physics GTO Control System Notes

- *TheSkyX* always places the Astro-Physics control system into the "long format" mode upon establishing a link.
- Click the ***Location, Date, Time*** command from the ***Tools*** pop-up menu on the ***Telescope Setup*** window (***Display*** menu) to compare *TheSkyX's* date, time, latitude, longitude and time zone settings to the mount. Click the ***>>*** button to reset the AP GTO's values to match *TheSkyX's*.

Astro-Physics Specific Commands

Select the ***Astro-Physics Specific*** command from the ***Display*** menu to show commands that are specific to this control system. This command is only available when an Astro-Physics model mount is selected ***Telescope > Telescope Setup*** window.

Figure 171: The Astro-Physics Specific window (Display menu).

Most of the AP-specific commands are self-explanatory. Details about each command can be found in AP RS-232 Command Language document which is available from Astro-Physics web site.

Convert Sync to Re-Cal (Highly Recommended)

When this checkbox is turned on (and is by default), the Astro-Physics Re-Cal command is used in place of the Astro-Physics Calibrate command whenever a telescope ***Synchronize*** command (page 295) is issued by *TheSkyX*. Turn this checkbox off to use the Astro-Physics Calibrate command instead of the Re-Cal command.

The Communications Log (page 289) can be used to verify that *TheSkyX* is sending the appropriate commands to the mount.

Celestron and NexStar-Compatible Mounts

Figure 172: The Celestron C11-SGT (XLT) Computerized Telescope (NexStar-compatible). © Celestron International.

TheSkyX controls most NexStar-compatible telescopes manufactured by Celestron International, including:

- Celestron™ Advanced Series (all models)
- Celestron™ NexStar (all models)
- Celestron™ CG Series (all models)
- Celestron™ CGE Series (all models)
- Celestron™ CPS Series (all models)
- Celestron™ GT Series (all models)
- Celestron™ SLT Series (all models)
- Celestron™ NexStar i Series (all models)

The NexStar control system is also used on telescopes from other manufacturers, including:

- Orion Telescopes and Binoculars go to telescopes
- Sky-Watcher SkyScan go to telescopes
- Tasco go to telescopes

Celestron Minimum System Requirements

TheSkyX can control telescopes that employ the NexStar control system using firmware version 1.6 and later and motor controller version 4.2 or later. If you have an older version of the firmware, contact the manufacturer for details about upgrading.

NexStar-Compatible Telescope Hardware Requirements

- A NexStar-compatible telescope.
- A NexStar Telescope Interface Cable. This cable can be purchased from Software Bisque, or the manufacturer.
- A USB to serial adaptor.

Important Notes

- The NexStar firmware version 1.6 and later, and motor controller version 4.2 and later are required to support high precision (24-bit) slewing and variable tracking rates.

To determine the NexStar firmware version for your mount, when the hand paddle LED reads **NexStar GPS**, press the **Menu** button, then press the button labeled UP or DOWN (6 key or 9 key) until the **Utilities** menu appears. Press the UP or DOWN arrows on the keypad until the **Version** option appears, then press the **Enter** button. The versions for different firmware components are listed in the following order: hand controller, motor controller version for each axis, GPS version and then the bus control version.

Contact Celestron International for details about obtaining updated firmware for your NexStar.

- NexStar GT Series telescopes using firmware version 1.6 and earlier and motor controller version 4.2 and earlier must use the ***Ultima 2000*** model mount.
- The NexStar command protocol version 4.1 or later supports software synchronization (that is, the telescope's position can be defined by external software like *TheSkyX*). See page 295 for details about synchronizing your mount with *TheSkyX*.

TheSkyX does not require third-party software, such as Celestron’s NexRemote application, or virtual serial port drivers, to control NexStar mounts.

Step-by-Step NexStar Setup Procedure

1. Turn off both the computer and the telescope (always a good idea when connecting devices).
2. Connect the telescope interface cable to the serial port of the computer and the hand paddle of the NexStar (RJ22 end connector).
3. After the telescope interface cable is plugged into the NexStar’s hand paddle and into the USB to serial adaptor, turn both the computer and the telescope on (the order does not matter).
4. Click the ***Telescope Setup*** command from the ***Telescope*** menu.
5. Select ***Mount*** in the ***Imaging System*** list on the left side of the ***Imaging System Setup*** window.

6. On the ***Choose Mount*** window, select your model telescope and click ***OK***. If the *exact* model of your telescope is not listed, don't worry; just select a similar model telescope. The underlying serial communication protocol is the same for similar models.
7. Click the ***Settings*** command on the ***Mount Setup*** pop-up menu and then select the correct ***COM*** port (Windows) or the correct ***Serial Device*** (Mac).
8. On the ***Imaging System Setup*** window, turn on the desired preferences and then click ***Close***.
9. Select the ***Connect*** command from the ***Telescope*** menu.
10. Click the ***Synchronize*** command on the ***Start Up*** pop-up menu (page 295), then follow the on-screen instructions to complete the initialization.

The telescope cross hairs show the current position of the telescope should appear on the Sky Chart.

For NexStar models 4, 5, 8 (non GPS), 60, 80 and 114

Before connecting *TheSkyX* to the NexStar models 4, 5, 8 (non GPS), 60, 80 and 114, make sure that the hand paddle is in the ***RS 232 mode***. That is, the NexStar hand paddle must display the text ***RS-232*** on the top line, and ***Undo to Exit*** on the bottom line, ***at all times*** so that the hardware's serial port is operational; otherwise a connection cannot be established to the device through software. If the hand paddle does not remain in ***RS232*** mode at all times, *TheSkyX* will not be able to communicate with the telescope.

NexStar/TheSkyX Communication Notes

- Make sure so set the correct Daylight Saving Time setting on the NexStar hand paddle, otherwise *TheSkyX's* positions for solar system object, and object rise/set times, will differ from the NexStar hand paddle's values by one hour.
- The NexStar models 4, 5, 8 (non GPS), 60, 80 and 114 hand paddle must be in ***RS232*** mode in order to communicate with *TheSkyX*.
- The NexStar models 4, 5, 8 (non GPS), 60, 80 and 114 must be initialized and aligned in order to communicate with *TheSkyX*.
- The NexStar models 8 GPS and 11 GPS hand paddle *does not need to be in any particular menu* in order to communicate with *TheSkyX*.
- The NexStar firmware version 1.6 and later supports Motion Control buttons.
- The NexStar firmware version 1.6 and later has built-in slew limits. If a slew from *TheSkyX* fails, check the LED readout from the hand paddle to make sure these limits have not been exceeded.

Gemini Astronomical Positioning System

Figure 173: The Losmandy Gemini astronomical positioning system. © Losmandy Instruments.

Gemini Minimum System Requirements

TheSkyX can control any mount that employs the Gemini Astronomical Positioning System firmware version 1.05 or later. If you have an older version of the firmware, contact the manufacturer for details about upgrading.

Hardware Requirements

- Gemini Astronomical Positioning System with firmware version 1.05 or later.
- A Gemini telescope cable. (Contact Losmandy Instruments to purchase this cable.)
- A USB to serial adaptor.

Step-by-Step Gemini Setup Procedure

1. Using the Gemini telescope serial cable, plug the male RJ22 end of the cable into the port labeled RS-232 on the Gemini controller and the female end to the USB to serial adaptor.
2. Click the ***Telescope Setup*** command from the ***Telescope*** menu.
3. Select ***Mount*** in the ***Imaging System*** list on the left side of the ***Imaging System Setup*** window.
4. On the ***Choose Mount*** window, select your model telescope and click ***OK***. If the *exact* model of your telescope is not listed, don't worry; just select a similar model telescope. The underlying serial communication protocol is the same for similar models.
5. Click the ***Settings*** command on the ***Mount Setup*** pop-up menu and then select the correct ***COM*** port (Windows) or the correct ***Serial Device*** (Mac).
6. On the ***Telescope Setup*** window, turn on the desired preferences and then click ***Close***.
7. Select the ***Connect*** command from the ***Telescope*** menu.

8. If the telescope has not been initialized, click ***Tools > Locate, Date, Time*** command on the ***Telescope*** window (***Display*** menu). This window shows *TheSkyX's* settings, and the Gemini's. Click the ***>>*** button to set the Gemini's values to *TheSkyX's*.
9. Click the ***Synchronize*** command on the ***Start Up*** pop-up menu (page 295), then follow the on-screen instructions to complete the initialization.

The Gemini should now be initialized and ready to use.

Gemini Specific Commands

Select the ***Gemini Specific*** command from the ***Display*** menu to show commands that are specific to this control system.

Note that this command is only available when the ***Gemini*** is selected in the Mount pop-up menu on the ***Telescope > Setup*** window.

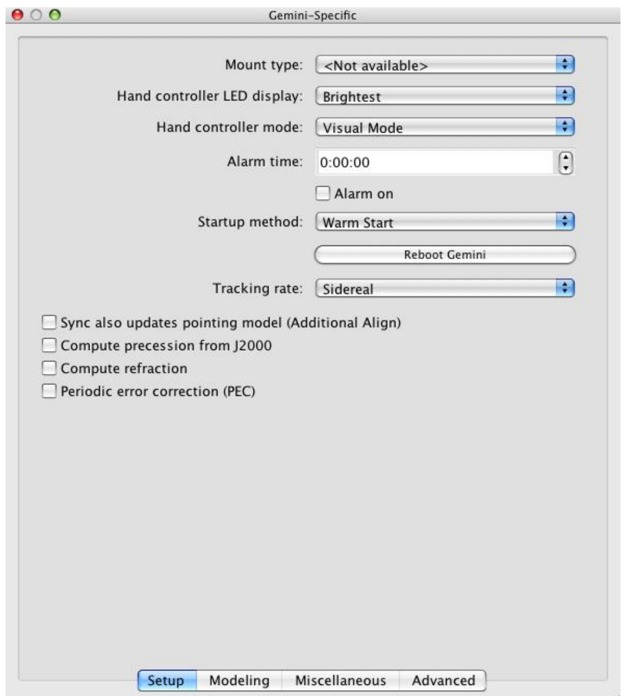


Figure 174: The Gemini Specific window (Display menu).

Details about the Gemini-specific commands can be found in Gemini User Manual; this document is available on the Losmandy web site (http://www.losmandy.com).

iOptron Mounts

Figure 175: The iOptron SmartStar™-E Go To Alt/Az mount ("The Cube"). © iOptron.

iOptron Minimum System Requirements

TheSkyX can control iOptron SmartStar model altitude/azimuth and equatorial mounts.

iOptron Hardware Requirements

- An iOptron SmartStar mount using the GOTONova 8401 or 8402 controller.
- A standard USB cable (supplied with the mount).
- A Mac or Windows computer running TheSkyX Professional Edition or TheSkyX Serious Astronomer Edition.

iOptron Software Driver Requirements

- An operating system-specific *Virtual Serial Port Driver* must be installed before *TheSkyX* can communicate with this mount. The SmartStar uses the Silicon Labs CP210X USB to UART Bridge computer chip for serial communications, and the driver can be downloaded from the Silicon Laboratories' web site:

The URL of Silicon Labs web site is:
http://www.silabs.com.

The USB to UART Bridge product page (and drivers) is:
http://www.silabs.com/products/interface/usbtouart/Pages/usb-to-uart-bridge.aspx

On the above web page, click the ***Tools*** tab to view the VCP driver installers for this product.

Operating System	Installer Name	Description
	Mac_OSX_VCP_Driver.zip	CP210x VCP Mac OSX Drivers
	CP210x_VCP_Win_XP_S2K3_Vista_7.exe	CP210x VCP Win XP S2K3 Vista 7

Download and run the above installer for your operating system to install the VCP driver.

iOptron Firmware Version 1.00 Notes

The iOptron firmware used to develop *TheSkyX's* driver contained significant limitations that prevent the mount from being initialized by *TheSkyX*; slews cancelled by *TheSkyX* also report errors. (Representatives from iOptron indicate that these issues will be addressed in future firmware updates.) Make sure to setup the iOptron to run standalone before attempting to control it using *TheSkyX*.

Step-by-Step iOptron Setup Procedure

1. Install the virtual serial port drivers for the iOptron for your operating system (see iOptron Software Driver Requirements on page 320).
2. From *TheSkyX*, click the ***Telescope Setup*** command from the ***Telescope*** menu.
3. Select ***Mount*** in the ***Imaging System*** list on the left side of the ***Imaging System Setup*** window.
4. Click the ***Choose*** command in the ***Mount Setup*** pop-up menu.
5. On the ***Choose Mount*** window, select your model telescope and click ***OK***. If the *exact* model of your telescope is not listed, don't worry; just select a similar model telescope. The underlying communication protocol is usually the same for similar models.
6. Click the ***Settings*** command on the ***Mount Setup*** pop-up menu and then select the correct ***COM*** port (Windows) or the correct ***Serial Device*** (Mac).
7. On the ***Telescope Setup*** window, turn on the desired preferences and then click ***Close***.
8. Select the ***Connect*** command from the ***Telescope*** menu.
9. Click the ***Synchronize*** command (page 295) on the ***Start Up*** pop-up menu, then follow the on-screen instructions to complete the initialization.

The iOptron should now be initialized and ready to use.

Meade Instruments Mounts

Figure 176: The Meade Autostar ETX-90PE telescope. © Meade Instruments.

Meade Mount Minimum System Requirements

TheSkyX can control LX200 Classic, Autostar, Autostar II, Autostar III and Autostar-compatible mounts, including the RCX400 series and telescopes that use the LX200 protocol (including the Vixen SkySensor 2000).

LX200 Classic Hardware Requirements

- LX200 “classic” model by Meade Instruments Corporation telescope (or a control system that uses the LX200 command protocol).
- An LX200 telescope cable. This cable can be purchased from the Software Bisque Store or the manufacturer.
- A USB to serial adaptor.

Autostar and Autostar II Hardware Requirements

- Autostar, Autostar II-compatible telescope by Meade Instruments Corporation telescope (or a control system that uses the LX200/Autostar serial communications protocol).
- An Autostar telescope cable. This cable can be purchased from the Software Bisque Store or from the telescope’s manufacturer.
- A USB to serial adaptor.

Autostar III Hardware Requirements

- A standard USB cable for the Autostar III controller. The Autostar III controller (for example, the ETX-LS) has an integrated USB to serial adaptor so the square end of a USB cable can be plugged into the mount’s port labeled USB-B, and the other end connected directly to your personal computer’s USB port.

The integrated USB to serial adaptor requires installation of a software driver before *TheSkyX* can communicate with the mount. Consult the user guide for your mount for instructions on how to install the Meade mount's USB to serial adaptor driver for the Windows operating system (32- and 64-bit operating systems require a different driver). You might also check the Meade USB to Serial Downloads page for the most recent drivers.

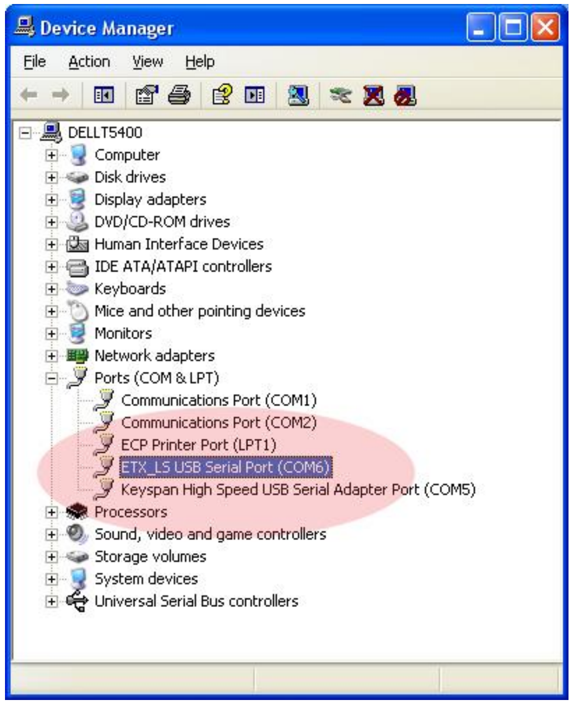


Figure 177: Windows XP Device Manager showing the ETX LS USB serial port driver's COM port number assignment.

The authors have not found a Mac-compatible driver for Meade eFinder Serial Emulator.

Installing Windows 64-bit Autostar III Drivers

Use the following procedure to install the latest Autostar III Meade eFinder Serial Emulator drivers.

1. Run the Autostar Update application (by choosing the Product Updates command on the Telescope menu of the Autostar Suite app), then click the Download My Autostar button. This will download the latest version of Autostar Update that includes the Windows 64-bit compatible LS drivers (this step does not actually install the LS drivers, it just updates the installer).
2. Plug the Autostar III telescope into the computer's USB port.
3. From Windows Device Manger, under ***Unknown Devices***, right-click on the ***Meade eFinder Serial Emulator*** and click the ***Update Software Driver*** command. IMPORTANT NOTE: Meade eFinder Serial Emulator is the USB device's name (not the actual USB driver name) and the Autostar III device will be listed under ***Unknown Devices*** until the actual driver has been installed.
4. From the Update Driver Software window, click the ***Browse My Computer for Software*** option.

5. Choose the folder where the Autostar Suite is installed and turn on the ***Include Subfolder*** checkbox then click ***Next***.
6. After the driver is installed, the name of the device is ETX_LS USB Serial Port (COMN) and the location of the driver is listed under Ports (COM & LPT).

Meade RCX400 (Autostar II) Hardware Requirements

- Meade RCX400 by Meade Instruments Corporation telescope.
- An LX200-compatible telescope cable. This cable can be purchased from the Software Bisque Store or the manufacturer.

Step-by-Step Meade Mount Setup Procedure

TheSkyX must be properly configured before it can communicate your mount.

1. Turn off the telescope.
2. If your mount has a USB port, insert the square end of the USB cable into the port labeled *USB-B* and the rectangular end into a USB port on your computer. If the mount has a serial port, insert the phone-type connector of the telescope cable into the bottom of the hand paddle, and the DB9 connector to the USB to serial adaptor.
3. Turn on the telescope.
4. Click the ***Telescope Setup*** command from the ***Telescope*** menu.
5. Select ***Mount*** in the ***Imaging System*** list on the left side of the ***Imaging System Setup*** window.
6. On the ***Choose Mount*** window, select your model telescope and click ***OK***. If the *exact* model of your telescope is not listed, don't worry; just select a similar model telescope. The underlying serial communication protocol is essentially the same for similar models.
7. Click the ***Settings*** command on the ***Mount Setup*** pop-up menu and then select the correct ***COM*** port (Windows) or the correct ***Serial Device*** (Mac). If your mount has a built-in USB to serial adaptor, and you've installed the drivers for it, use the Windows Device Manager to see the COM port number that is assigned to the mount's USB port.
8. Click ***Close.***
9. Click Telescope > Connect.
10. Click the ***Synchronize*** command (page 295) on the ***Start Up*** pop-up menu, then follow the on-screen instructions to complete the initialization.

Meade Control Window

Meade specific telescope controls can be accessed from the Meade window. By default, this window is docked to the left side of the Sky Chart and is turned on when you select a Meade Instruments mount from the mount list. Select the ***Meade*** command in the ***Display*** menu to show or hide this window.

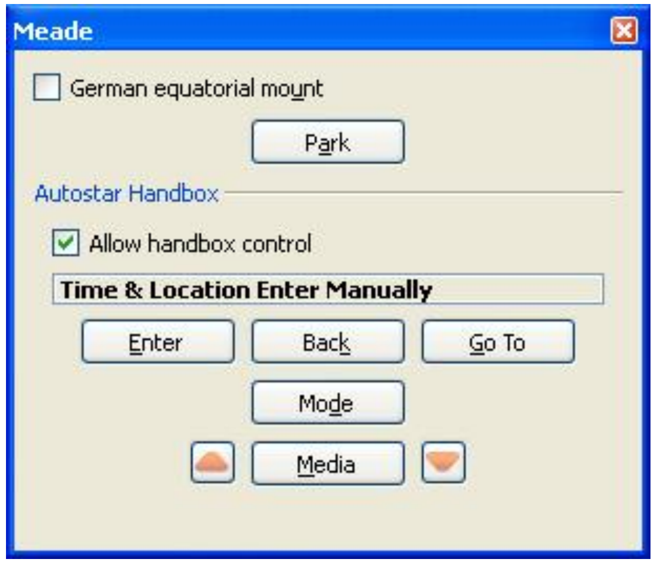


Figure 178: The Meade specific telescope control window.

German Equatorial Mount

Turn this option on if your mount is a German equatorial mount. This setting is used by the *TPoint Add On* so that it can correctly determine and record which side of the pier the OTA end of the declination axis is on when collecting pointing calibration data.

Parking a Meade Telescope Mount (Park button)

Press the ***Park*** button on the Meade window to send the mount to the park position. The handbox LED display will show the ***Turn the Mount Off Now*** message once parking complete. The next time the mount is powered on, no initialization is required.

Note that *TheSkyX's* software-based parking is not compatible with Meade mounts due to the protocol limitations discussed below. Therefore, do not use the ***Park*** and ***Unpark*** commands on the Telescope window to park your Meade mount.

See the following section for details on how to set a Meade mount's park position using the simulated handbox controls.

Simulated Meade Handbox (Autostar Handbox)

These controls can be used to simulate button presses to the Autostar handbox. Any command that can be accessed by pressing buttons on the handbox can also be accessed through software.

Simulated handbox control is particularly useful to perform certain features that are either not supported or inaccessible through the mount's serial communication protocol. For example, according to the published Meade protocol, the command to set the park position using the current position of the telescope (:hS#) is supported for LX200 GPS/RCX400 and LX16 models only.

If your Meade handbox includes the ***Select Item: Setup > Select Item: Preferences > Select Item: Parking Place > Select Item: Park Scope Here > Yes/No*** option, then you can navigate to this command using the simulated handbox control buttons to manually set the mount's park position. (The Autostar I and Autostar III we tested allow the mount's park position to be configured this way.)

When the mount is subsequently parked using the ***Park*** button on the Meade window, the mount will dutifully slew to this park position before shutting down.

Allow Handbox Control

Turn this checkbox on to allow handbox simulation. (The Autostar I and III mounts we tested allow simulated handbox control. The LX200 Classic handbox has not been tested.)

Hand Control Display Text

When the ***Allow Handbox Control*** checkbox is turned on, and the telescope is connected, the text that is displayed on the handbox LED display is also shown in here.

Enter/Back/Go To/Mode/Media/Up Arrow/Down Arrow Buttons

These buttons perform the same operation as the equivalent button on the handbox. The up/down arrow buttons represent the buttons on the bottom of the handbox, not the direction buttons. The ***Media*** button is found on the Autostar III handbox only.

Troubleshooting the Meade Telescope

TheSkyX will successfully establish communications with the Meade mounts, provided all of the following are true:

- The device is turned on and functioning.
- The hand paddle is plugged into the telescope's base panel.
- The hand paddle is in Polar or Alt/Az mode and *not* in Land Mode. See the documentation for setting this mode.
- For mounts that require a serial telescope cable, the telescope cable is wired correctly for bi-directional communications.
- For mounts that require a serial telescope cable, the telescope interface cable is plugged into the correct serial communications port or USB to serial adaptor.
- The telescope cable is plugged into the RS232 port on the LX200 base panel.
- The telescope cable is not plugged into a modem port (Windows).
- The COM port or USB to serial adaptor is functional, the software drivers are installed, and the functioning USB serial port appears in Windows Device Manager.
- For mounts that require a serial telescope cable, the telescope serial cable (the one sold by Software Bisque) is using the DB9 end connector labeled "LX200" not "BBox and Compatible".
- The correct model mount is selected on the ***Telescope Setup*** window.
- The selected serial device (Mac) or COM port (Windows) is correct. Click ***Telescope > Telescope Setup > Settings*** to check this setting.

Verify that all of the above is true, and *TheSkyX* will successfully communicate and control the telescope.

Software Bisque Paramount Robotic Telescope Systems

PROFESSIONAL

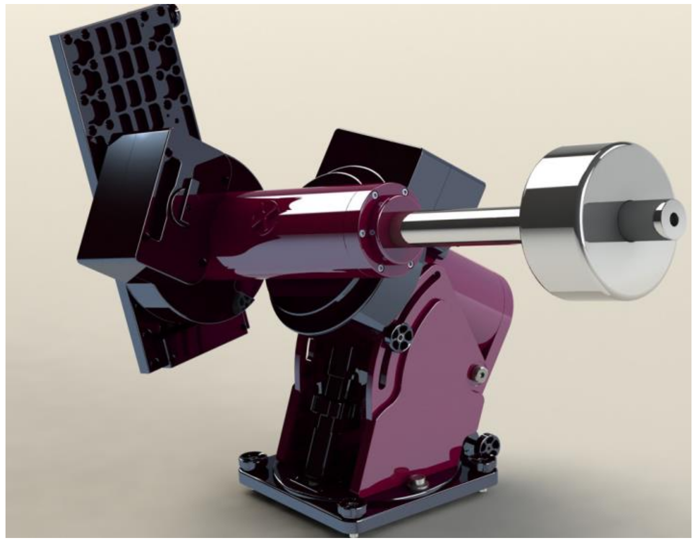


Figure 179: The Software Bisque *Paramount MX* Robotic Telescope Mount. © Software Bisque, Inc.

Please refer to the *Paramount ME User Guide* for detailed instructions on setting up and using the Paramount ME or Paramount GT-1100S with *TheSkyX Professional Edition*. Paramount ME II and Paramount MX owners should refer to the *Paramount ME II and MX User Guide* for setup instructions for this mount. Paramount User Guides are included with the mount, and can be downloaded by clicking the Downloads link on the Software Bisque web site. From there, click the Documentation link in the left column, then click on the desired user guide.

Paramount ME and Mac OS X

Controlling the Paramount ME from *TheSkyX Pro for Mac* requires the Paramount ME's serial (RS232) port. The Paramount ME's USB port is presently not supported on Mac OS X. You'll need to purchase a Mac OS X-compatible USB to Serial Adaptor as well as install the Mac OS X-specific driver for this device.

The High-Speed USB Serial Adapter Keyspan by Tripp Lite is one example of a USB to Serial Adaptor that works well on the Mac.

StellarCAT

The StellarCAT hardware permits “go to” functionality for Dobsonian-class telescopes.

Computer Assisted Telescope Innovations

Figure 180: ServoCAT and ServoCAT Jr. Track/GOTO. © StellarCAT.

StellarCAT Minimum System Requirements

TheSkyX can show the position of your telescope that uses the StellarCAT and StellarCAT Jr. control system, as well as issue slew commands to point the telescope to any object.

StellarCAT Hardware Requirements

- StellarCAT or StellarCAT Jr. Track/GOTO system
- Sky Commander or Argo Navis DSC. (See the “ServoCAT Quick Start and Troubleshooting Guide” for details about setting up the Digital Setting Circle or DSC.)
- A USB to serial adaptor.

Step-by-Step StellarCAT Setup Procedure

TheSkyX must be configured correctly before it can communicate with the StellarCAT. Please consult the StellarCAT User’s Manual for details about setting up and configuring the system before attempting to connect it to *TheSkyX*.

1. Turn off the control system.
2. Using the appropriate cable, connect the serial port from the serial interface box to the computer’s USB to serial adaptor (or serial port).
3. Turn on the control system.
4. Select the ***Telescope Setup*** command from the ***Telescope*** menu.
5. Select ***Mount*** in the ***Imaging System*** list on the left side of the ***Imaging System Setup*** window.
6. Select the ***Choose*** command from the ***Mount Setup*** pop-up menu.
7. On the ***Choose Mount*** window, select your model telescope and click ***OK***. If the *exact* model of your telescope is not listed, don’t worry; just select a similar model

telescope. The underlying serial communication protocol is the same for similar models.
8. Click the ***Settings*** command on the ***Mount Setup*** pop-up menu and then select the correct ***COM*** port (Windows) or the correct ***Serial Device*** (Mac).
9. Click ***Close***
10. Click Telescope > Connect.

Troubleshooting the StellarCAT Connection

TheSkyX will successfully establish communications with the StellarCAT, provided all of the following are true:

- The device is turned on and functioning.
- The DSC serial cable is wired correctly for bi-directional communications. See the ServoCAT User's Manual for details about this cable.
- The ServoCAT serial cable is plugged into the correct serial communications port or USB to serial adaptor (PC side).
- The ServoCAT telescope cable is plugged into the RS232 port on back of the .
- The telescope cable is not plugged into a modem port (Windows).
- The COM port or USB to serial adaptor is functional and the software drivers are installed.
- The telescope interface cable (the one sold by Software Bisque) is using the DB9 end connector labeled "LX200" and *not* "BBox and Compatible".
- Autostar/LX200 is selected as the ***Mount***.
- The selected serial device (Mac) or COM port (Windows) is correct. Click ***Telescope > Telescope Setup > Mount Setup > Settings*** to check it.

Verify that all of the above is true, and *TheSkyX* will successfully communicate and control the telescope.

Takahashi Temma Mounts

Figure 181: Takahashi Temma mounts. © Takahashi.

Temma Minimum System Requirements

TheSkyX can control Takahashi Temma model altitude/azimuth and equatorial mounts, including:

- EM-10 Temma PC Jr. (USD2)
- EM-200 Temma PC Jr. (USD2)
- EM-200 Temma PC
- NJP Temma PC
- EM-500 Temma PC
- EM-10 Temma2 Jr. (USD3)
- EM-200 Temma2 Jr. (USD3)
- EM-11 Temma2 Jr. (USD3)
- EM-200 Temma2
- EM-400 Temma2
- EM-500 Temma2

Hardware Requirements

- Any Takahashi Temma or Temma2 mount.
- A Takahashi telescope cable (supplied with the mount).
- A USB to serial adaptor.

Step-by-Step Temma Setup Procedure

TheSkyX must be configured correctly before it can communicate with the Temma mount. Make sure to set *TheSkyX's* location, date, time, time zone and Daylight Saving Time correctly before proceeding.

Figure 182: Temma PC Jr. Control Panel

1. Turn off the Temma telescope mount.
2. Using the gray Temma telescope cable (supplied with your mount), connect the round end to the port labeled RS-232C on the Temma mount, and the DB9 end to the USB to serial adaptor.
3. Turn the MOTOR and COMPUTER STAND BY switches to the ON position. When the Temma control system is powered on, it is initialized with the following default parameters.

    - The control system "thinks" the optical tube assembly end of the declination axis is on the West side of the mount.
    - The control system "thinks" telescope is pointing right ascension 0.0 and declination 0.0.
    - The right ascension and declination correction speeds are set to 90.
    - The control system's tracking is direction is for the Northern Hemisphere.

These default parameters will not match the actual position of the optical tube assembly. *TheSkyX* allows you to correctly initialize the Temma's control system to match the position of the OTA. See the step below to do so.

1. Select the ***Telescope Setup*** command from the ***Telescope*** menu.
2. Select ***Mount*** in the ***Imaging System*** list on the left side of the ***Imaging System Setup*** window.

3. Select the ***Choose*** command from the ***Mount Setup*** pop-up menu.
    4. On the ***Choose Mount*** window, select your model telescope and click ***OK***. If the *exact* model of your telescope is not listed, don't worry; just select a similar model telescope. The underlying serial communication protocol is the same for similar models.
    5. Click the ***Settings*** command from the ***Mount Setup*** pop-up menu and then select the correct ***COM*** port (Windows) or the correct ***Serial Device*** (Mac).
    6. Click ***Close***.
    7. Click ***Telescope > Connect***. The Temma's local sidereal time and latitude are set according to *TheSkyX*'s values. The telescope cross hairs appear on the Sky Chart at 0,0 right ascension/declination. The Temma's tracking direction is automatically set according to *TheSkyX's* ***North*** or ***South*** latitude setting.
    8. Click the ***Synchronize*** command (page 295) on the ***Start Up*** pop-up menu, then follow the on-screen instructions to complete the initialization. See "Temma Synchronization" below for more information.

Temma Synchronization

When the Temma mount is powered off, then on, the Temma control system's right ascension/declination coordinates are always 0.0, 0.0.

At this point, you must point the telescope to a known position, and then synchronize *TheSkyX* at that position.

Synchronization Method	Procedure
To synchronize when the optical tube assembly end of the declination axis is on the *West* side of the mount.	1. Loosen the clutches on the mount and orient the telescope so that the optical end of the declination axis is on the West side of the mount. 2. Keeping the OTA end of the declination axis on the West side of the mount, center a known star that is on the *opposite* side of the meridian. 3. Identify this star in *TheSkyX* (either by clicking on it or using *TheSkyX's* Find command from the Edit menu.) 4. On the *Telescope* window, select the ***Synchronize*** command in the ***Start Up*** pop-up menu and follow the on-screen instructions.
To synchronize when the optical tube assembly end of the declination axis is on the *East* side of the mount.	1. Loosen the clutches on the mount and orient the telescope so that the optical end of the declination axis is on the East side of the mount. 2. Keeping the OTA end of the declination axis on the East side of the mount, center a known star that is on the *opposite* side of the meridian. 3. Identify this star in *TheSkyX* (either by clicking on it or using *TheSkyX's* Find command from the Edit menu.) 4. On the *Telescope* window, select the ***Synchronize*** command in the ***Start Up*** pop-up menu and follow

Synchronization Method	Procedure
	the on-screen instructions.
To synchronize by pointing the telescope at the zenith.	1. Loosen the clutches on the mount and orient the telescope so that the optical tube assembly is pointing straight up (that is, the OTA is vertical). 2. Select the ***Temma*** command from the ***Display*** menu to show the Temma window if necessary. 3. Click the ***Settings*** tab on the Temma window. 4. Click the ***Sync At Zenith*** button on the Temma window.
No synchronization.	If the Temma has been initialized using other software, or is still initialized from a previous observing session (that is, you did not turn off the Computer Stand By switch on the mount). Click the ***Connect*** command from the ***Telescope*** menu.

Built-in Backlash Compensation

The Temma control system has a built-in "backlash compensation" feature that attempts to minimize the effects of gear slop. When the mount is commanded to slew from *TheSkyX*, it actually slews past the object a small amount, then slews back to it in the direction of sidereal tracking.

Temma Mount Specific Commands (Temma Window)

Select the ***Temma*** command from the ***Display*** menu to show commands that are specific to this control system.

Note that this command is only available when the ***Temma*** is selected in the Mount pop-up menu on the ***Telescope > Setup*** window.

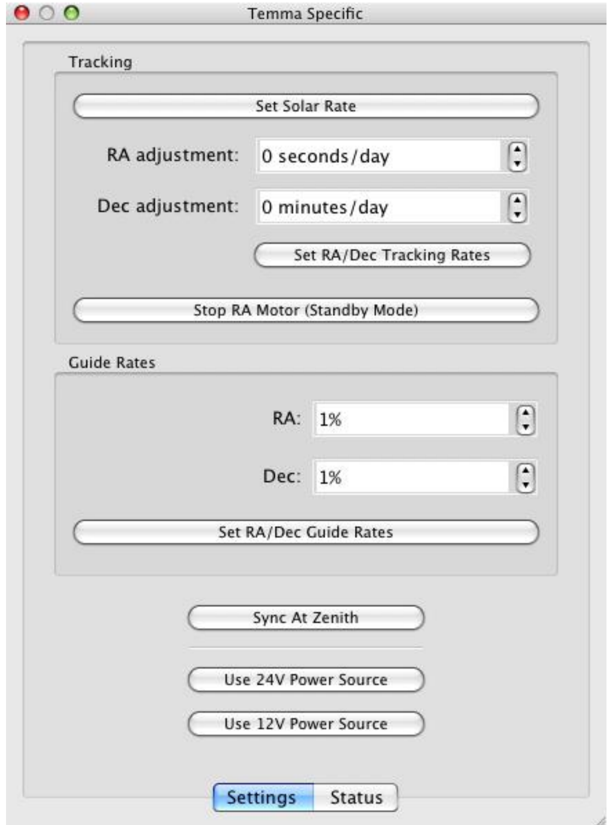


Figure 183: The Temma commands window (Display menu).

Settings Tab

The following Temma settings are available.

Set Solar Rate

Click this button to set the mount's tracking rate to approximate the Sun's rate of motion across the sky.

RA Adjustment (sidereal seconds/day)

Enter the adjusted tracking rate for the right ascension axis in *sidereal* seconds per day. There are 86,164 seconds in one *sidereal* day (1 "earth day" = 1.002738 "sidereal day"). See the tracking rate example below.

Dec Adjustment (min/day)

Enter the adjusted tracking rate for the declination axis in minutes per day. See the tracking rate example below.

Tracking Rate Example

The following example shows how to set the Temma's tracking rates to match (approximately) the Moon's reported rate. This same procedure can be used for any solar system object.

1. From *TheSkyX*, click the ***Find*** command from the ***Edit*** menu.
2. Type ***Moon*** in the Find text box, and then click the ***Find*** button.

3. On the Object Information dialog report, note the ***RA Rate (arcseconds/sec)*** and the ***Dec Rate (arcseconds/sec)***. For this example, suppose RA = 0.4334 and Dec = 0.2567.
4. Compute the RA adjustment using the following equation: (*TheSkyX's* RA Rate × 5760) × –1. The value is –2496.
5. Compute the Dec adjustment using the following equation: (*TheSkyX's* Dec Rate × 1440) × –1. The value is 370.
6. Enter both values and click the ***Set Tracking Rates*** button.

Stop RA Motor (Standby Mode)

Click this button to turn tracking off. Note that this command is not supported by all Temma models. You may wish to verify that the mount's motor actually stops tracking before relying on this command to enter standby mode.

Guide Rates

RA

Enter the right ascension correction speed (as a percentage of the sidereal rate). This setting is used for the slow speed when using the Motion Controls.

Dec

Enter the declination correction speed (as a percentage of the sidereal rate).

Set RA/Dec Guide Rates

Click this button to set the current tracking rate using the number entered in the ***New*** text box.

Sync At Zenith

Click this button to synchronize the Temma mount when the OTA is pointing at the zenith.

Use 12V Power Source Button

Click this button to configure the Temma control system to use 12-volt power supply.

Use 24V Power Source Button

Click this button to configure the Temma control system to use 24-volt power supply.

- Issuing these commands when the Temma is slewing will cause the mount's motors to stop.
- Even when a 12-volt power supply is used, clicking the 24V Power Source Button results in higher slew rates.

Status Tab

Temma's Local Sidereal Time

Displays the local sidereal time reported by the Temma control system, in hours, minutes and seconds.

OTA is on this Side of Mount (East/West)

For German equatorial mounts, the optical tube assembly (OTA) end of the declination axis can be located on the East or West side of the mount. The Temma reports which side of the mount it "thinks" the optical tube assembly is on. Select the appropriate side from the pop-up menu.

Voltage From Power Supply

The Temma mount can use either 12V or 24V power. The *actual* voltage that is being supplied to the control system is shown here.

Hemisphere Tracking Direction

TheSkyX's North/South latitude setting in the ***Input > Location*** window is used to configure the Temma's direction of tracking.

Standby Mode

Reports whether or not the Temma mount is in "standby mode," which means the mount's MOTOR switch (Figure 182 on page 332) is turned off. When this switch is in the off position, the mount's right ascension axis will not track at the current tracking rate.

Parking the Temma PC Jr.

Temma PC Jr. mounts do not allow the mount's tracking rate to be turned off through software (the Motor Power switch must be turned off to stop the motors from tracking at the current rate). Therefore, when the Park command is issued for this mount, *TheSkyX* still slews the mount to the park position, but it must then periodically slew back to the park position every few minutes (to undo the rotation or the right ascension axis that is the result of the mount tracking at the sidereal rate).

Note that "software-based parking and continuous rewinding" is a *poor workaround* to a *fundamental shortcoming* in the mount's control system. Loss of communication between the mount and *TheSkyX* will prevent *TheSkyX* from correcting the mount's park position, and will most likely result in the mount tracking into itself. This unfortunate event will most likely cause damage to the mount, equipment, cabling or all three. The Temma control system has no built-in software or hardware tracking limits and it will try to rotate the right ascension axis even after the mount has tracked into a fixed object like, such as the pier.

At a minimum, this telescope control system should allow tracking to be turned off through software. Ideally, the telescope's firmware should support a park/unpark mechanism that allows the mount to be shut down and restarted to restore the last session.

Vixen HTTP Equatorial Mounts

Figure 184: The Vixen™ Sphinx HTTP mount. © Vixen Optics.

Vixen Minimum System Requirements

TheSkyX can control Vixen Sphinx HTTP mounts using firmware version 1.2 build 35 and later. If you have an older version of the firmware, contact the manufacturer for details about upgrading.

Hardware Requirements

- Any Vixen Sphinx model German equatorial mount that uses the STAR BOOK™ Star-Chart Go To System.
- An Ethernet ***crossover*** cable for direct connection from the computer to the STAR BOOK or an Ethernet straight cable for network connection to the telescope through a router.

Cabling Notes

The Vixen HTTP mount uses standard network protocol rather than serial communications. In the Settings dialog, enter the URL of the mount on your network. The default URL is http://169.254.1.1. Use this address if the Vixen is connected directly to the computer's network port using with an Ethernet *crossover cable*.

If your mount is plugged into a network router, use a standard network cable instead.

Step-by-Step Vixen HTTP Setup Procedure

1. Plug the network cable into the base of the Star Book and into the computer's network port (a network crossover cable is required) or into a network router or hub (using a standard Ethernet cable).
2. Select the ***Telescope Setup*** command from the ***Telescope*** menu.

3. Select ***Mount*** from the ***Imaging System*** list on the left side of the ***Imaging System Setup*** window.
4. Select the ***Choose*** command from the ***Mount Setup*** pop-up menu.
5. On the ***Choose Mount*** window, select your model telescope and click ***OK***. If the *exact* model of your telescope is not listed, don't worry; just select a similar model telescope. The underlying serial communication protocol is the same for similar models.
6. On the ***Imaging System Setup*** window, click the ***Settings*** button from the ***Mount Setup*** pop-up menu and enter the URL of the Vixen Star Book. When the mount is turned on and the network cable is plugged into both the Star Book hand paddle and the network router, the Star Book's About box shows the URL of this device on the network. Enter this address into the URL text input on the HTTP Port Settings dialog.
7. On the ***Imaging System Setup*** dialog, turn on the desired preferences and then click ***Close***.
8. Select the ***Connect*** command from the ***Telescope*** menu. The telescope cross hair displays the current coordinates of the telescope.
9. Click the ***Synchronize*** command (page 295) on the ***Start Up*** pop-up menu, then follow the on-screen instructions to complete the initialization.

The Vixen mount should now be initialized and ready to use.

Camera Control

PROFESSIONAL

TheSkyX Professional Edition for Mac and Windows and the optional Camera Add On can be used to take photos with CCD, DSLR or video cameras. The optional *Camera Add On* can be purchased from the Software Bisque Store and is activated using the serial number that is assigned to your Software Bisque account. (You do not need to download and install additional software to use the Camera Add On.) See "Activating the Camera Add On" below for more information about activating the Camera Add On.

Activating the Camera Add On

When you purchase the *Camera Add On to TheSkyX Professional Edition* from the Software Bisque Store, your *Camera Add On* serial number is automatically registered to your account and can be viewed by visiting your Software Bisque account's Subscriptions page.

The Camera Add On serial number is used to activate the camera control features directly from TheSkyX Professional Edition. ***No additional installers, software or software downloads are required to use the Camera Add On.***

To access your serial number and activate the *Camera Add On*,

1. Sign in to the Software Bisque web site by clicking the ***Sign In*** link in the upper right corner of the site. After you are signed in, your ***Sign In Name*** appears in the upper right corner of the site.
2. Navigate to your subscriptions page by clicking your ***Sign In Name***, then click the Subscriptions link.
3. From TheSkyX Professional Edition, click the ***Telescope Setup*** command on the ***Telescope*** menu.
4. Highlight ***Camera*** on the ***Imaging System*** list.
5. Click the ***Camera Setup*** pop-up menu and select the ***Enter Serial Number*** command.
6. Manually enter your ***Name*** and your *Camera Add On* ***Serial Number***.
7. Click ***OK***.

The *Camera Add On to TheSkyX Professional Edition* is now activated and ready to use. You'll need to repeat the above procedure on each computer that is running a licensed copy of *TheSkyX Professional Edition* and the *Camera Add On*.

Before you attempt to link to the camera, run through this checklist to make sure you are ready to begin imaging:

- The camera should be securely attached to the telescope. If practical, attach a safety wire, cable, or strap to catch the camera if it works loose. The camera's power and other cables may tug on the camera as you move your mount, and if the camera isn't completely secure it can work loose, fall off the telescope and damage or destroy the camera.
- All electrical connections should be secure, and power to the camera should be turned on.
- The cable from the camera or control box to your computer should be securely attached, especially if you have a laptop that may get moved about during use.
- Double check the routing of all cables to make sure they will not catch on the mount, telescope, or other accessories. We suggest that you route your cables next to the mount, then along the telescope to the camera. This reduces the free-swinging weight of the cables and will provide a steadier imaging platform. If your mount provides internal routing for cables, make sure all cables attached to the mount are secure.

Supported Cameras

TheSkyX Professional Edition with the optional *Camera Add On* can take photos with:

- Apogee Instruments cameras (Windows only)
- ASCOM-supported cameras (Windows only)
- Canon DSLR cameras, selected models (Mac and Windows)
- Finger Lakes Instruments cameras (Mac and Windows)
- Orion SSAG (Mac and Windows)
- QSI model cameras (Mac and Windows)
- SBIG cameras (Mac and Windows)
- Video cameras (Windows)
- Any camera with an X2 Camera Plug In that adheres to the X2 Standard (page 342)

Note that third-party vendors can develop, distribute and install third-party camera drivers independent of Software Bisque and *TheSkyX Professional Edition's* installers, so the above list may not be comprehensive.

To view the list of supported cameras by the *Camera Add On*:

1. Click the ***Telescope Setup*** command on the ***Telescope*** menu
2. Highlight ***Camera*** in the ***Hardware List*** on the left side of the ***Imaging System Setup*** window.
3. Click the ***Choose*** command from the ***Camera Setup*** pop-up menu.

If your model camera is not listed, check with the camera's manufacturer to find out if a *TheSkyX Professional Edition* Camera Add On or X2 Camera Plug In is available.

X2 Camera Plug In and Camera Drivers

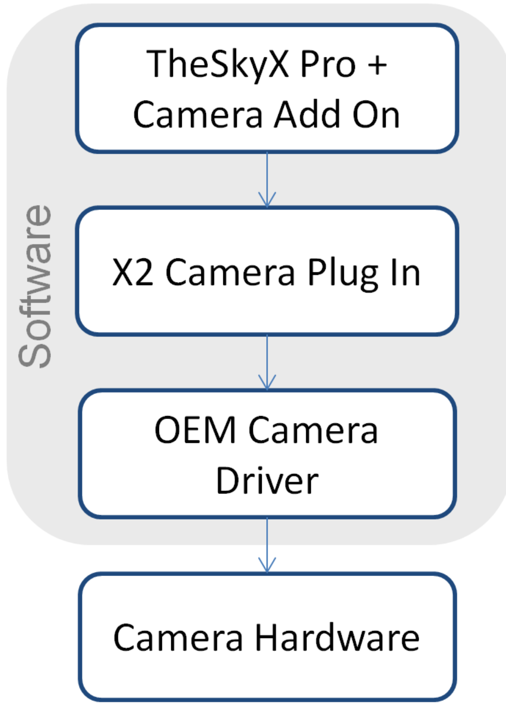


Figure 185: Minimum requirements for camera control.

Figure 185 shows the *minimum software and hardware components* that are necessary for the Camera Add On to "take a picture" with an astronomical camera. The top and bottommost components are obvious; the purpose of the less obvious middle two software components is described below.

Original Equipment Manufacturer (OEM) Camera Driver

Camera hardware and firmware require a *camera software driver* (or *camera driver*) to send commands to, and receive commands from, a personal computer. This two way communication is usually performed using a USB, Ethernet, Wi-Fi, parallel port, or other standard communications interface.

The camera driver is normally developed, distributed and updated by the original equipment manufacturer (OEM), not Software Bisque.

For cameras that require a separate OEM driver, you must download and install the camera driver from the manufacturer's web site *before* the Camera Add On can control it. See the table under "X2 Plug In and Driver Distribution" on page 343 for a list of each camera manufacturer and the Mac/Windows OEM camera driver availability.

Like all software, camera drivers are periodically updated to fix bugs, or add new features. Software Bisque recommends that you keep your camera driver up to date by installing the latest drivers from the OEM's web site. Installing the latest camera driver is also an excellent first step when troubleshooting camera-related problems.

X2 Camera Plug In

The Camera Add On communicates with a camera device driver through a software component called the X2 Camera Plug In. X2 Camera Plug Ins are based on Software Bisque's X2 Plug In Standard Interface (www.bisque.com/x2).

X2 Plug In and Driver Distribution

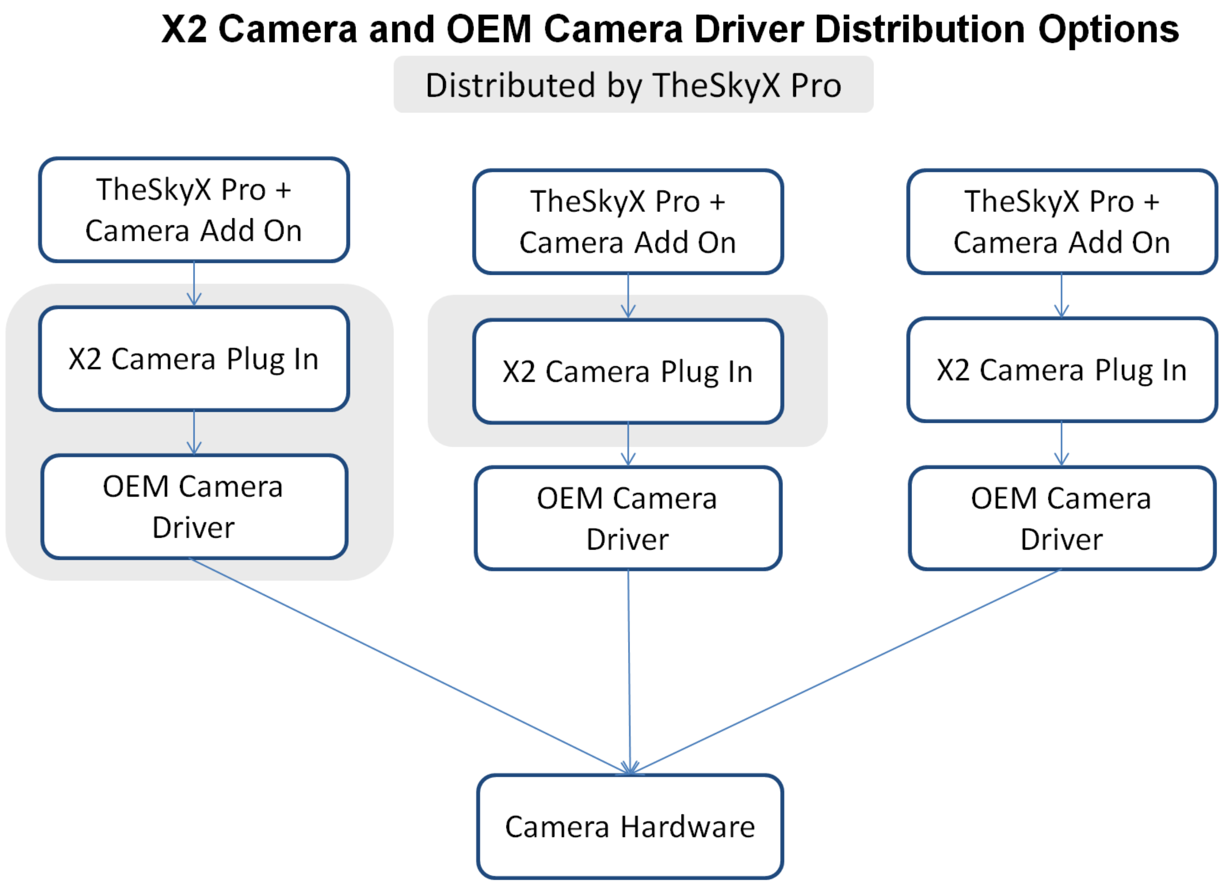


Figure 186: X2 Camera Plug In and OEM Camera Driver distribution options.

Figure 186 shows the three camera driver distribution options for the TheSkyX Professional Edition and the Camera Add On. The shaded regions indicate which component is distributed by TheSkyX Professional Edition.

The camera driver and X2 Plug In distribution options include:

- TheSkyX Pro distributes both the X2 Camera Plug In and the OEM Camera Driver.
- TheSkyX Pro distributes only the X2 Camera Plug In. The OEM Camera Driver must be downloaded and installed from the camera manufacturer's web site.
- TheSkyX Pro does not distribute either the X2 Camera Plug In or the OEM Camera Driver. Both must be must be downloaded and installed separately from the camera manufacturer's web site.

The table below lists each camera manufacturer, and whether or not an X2 Camera Plug In or OEM camera driver is required for the Camera Add On to operate the camera.

Camera Manufacturer	X2 Camera Plug In	OEM Camera Driver	X2 Camera Plug In	OEM Camera Driver
Apogee Instruments	🔴	Apogee downloads page	🟢	Apogee downloads page
Canon DSLR	🟢	🟢	🟢	🟢
FLI	FLI downloads page	FLI downloads page	FLI downloads page	FLI downloads page
Orion SSAG	🟢	🟢	🟢	🟢
QSI	🟢	🟢	QSI downloads page	QSI downloads page
SBIG	🟢	SBIG downloads page	🟢	SBIG downloads page

🟢 Distributed with TheSkyX Professional Edition; no separate download necessary.
🔴 Not currently supported by this operating system.

Cameras that can be controlled by the Camera Add On using an X2 Camera Plug In and the OEM Camera Driver are considered “natively supported.”

To configure the Camera Add On to control a natively supported camera:

1. If necessary, install the OEM camera driver from the manufacturer’s web site listed in the table above.
2. If necessary, install the X2 Camera Plug In from the manufacturer’s web site listed in the table above.
3. From TheSkyX Professional Edition, click the ***Telescope Setup*** command from the ***Telescope*** menu.
4. Double-click ***Camera*** in the ***Imaging System*** list to display the ***Choose Camera*** window.
5. Expand and highlight your model camera, then click ***OK***. If the exact model of your camera is not listed, choose a similar model camera.
6. Click the ***Settings*** command from the ***Camera Setup*** pop-up menu to display the ASCOM Chooser window then choose your camera.
7. Click the ***Properties*** button on the Chooser window to configure the camera and click ***OK***.
8. Click ***OK*** to close the Chooser window.
9. Click the ***Connect*** command from the ***Camera Setup*** pop-up menu on the ***Imaging System Setup*** window to connect to the camera.

Third-Party Camera Drivers

The Camera Add On can also control cameras that have an ASCOM driver.

Third-Party Driver	X2 Camera Plug In	OEM Camera Driver	X2 Camera Plug In	ASCOM Driver	OEM Camera Driver
ASCOM Camera Driver	🔴	🔴	🟢	Visit the ASCOM site, or the camera manufacturer's download page	Visit the camera manufacturer's downloads page

🔴 ASCOM is available for the Windows operating system only.

To configure the Camera Add On to control a camera that has an ASCOM camera driver:

1. Download and install the ASCOM platform. Details how can be found on the ASCOM web site.
2. Download and install the ASCOM-driver for your camera (visit the ASCOM web site, or the camera manufacturer's web site to download it).
3. From TheSkyX Professional Edition, click the ***Telescope Setup*** command from the ***Telescope*** menu.
4. Double-click ***Camera*** in the ***Imaging System*** list to display the ***Choose Camera*** window.
5. Expand ***ASCOM*** and highlight ***ASCOM Camera***, then click ***OK***.
6. Click the ***Settings*** command from the ***Camera Setup*** pop-up menu to display the ASCOM Chooser window then choose your camera.
7. Click the ***Properties*** button on the Chooser window to configure the camera and click ***OK***.
8. Click ***OK*** to close the Chooser window.
9. Click the ***Connect*** command from the ***Camera Setup*** pop-up menu on the ***Imaging System Setup*** window to connect to the camera.

The ASCOM camera is now ready to be controlled from the Camera Add On.

MaxIm DL Controlled Cameras

In addition to native camera support and ASCOM camera support, the Camera Add On can acquire photos from any camera that can be controlled through Cyanogen's MaxIm DL camera software. Note that MaxIm DL is required for the Camera Add On to be able to control cameras supported by MaxIm DL.

Third-Party Driver	**X2 Camera Plug In**	**OEM Camera Driver**	**X2 Camera Plug In**	**Camera Driver**	**OEM Camera Driver**
MaxIm DL-controlled camera				Follow MaxIm DL's instructions for configuring the camera	Visit the camera manufacturer's downloads page

MaxIm DL is available for the Windows operating system only.

To configure the Camera Add On to control MaxIm DL's camera:

1. Install the MaxIm DL Pro or MaxIm DL DSLR software and configure your camera based on the software's instructions.
2. From TheSkyX Professional Edition, click the ***Telescope Setup*** command from the ***Telescope*** menu.
3. Double-click ***Camera*** in the ***Imaging System*** list to display the ***Choose Camera*** window.
4. Expand ***Diffraction Limited*** and highlight ***MaxIm DL's Camera***, then click ***OK***.
5. Click the ***Connect*** command from the ***Camera Setup*** pop-up menu on the ***Imaging System Setup*** window to connect to the camera.

The Camera Add On will now use the MaxIm DL-controlled camera to acquire photos.

Controlling a Camera

Once the camera and the computer are powered up, start *TheSkyX Professional Edition* and then choose the ***Telescope Setup*** command from the ***Telescope*** menu. This displays the ***Imaging System Setup*** window. In the ***Hardware List*** on the left side of this window, click on the ***Camera*** text to display the camera setup options shown in Figure 187.

Click the ***Choose*** command from the ***Camera Setup*** pop-up to select your camera from list (see Figure 189) and click ***OK***.

If you have a filter wheel, focuser or rotator installed/attached to the camera, select the model from the hardware list.

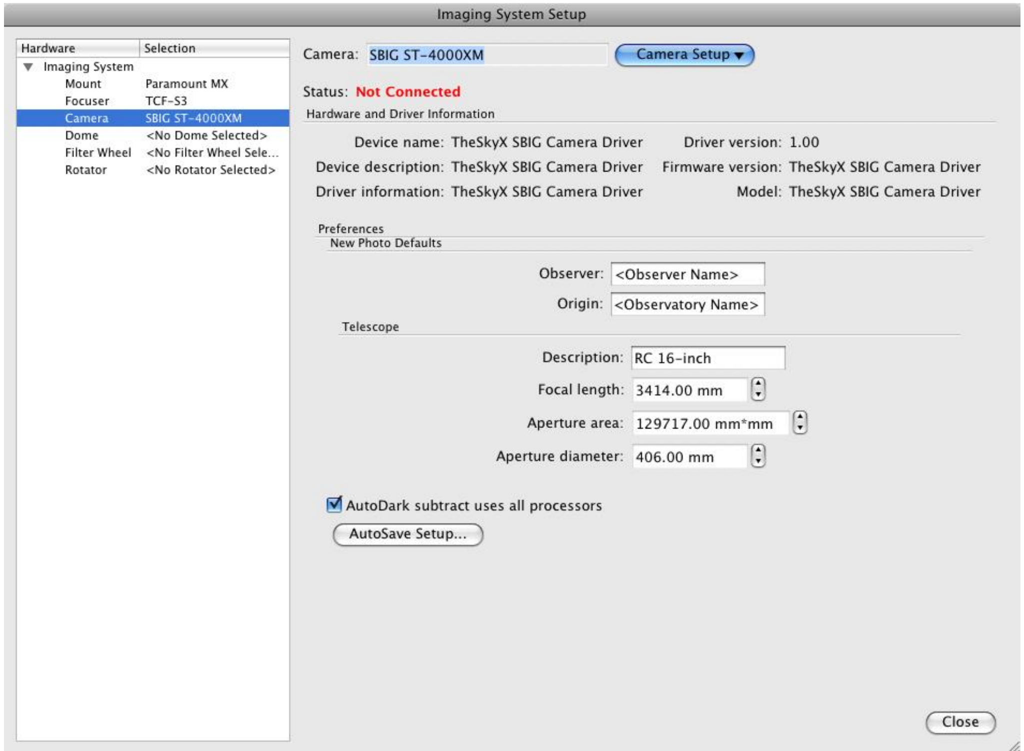


Figure 187: The Camera Setup options on the Imaging System Setup window.

Selecting ***Camera*** in the ***Hardware*** list displays camera driver details and other camera-specific preferences.

Currently Selected Camera (Camera text)

The ***Camera*** text at the top of the ***Imaging System Setup*** window shows the manufacturer and model of the currently selected camera.

Camera Setup Pop-Up Menu

The ***Camera Setup*** pop-up menu provides commands for choosing, setting up, connecting, disconnecting and entering the *Camera Add On* serial number.

Choose

Click this command to display the ***Choose Camera*** window. The ***Camera*** list shows all supported models.

Settings

Click this command to display camera-specific port setup and driver options.

Connect

Choose this command to establish a connection to the camera.

Disconnect

Choose this command to stop communicating with the camera.

Enter Serial Number

Choose this command to enter your Camera Add On serial number. See "Activating the Camera Add On" on page 340.

After selecting your model camera, click the ***Settings*** command in the ***Camera Setup*** pop-up menu to configure the communication interface and other camera-specific options.

Camera Status (Status text)

This text box displays the current camera status.

Hardware and Driver Information

When ***Camera*** is highlighted in the ***Hardware*** list on the Imaging System Setup window, the following camera hardware and camera driver-specific information is displayed.

Device Name

This text box shows the name of the selected device.

Device Description

This text box shows an abbreviated description of the device.

Driver Information

This text box shows additional information about the driver for this device.

Driver Version

This text box shows the version of the software driver used to control this device.

Firmware Version

This text box shows the version of the device's firmware, when available.

Firmware Version

This text box shows the hardware's model as reported by the device's firmware, when available.

Figure 188: The SBIG Camera Settings window.

SBIG Camera Settings

Use the SBIG Settings window to set the communications interface, binning options and the roles of the camera's imaging and autoguiding sensors.

Camera Communications (Interface text box)

SBIG cameras can be connected to a computer using one of the following communication interfaces.

Interface Name	Description
Ethernet	SBIG offers an optional Ethernet communications box that uses TCP/IP network protocol to communicate with the camera. After selecting the Ethernet option, enter the IP Address assigned to the camera and click ***OK***.
Parallel Port	Older model SBIG cameras use the Windows parallel port to connect to the computer. If your camera uses the parallel port, choose one of the following options: LPT1 LPT2 LPT3 And click ***OK***.
USB	The ***USB*** option applies to all "modern" SBIG cameras. Selecting the **USB** interface allows the SBIG camera driver to automatically locate the camera plugged into the USB port. If you own two SBIG cameras and want to assign a specific USB port to a specific camera, choose the ***USB1***, ***USB2***, ***USB3*** or ***USB4*** option and click ***OK***.

Use Off-Chip Binning

Turn this checkbox on to have the SBIG camera driver perform binning rather than the SBIG camera hardware.

Vertical N Binning (Spectroscopy Use Only)

Enter the bin value (1-255) used when performing spectroscopy with the SBIG camera.

Swap Detector Roles

Turn this checkbox on to use the camera's main sensor as the guiding sensor and the guiding sensor for the imaging sensor.

Setting Up an SBIG Camera

Follow the steps below to configure *TheSkyX Professional* to directly control an SBIG camera.

1. Install the SBIG camera drivers for your operating system. If necessary use SBIG's free CCOPS software for your OS to make sure the driver is properly installed and you can take photos with the camera.
2. Make sure your camera is plugged in, turned on and connected to a USB port on your computer. Before attempting to connect to the camera, allow about 30 seconds or so for the SBIG camera to initialize.
3. From *TheSkyX*, select the ***Telescope Setup*** command from the ***Telescope*** menu.
4. Select the ***Camera*** text in the ***Imaging System*** list.
5. Click the ***Choose*** command on the ***Camera Setup*** pop-up menu to display the ***Choose Camera*** window. If you have not purchased the *Camera Add On*, click the ***Run Trial*** button to use begin the 90 day trial period.

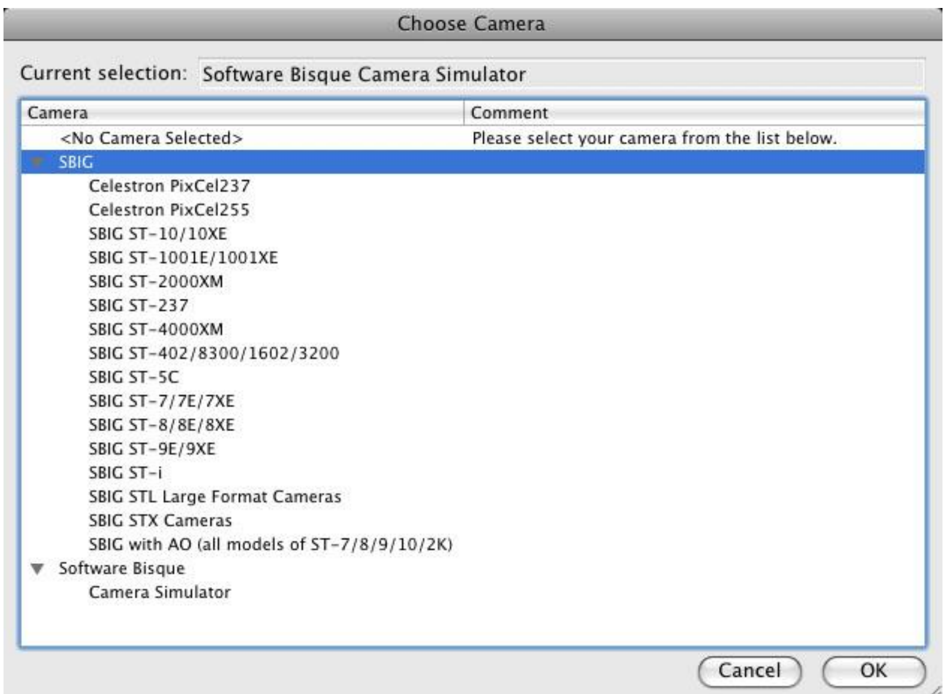


Figure 189: Figure 158: The Choose Camera window.

5. Expand ***SBIG***, then select your camera model and click ***OK***. The name of the selected camera will appear at the top of the ***Camera*** window (Figure 191).
6. If your computer has more than one processor, turn on the ***AutoDark Subtract Uses All Processors*** checkbox to speed up dark frame from light frame subtraction.
7. Select the ***Connect*** command from the ***Camera Setup*** pop-up menu or click the ***Connect*** button on the ***Camera*** window. If the SBIG drivers are installed properly, after about fifteen

seconds, the green Ready status text appears on the ***Imaging System Setup*** window and on the ***Camera*** window.

Canon DSLR Cameras

The Canon DSLR Camera Plug In is distributed with *TheSkyX Professional Edition* version 10.1.11 Build 5587 and later. This update can be downloaded from the Software Bisque web site.

The Canon plug in is presently in at the "beta test" state, but has been tested on many Dicic 4 model cameras. Software Bisque welcomes feedback, including camera models that work and do not work with this plug in.

Canon Camera Plug In Minimum Requirements

TheSkyX Professional Edition's Canon DSLR Plug In is intended to work with all Canon Digic 4 or later DSLRs on the following operating systems.

Mac OS X Minimum Requirements

- An Intel-based Mac running Mac OS X 10.6 (Snow Leopard) or later. Attempting to connect to a Canon DSLR using Mac OS X 10.5 or earlier with this plug in will always result in the error message: "A necessary driver was not found."

Windows Minimum Requirements

- Windows 8 or Windows 7, 32- or 64-bit operating system.

The Canon camera's mirror must be unlocked before the camera can be controlled from the Camera Add On. See the camera's documentation for details how to unlock it.

Canon Camera Minimum Requirements

The Camera Add On supports Digic 3, 4, and 5 model Canon EOS cameras, including:

- 1D X
- 5D Mark II
- 5D Mark III
- 6D
- 7D
- 50D
- 60D(a)
- 100D Rebel SL1
- 450D Rebel XSi
- 500D Rebel T1i
- 550D Rebel T2i
- 600D Rebel T3i

- 650D Rebel T4i
- 650D Rebel T4i
- 700D Rebel T5i
- 1000D Rebel XS
- 1100D Rebel T3

Choose ***Universal/Generic for unlisted Digic 3, 4, or 5 models*** from the Canon camera list if your model is not listed.

The Digic 4 processor was also used in some of the latest Canon PowerShot series cameras. However, the mechanics of connecting these models cameras to a telescope can be difficult and are beyond the scope of this document.

The Canon X2 Plug In may be compatible with older model cameras, but may not be able to take exposures over 30 seconds (which is a severe limitation for anything beyond automated TPoint calibration runs).

Canon Camera Acquisition Modes

Canon cameras have the following methods for taking a photo (also known as "acquisition modes").

1. **Luminance**: This mode works best for automated pointing calibration runs and Image Links. (This mode is a bit of a cheat for a one-shot color camera. It uses a standard RGB to Luminance formula to derive the luminance values from the RGB components. Not perfect, but works very well for these tasks.) ***THIS IS THE ONLY CURRENTLY FUNCTIONING MODE FOR THE CANON PLUG IN.***
2. **Canon Debayer**: For color images, this will use the built-in Canon debayer algorithms. (Under development.)
3. **RAW Color**: Better debayer routines. This mode may replace the Canon Debayer mode after further testing takes place.
4. **SuperPixel**: Converts a 2x2 RAW pixel block (before debayering) into a single RGB pixel. This mode will provide good color results, at a lower reduced resolution. (Under development.)
5. **LiveView**: This mode has many potential applications, but is still under development.

Binning

Canon DSLR's do not support hardware binning. This software binning mode simply sums neighboring pixels.

Known Canon Driver Limitations

- Luminance acquisition only.
- Mirror lock cannot be enabled. No error messages reported, the driver will just hang when attempting to take an exposure.
- Camera mode dial must be set to Manual.

Setting Up a Canon Camera

Follow the steps below to configure *TheSkyX Professional* to directly control a Canon camera.

1. Download and install *TheSkyX Professional Edition* version 10.2.0 or later from the Software Bisque web site: http://www.bisque.com/sc/media/p/47013.aspx.
2. Make sure your camera is plugged in and turned on.
3. From *TheSkyX*, select the ***Telescope Setup*** command from the ***Telescope*** menu.
4. Select the ***Camera*** text in the ***Imaging System*** list.
5. Click the ***Choose*** command on the ***Camera Setup*** pop-up menu to display the ***Choose Camera*** window. If you have not purchased the *Camera Add On*, click the ***Run Trial*** button to use begin the 90 day trial period.
6. Expand ***Canon***, click *Canon DSLR* and click ***OK*** (or double-click on the camera model to select it and close the window.)

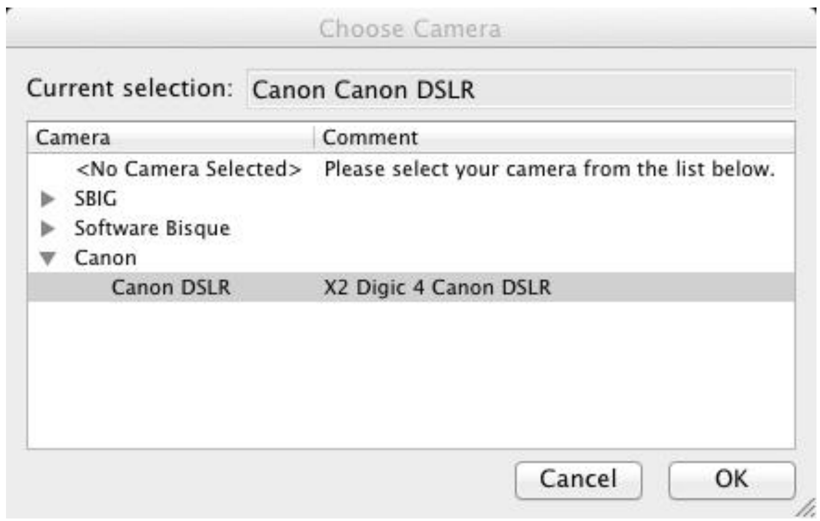


Figure 190: Choose the Canon DSLR camera.

7. If your computer has more than one processor, turn on the ***AutoDark Subtract Uses All Processors*** checkbox to speed up dark frame from light frame subtraction.
8. Select the ***Connect*** command from the ***Camera Setup*** pop-up menu or click the ***Connect*** button on the ***Camera*** window. After about thirty seconds, the green Ready status text appears on the ***Imaging System Setup*** window and on the ***Camera*** window.

TheSkyX Professional Edition can now acquire photos from the Canon camera.

Canon Driver Change Log

Version 0.1 March 19, 2012

- Initial Release. Mac only.

Version 0.16 April 6, 2012

- Properly reports firmware version & Camera model info.
- Initial Windows support.

Version 0.20 Released April 21, 2012

- Improved error checking, and detect camera disconnect. Camera's work in either M (manual), or B (bulb) mode. If you have a model with a Bulb setting and Manual, set it to Bulb. If you attempt to connect and the camera is not in Bulb or Manual mode, a connection error is displayed, by design.

Orion Starshoot Autoguider

The Camera Add On can autoguide telescopes via Relays using the Orion Starshoot Autoguider (SSAG) on both Mac and Windows.

1. The SSAG's hardware relays *do not* adhere to the SBIG ST-4 standard, so you must use the autoguiding cable that comes with the guider, otherwise the telescope will not respond to guider corrections issued from the camera.
2. On the two units the driver's author has tested, the first row of pixels in all full and subframes acquired with this camera are consistently "garbage" (random data). As a workaround to this behavior, the first two rows in the photo are ignored and appear all black.
3. Dark frames are strongly recommended to eliminate hot pixels while autoguiding with this camera.

Taking Photos

Figure 191: The Camera Add On window.

Once the camera is selected and communication established, take a photo using the default settings by clicking the ***Take Photo*** button on the ***Camera*** window.

When the exposure is complete, the photo is downloaded from the camera and displayed in the "FITS Viewer Window" (page 82).

Establish Communication with the Camera (Connect button)

Click the ***Connect*** button to establish a communication link between the camera and *TheSkyX*. The Ready status text indicates the camera is ready to acquire photos.

Camera Cooling (Temperature Setup button)

Click this button to specify the cooling point for the camera.

Terminate Communication with the Camera (Disconnect button)

Click the ***Disconnect*** button to end communication with camera. This step is usually performed at the end of the imaging session. The status text will show Not Connected.

Select Exposure Length (Exposure Length)

The maximum exposure length is determined by how good your polar alignment is, and by how accurately your mount tracks. If you see stars trailing into lines, shorten your exposure until this goes away (or take some time to improve your polar alignment or the accuracy of your mount's tracking). If you see wiggly lines on long exposures, then your mount's tracking error is too large for the current focal length. Use a focal reducer, or switch to a scope with a shorter focal length that better fits the capabilities of your mount.

The following table includes some recommended exposure times for various objects. The table assumes a focal ratio in the range of about f/7. Use longer exposures for longer focal ratios, and shorter exposures for shorter focal ratios. If you get blooming on a particular object, then go to a shorter exposure. If you don't get much detail in the image, or it seems washed out, go to a longer exposure. Generally speaking, unless you run into blooming, saturation, or other problems, longer exposures are generally better. Experiment to find the best exposures for your setup. You might want to keep a written record of successful exposures, which you can use as a guide for future imaging sessions.

Object	Suggested Exposure Range
Sun	Use a visual solar filter, plus any additional filters needed to cut the light. Polarizing filters, moon filters, or other specialized filters such as h-alpha filters can reduce the light so that your camera's shortest exposure will be sufficient for solar images. Do not use so-called photographic solar filters. These are intended for film, which is much less sensitive than your CCD detector. Never attempt to photograph or view the sun without a proper solar filter!
Bright planets	Planets such as Venus, Jupiter, Saturn and Mars require surprisingly short exposures with most setups, as little as 5 to 10 thousandths of a second. However, if you use a Barlow or eyepiece projection to increase the focal ratio to f/20 or even f/30, longer exposures (up to a full second) may be required.
Moon	The moon is also very bright, especially around full moon, and may require some effort on your part to attenuate the light sufficiently for imaging. Polarizing filters and moon filters, or both, will get the job done. As with solar images, the shortest possible exposure of your camera should be tried first. Then add additional filtering if that isn't short enough, or increase the exposure if it's not long enough.
Open clusters, bright globular clusters	These objects require relatively short exposures, and exposure length is usually limited by blooming if you don't have an anti-blooming camera. If you do have an anti-blooming camera, you can even image open clusters long enough to image background galaxies. For clusters with very bright members, or globular clusters with very bright cores such as M13, exposures

Object	Suggested Exposure Range
	under a minute should be enough. Dimmer clusters may require exposures longer than a minute. Very bright clusters, such as the Pleiades, may only work well with anti-blooming cameras. For color imaging, be careful not to saturate bright stars so you can get truer star colors.
Galaxies	Galaxies come in a enormous range of brightness levels. M31 will show up in an exposure of a few seconds; M101 may require 5 to 10 minutes or more. Generally speaking, edge-on spirals and elliptical galaxies are brighter and require shorter exposures. Face-on spirals are usually the dimmest galaxies and require longer exposures. When using a scope with a very long focal length, large pixels or binning may be required to get reasonable exposure times.
Nebulas	Nebulas come in an even wider range of brightness than galaxies do. Some, like M42, will yield excellent results in less than 20 seconds. Others, like the Rosette Nebula, may require 20-minute exposures to get good detail. A few trial exposures will help you determine the best exposure for any given nebula.

Generally speaking, longer exposures are better in most cases because they provide better-quality data. However, blooming, the risk of passing satellites or airplanes, and other factors usually limit the longest exposure time you can use. You can take multiple exposures and combine them in various ways to increase the quality of your photos.

Select Bin Mode (Binning pop-up)

Binning groups of pixels together allows you to match pixel size to telescope focal length. Pixels that are small require longer exposures and provide higher resolution. Large pixels allow shorter exposures but provide lower resolution. For any given combination of camera and telescope, one bin mode or another will provide the optimal compromise between exposure duration and resolution.

Figure 192 shows how binning works. Binning 2x2 groups four pixels together, giving you virtual pixels that are made up of 4 actual pixels. Binning 3x3 yields virtual pixels made up of nine actual pixels.

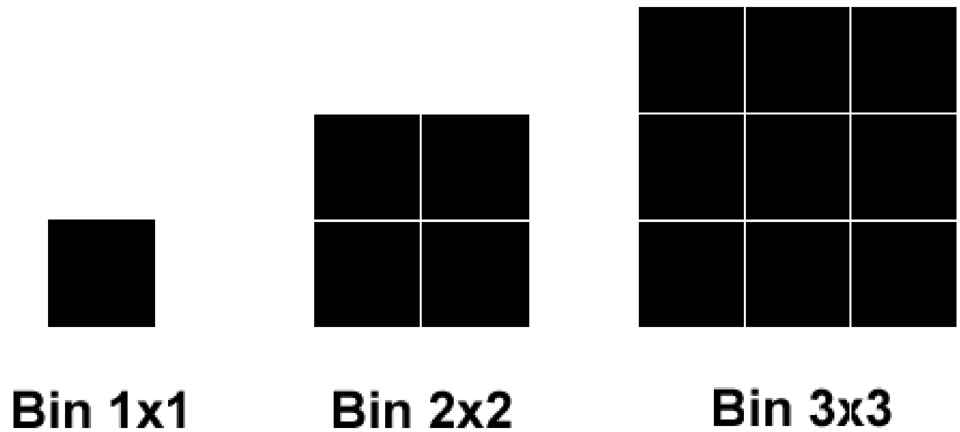


Figure 192: Bin modes group pixels together for greater sensitivity, at a cost of lower resolution.

Figure 193 shows the relative sizes of image taken with 1x1 binning (larger image) and 2x2 binning (smaller image). Both images cover exactly the same area of sky, about 1 by 1.5 degrees in this example. The 2x2-binned image shows that the binned detector is more sensitive because there is more detail visible in the dim areas of M42. It also shows that the binned pixels bloom less quickly – four pixels can hold more energy than one before they spill over into adjoining pixels.

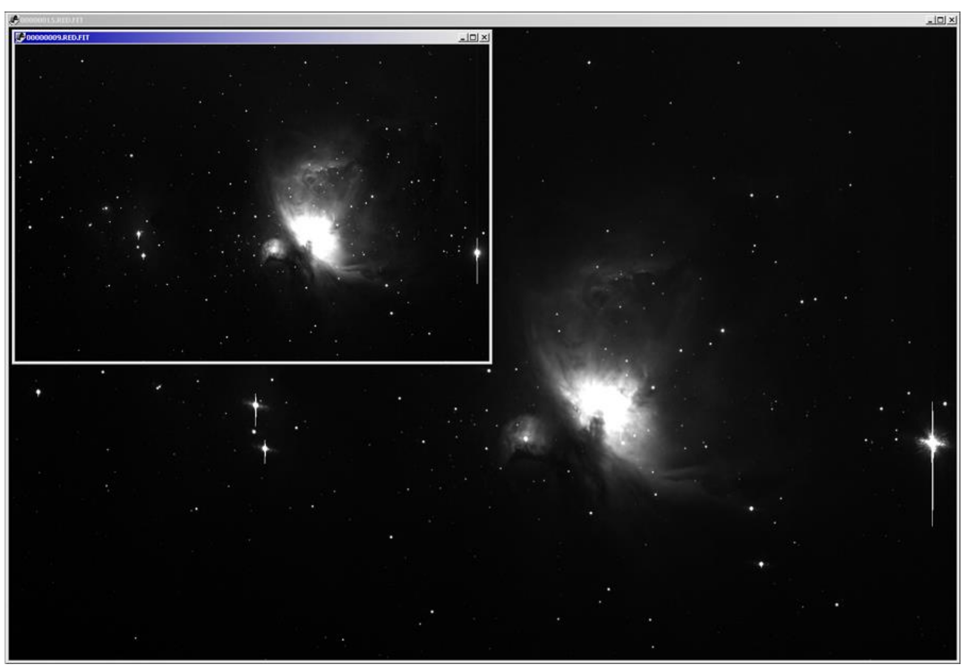


Figure 193: Relative sizes of a 1x1- and 2x2-binned image.

Generally speaking, you will most often use a bin mode that will delivers between 2 and 4 arcseconds per pixel. This is the most common range for general-purpose CCD imaging. When working in this range, each pixel in the image “sees” or covers 2 to 4 arcseconds of the sky. The seeing conditions on most nights allow approximately 2 to 4 arcseconds of detail, and that is the reason for this range of values. If you have better or worse seeing conditions, select a bin mode based on your local conditions.

High-resolution imaging provides fewer than 2 arc-seconds per pixel, and can only be done on nights when the seeing is exceptionally good. This type of imaging is used most often for planets, but can also yield very fine detail on galaxies. The key is to wait for exceptional seeing conditions that will support higher resolution.

Low-resolution imaging (more than 4 arc-seconds per pixel) allows you to image wide fields of view, and can be done with camera lenses or telescopes with very short focal lengths. Seeing is unlikely to affect low-resolution wide-field images, so you can do this kind of imaging on almost any clear night.

You can use various tools and web pages to determine arcseconds per pixel for your camera and telescope combination, or use the following formula:

$$\frac{(205 * pixel\_size\_in\_microns)}{telescope\_focal\_length\_in\_mm}$$

If you are binning 2x2, be sure to double the pixel size to get the correct value. For example, if you have an ST-7E camera (9-micron pixels) and are using it unbinned on a Meade LX200 8-inch at f/10, this is:

$$\frac{(205 * 9)}{2000}$$

Or 0.93 arcseconds per pixel. That's very high resolution. Since a typical night offers 2-4 arcsecond seeing conditions, you would rarely be able to use all that resolution. Binning 2x2 yields 18-micron pixels, which gives you 1.86 arc-seconds per pixel. This is just under two arcseconds per pixel, and offers a good compromise on nights of typical seeing.

You can also approach this from another direction: using a 50% focal reducer will bring the focal length of this scope down to 1000mm, which provides 1.86 arcseconds per pixel unbinned.

Binning also increases the sensitivity of your camera, as shown in Figure 193. Smaller pixel size means higher resolution, while larger pixel size means greater sensitivity.

When you bin 2x2, you are making the pixel size four times larger in area, so the virtual pixel is four times more sensitive to light. You are making a tradeoff between resolution and sensitivity whenever you select a bin mode for your image.

Try an experiment for yourself. Take a one-minute exposure of a galaxy using 1x1, 2x2, and (if available) 3x3. Note the differences in resolution and sensitivity.

Set Frame Type to Light

If you are just getting started, make sure that the ***Frame*** is set to ***Light***. The Frame pop-up also includes settings for taking photo reduction frames. A CCD detector generates a certain amount of noise, and photo reduction removes a great deal of that noise. When you are taking a photo, always set the frame type to ***Light***.

Frame Types	Description
Light	A normal photo, taken with the shutter open.
Bias	A frame of the shortest possible exposure, taken with the shutter closed. It represents the minimum noise in the CCD detector and camera circuitry. This frame is subtracted from Dark frames so that the dark frames can be scaled for time and temperature differences.
Dark	A photo taken with the shutter closed. It is in effect a picture of the electronic noise in the camera. This noise can be subtracted from a Light image to create a cleaner image.
Flat Field	A flat-field is an image taken of an evenly illuminated field, with the shutter open. Think of the flat-field as a photograph of the optical noise in the system, such as dust motes on glass surfaces or reflections off of the inside of the telescope. The ***Flat Field*** is applied to the Light frame to eliminate this source of noise.

Set an Appropriate Reduction Setting (Reduction pop-up)

When you select ***Light*** as the frame type, you can also choose the type of reduction to apply to the photo. Reduction is the process of applying bias, dark, and flat-field frames to your image to reduce system noise.

For your first images, choose the ***AutoDark*** reduction setting. After your exposure is finished, the software will automatically take a dark frame with the same exposure settings, and subtract it from the photo. This will give you a cleaner image with less thermal noise. When you gain more experience, you can explore the other reduction options:

Dark Frame	Description
None	The software performs no photo reduction. Use this setting when you wish to manually apply your own bias, dark, and flat-field images; or when you simply want a quick image without any reduction.

AutoDark This will follow the first exposure with a single dark frame. The dark frame is saved in memory and will be applied to all subsequent exposures with the same duration and temperature. If you change the exposure duration, or the camera's cooled temperature changes several degrees, a new dark frame will be taken.

Automatically Save Photos

Turn on the ***Automatically Save Photos*** checkbox to automatically save each acquired photo to the computer's hard drive.

On the ***Imaging System Setup*** window, highlight ***Camera*** in the ***Hardware*** list, then click the ***AutoSave Setup*** button to configure how photos are saved. The most common choice is to automatically save all photos. You can even save focusing photos if you so want. Photos from both the imager and autoguider can be saved automatically.

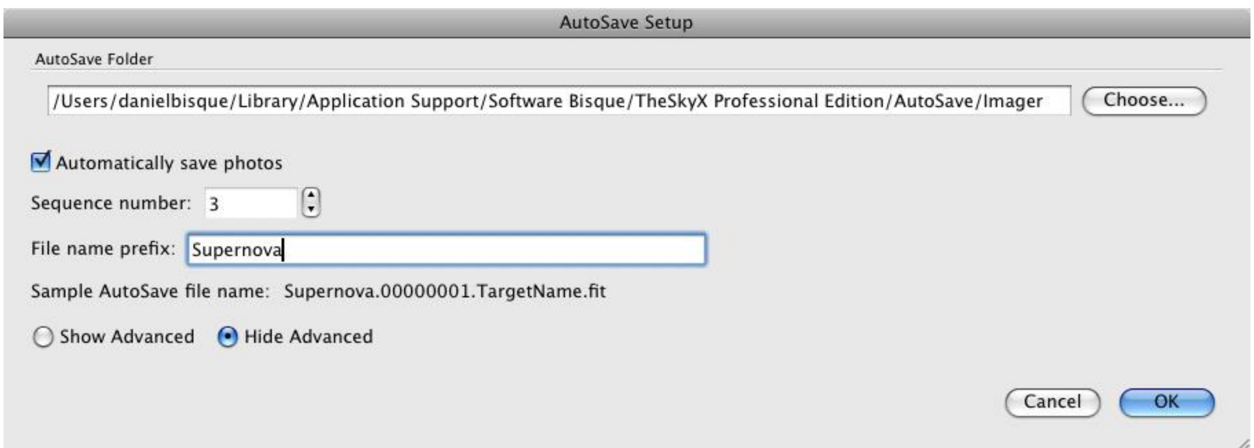


Figure 194: The AutoSave Setup window with the advanced settings hidden.

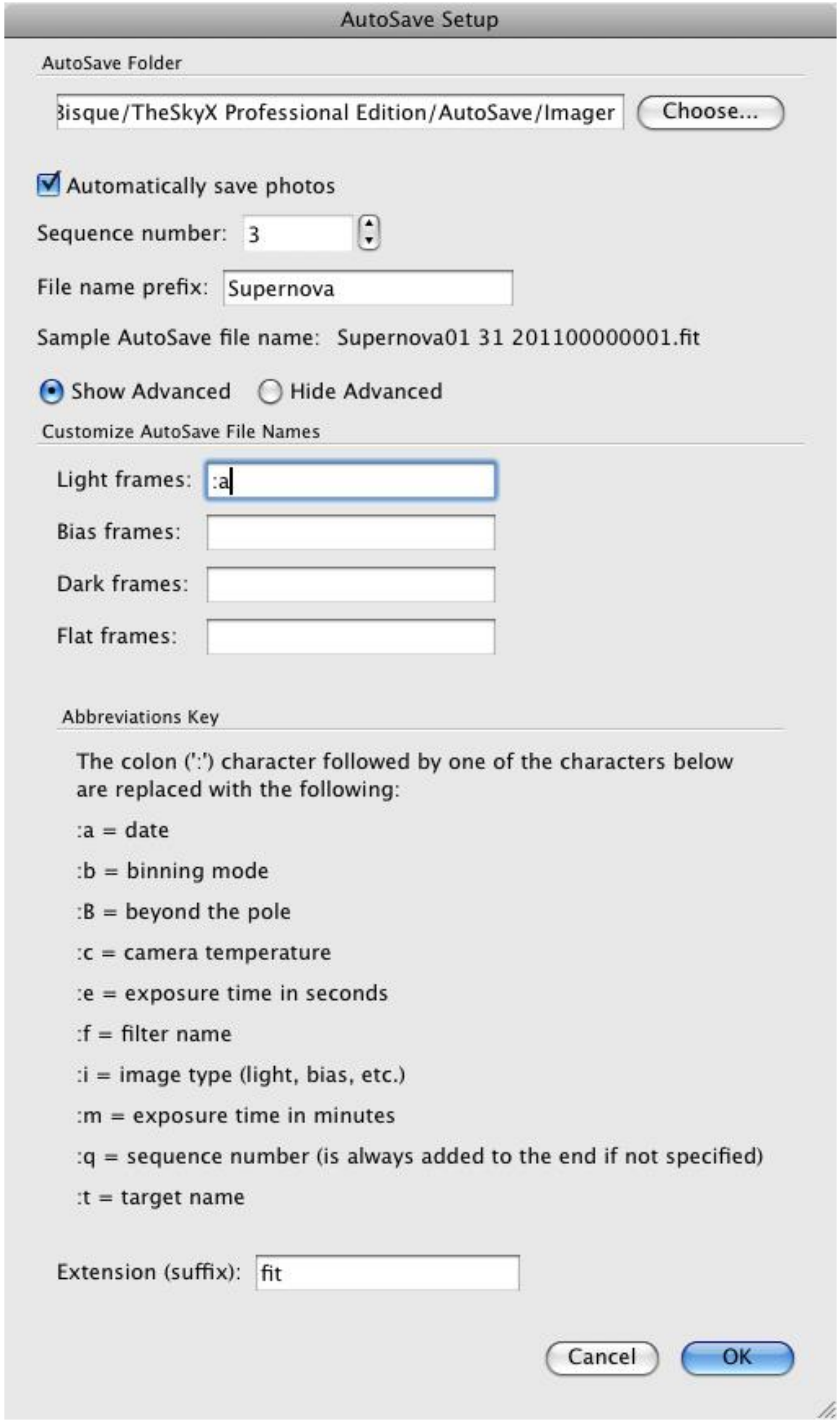


Figure 195: The AutoSave Setup window showing the Advanced settings.

AutoSave Folder

This text box shows the current folder where photos are saved. The default location is the AutoSave folder in the Application Support Files folder (page 24). Click the ***Choose*** button to select a different folder.

Automatically Save Photos

Turn the checkbox on to save all photos.

Sequence Number

Each time a photo is saved using AutoSave, this ***Sequence Number*** is incremented by 1. If you want to have a unique number for every photo, leave this value unchanged. Or, you can reset the sequence number back to 1 every observing session or every series of photos.

File Name Prefix

Use this text box to define the text that will appear at the beginning of each file name.

Sample AutoSave File Name

This text box shows what an automatically saved file name will look like based on the current settings.

Show/Hide Advanced

File names for light, bias, dark and flat frames can be customized individually by turning on the Show Advanced radio button and defining the frame-specific file name "keys". Each key defines specific information that is used to construct a unique file name.

Customize AutoSave File Names (Light, Bias, Dark, Flat Frames)

For each frame type, enter a set of "abbreviations" to define the file name.

Abbreviation	Explanation
:a	Enter the colon character followed by a lower case letter "a" to insert the date when the photo is acquired. For example, the text ***01 31 2012*** is inserted in the file name for photos acquired on January 31, 2012.
:b	Enter the colon character followed by a lower case letter "b" to insert text that defines the bin mode (***1x1***, ***2x2***, ***3x3***) used to acquire the photo.
:B	Enter the colon character followed by an upper case letter "B" to insert text that defines the orientation of a German equatorial mount when the photo is acquired. The "beyond the pole" (Btp) convention is used to define the position of the optical tube assembly end of the declination axis with respect to the celestial pole. ***NoBtp:*** The mount's current orientation is not

Abbreviation	Explanation
	beyond the pole. ***Btp:*** The mount's orientation is beyond the pole.
:c	Enter the colon character followed by a lower case letter "c" to insert the current temperature sensor. For example, ***–5.02C***.
:e	Enter the colon character followed by a lower case letter "e" to insert the exposure time, in seconds. For example, ***61.05secs***.
:f	Enter the colon character followed by a lower case letter "f" to insert the filter name used to acquire the photo. For example, ***Green***.
:i	Enter the colon character followed by a lower case letter "i" to insert frame type. For example, ***Light***. Options: Light Bias Dark Flat
:m	Enter the colon character followed by a lower case letter "m" to insert the exposure time, in minutes. For example, ***1.02mins***.
:q	Enter the colon character followed by a lower case letter "q" to insert the current sequence number in the file name. Note that a sequence number is *always included in AutoSave file name*. If no ***:q*** appears in the custom name, the sequence number appears at the end of file name, before the file name suffix. Otherwise, add a ***:q*** at the desired position of the sequence number.
:t	Enter the colon character followed by a lower case letter "t" to insert the name of the target object. For example, ***Andromeda Galaxy***.

Extension (suffix)

Enter an extension for the AutoSave file name that appears after the period character in the file name. By default, the three letter extension ***fit*** is used when automatically saving Flexible Image Transport files.

Digitized Sky Survey Photos (Simulate Photo Using DSS)

Turn on the ***Simulate Photo Using DSS*** checkbox to take photos of Digitized Sky Survey objects, instead of collecting “actual” photons with the camera’s detector and a telescope. See “Creating a FITS File of a Digitized Sky Survey Photo” on page 81 for more information about configuring *TheSkyX Pro* to retrieve photos from the Digitized Sky Survey.

You can control *where* in the sky the simulated camera is pointing by selecting a new target in the ***Find*** window (page 55), or connecting to a simulated (or actual) telescope, and then slewing the telescope to the target (page 298)

Taking a Photo

To take a photo, click the ***Camera*** tab, enter the ***Exposure Length***, ***Binning*** and click ***Take Photo*** button.

When the photo is ready, it is displayed in the ***FITS Image Viewer*** window (page 82).

Autoguiding

The *Camera Add On* incorporates many powerful features for autoguiding using CCD, DLSR or video camera.

This chapter describes how to use the *Camera Add On* to autoguide using a camera with dual CCDs from SBIG (essentially two cameras in one, where autoguiding is called Self-Guiding) or autoguide using two independent cameras, one for imaging and one for autoguiding. We typically refer to the imaging camera or "main camera", the one that is capturing the resultant autoguided photo, as the "Imager" and the autoguiding camera as the Autoguider.

Here you will learn how to:

- Determine how well your mount can autoguide.
- How to fine-tune your mount for autoguiding.
- How to use the autoguiding features in the *Camera Add On* effectively.
- How to customize the autoguiding settings to meet your needs.

Quick Start for Experienced Users

For this chapter, an experience user is someone who has already used other camera control program to autoguide.

One important feature in the ***Camera Add On*** is the ability to continue autoguiding even after downloading an image. This allows you to take multiple, autoguided photos without restarting autoguiding. The autoguiding process runs independently of the imaging process. In fact, if you have a physically separate, independent autoguider, autoguiding is continuous (with an SBIG dual CCD the imager and autoguider share the same shutter so autoguiding is briefly paused while the imager is downloaded).

Another key feature: since the *TheSkyX Professional Edition* with the *Camera Add On* includes a complete framework for star charting and telescope control, the *Camera Add On* offers unsurpassed camera, guider, focuser, filter wheel, rotator, and mount integration.

Before you can autoguide, you must first *calibrate the autoguider*. Open the ***Autoguider*** tab (click **Display > Autoguider** if the window is not visible), and follow these steps:

Autoguider Calibration

1. From the ***Autoguide*** tab on the ***Autoguider*** window, click **Connect**.
2. Click **Take Photo** and use the mount’s motion controls, or the camera's relay buttons, to position a bright calibration star on the autoguider photo, and not near an edge of the photo. For best results, the star should not be saturated and there should not be any stars

of similar brightness on the photo so that the bright calibration star can be easily recognized.
3. Click ***Calibrate***. While the calibration is in progress, the autoguider photo shows arrows on the photo to indicate the direction the calibration star moves as each relay is activated (that is, when the mount is moved). If calibration fails due to insufficient guide star movement, click **Settings** and increase the ***X*** and ***Y*** calibration times and or check the relay cable from the camera to the mount to make sure it is functioning properly.
4. When calibration is complete, the results are displayed (you can view the results any time by clicking **Setup** and going to the ***Relay Calibration Results*** tab).

Autoguiding

From the ***Autoguide*** tab for the Autoguider:

1. With no sub-frame and ***1x1*** binning, click ***Take Photo***. Adjust exposure time so that one or more guide stars are visible. See "Choosing a Good Autoguider Calibration Star" on page 375 for details.
2. Double click on the guide star. A *track box* is centered on the guide star and momentarily flashes to identify the guide star selection. You can also choose the guide star by clicking the ***Auto Find Guide Star*** button to scan the entire image for the brightest light source and place the track box on it.
3. Click ***Take Photo*** to confirm the brightness, location and presence of the guide star.
4. Click ***Autoguide*** to start the autoguiding process. Watch the ***X*** and ***Y*** errors; when they "settle down" and are at acceptable levels, from the ***Camera*** tab, click **Take Photo** to begin acquiring your "guided" photo.

Principles of Autoguiding

The fundamental idea behind autoguiding is simple: For successive photos, the *Camera Add On* measures the exact position (the star's *centroid*) of the guide star. If the star's position deviates from one exposure to the next, the *Camera Add On* adjusts the telescope to keep the guide star at its original position. This process minimizes mount tracking errors that cause elongated stars.

The *Camera Add On* can control *two independent cameras* (one for autoguiding and the other for imaging), or an SBIG dual CCD that contains both an imaging CCD and an autoguiding CCD.

You can also configure the *Camera Add On* to use *either detector* as the imager or the autoguider. This means that every feature available to the imaging camera is also available to the autoguiding camera, and vice versa. To use this advanced capability, turn on the ***Advanced Camera User Interface (Restart Required)*** checkbox from the ***Advanced*** pane of the ***Preferences*** window (The ***Preferences*** command is accessed from ***TheSkyX*** menu on the Mac, the ***Tools*** menu on Windows).

When this checkbox is turned on and, after *TheSkyX Professional Edition* is restarted, the ***Camera*** window has both a ***Take Photo*** tab and an ***Autoguide*** tab. Similarly, the ***Autoguider*** window has both a ***Take Image*** tab and an ***Autoguide*** tab. To minimize confusion, this option is off by default. Just remember, the ***Camera*** and the ***Autoguider*** can both image and autoguide and you are free to choose which configuration option best suits your needs.

The basic steps to autoguide are:

1. Calibrate your autoguider (The *Camera Add On* determines how the mount reacts to guider corrections).
2. Choose a guide star.
3. Autoguide; that is, continually adjust the position of the mount so the guide star remains at a fixed position.

Unwanted motion of the guide star typically results from three sources:

- Poor polar alignment, which causes a slow drift of the field.
- Periodic error in the mount's mechanics, which causes star images to elongate as the mount speeds up and slows down by very small amounts during rotation of the worm gear.
- Systematic errors due to flexure, variations in gears, etc. (Paramount owners should turn on ProTrack so the autoguider has less to do).

Various complexities creep into the seemingly simple autoguiding operation (that is, slewing the telescope to a star and guiding on a star over a long period):

- The required pointing accuracy is very high, usually on the order of several arcseconds. Since one arcsecond equates to one part in 1,296,000, the magnitude of pointing accuracy isn't just high; it's extraordinarily high.
- The longer the focal length of your telescope, the greater the accuracy required for accurate, successful guiding.
- Mounts have some degree of repeating error, called periodic error. Some mounts have built in periodic error correction (PEC); some do not. Autoguiding can correct most tracking errors related to periodic error.
- If the mount is even slightly misaligned from the celestial pole, telescope drift over time is introduced and will cause tracking errors. The greater the misalignment, the greater the drift. Good polar alignment makes autoguiding easier.
- Any mechanical "looseness" in the mount can contribute to pointing error (hysteresis). There are many potential sources of hysteresis, including backlash (slop) in the gears, mirror flop, and endplay of a worm gear. Some hysteresis can create counterintuitive movements, such as a movement in declination causing a movement in right ascension. You can diagnose these types of problems by using a high-power reticle eyepiece to observe what happens during tracking and guiding.
- The tripod, mount, and the optical tube assembly are subject to different amounts of flexure as the weight of the telescope moves over time. This can contributes to guiding errors and to pointing errors as well.
- If all of the parts of the mount aren't exactly aligned with each other, pointing error is the result. For best results, you want your telescope orthogonal to the mount, especially when

polar aligning. (The optional *TPoint Add On* to *TheSkyX* can be used to automatically correct these errors.)

- Turbulence in the atmosphere (seeing) can change the apparent position of the star used for reference in a random manner over time. This makes it look as if a guiding correction is needed even when it is not, or depending on timing, it could also mask the need for guiding corrections. The worse the seeing, the harder it is to guide accurately. Longer guide exposures can compensate for poor seeing, to some degree.

In short, keeping a telescope pointing at an object over the length of time involved in an extended exposure is not a trivial task. Any given mount will have a certain level of accuracy that it can reach. Pushing a mount past this point will result in guiding and tracking errors that will at the very least reduce the quality and sharpness of your images, and at worst turn stars from round circles into ellipses or worst case lines. Generally speaking, if you find that your mount simply cannot track or guide accurately enough for your equipment, try shortening your focal length with a focal reducer, or switch to a telescope with a shorter focal length.

Assessing Mount Accuracy

A mount has two axes, and most mounts today can guide by making adjustments to both axes. However, the right ascension and declination axes behave in fundamentally different ways.

The right ascension axis is always moving to keep up with the apparent motion of the stars. This rate of motion is called the sidereal rate, and is very nearly one revolution per day. You will often see reference to some fraction of the sidereal rate, such as 1x (exact sidereal rate), 0.5x (one-half sidereal rate), etc.

Because the right ascension axis is always moving, you have an opportunity to eliminate many (but not all) sources of error by simply making guiding corrections at speeds slower than the sidereal rate. For example, it is common to make right ascension adjustments using either 0.5x sidereal (slow the mount down to half speed to move it further east), or 1.5x sidereal rate (speed the mount up to 150% of sidereal rate to move it further west). Depending on the focal length of your telescope, you may get better results at 0.75x/1.25x (shorter focal lengths), or at 0.25x/1.75x (longer focal lengths).

The declination axis, on the other hand, is stationary until a correction needs to be made. If there is substantial looseness in the declination axis at any point (motor bearings, reduction gears, worm endplay, or worm mesh with the worm gear), the mount may literally be unable to guide adequately in declination.

The result of these differences is that special attention must be paid to the state of the declination axis components to obtain high-quality guiding results. See “Assessing Autoguiding Possibilities,” for detailed information about getting the best autoguiding results out of your mount.

Autoguider Calibration

Once your mount is tuned to minimize backlash and/or correct any other problems, you can use it for autoguiding. See the section “Adjusting and Tuning Your Mount” for details on getting the most out of your mount.

Autoguiding makes small corrections to keep a guide star at a given location on a CCD. This corrects for small errors in polar alignment; for periodic error that results from slight eccentricity in the worm or worm gear; and other errors that result from a mount and system that is simply not perfect. The pixel size of your CCD, the focal length of your telescope, and the length of your guide exposures all affect the rate and amount of movement during an autoguiding correction.

The autoguide correction speed also changes with declination. At the celestial equator, correction speed is highest because the lines of equal right ascension are furthest apart. Near the poles, the effective correction speed is slower because the lines of equal right ascension are closer together. The autoguider calibration takes care of this.

Before you can autoguide, you need to perform an autoguider calibration. Calibration allows *Camera Add On* to determine your system's behavior during autoguiding corrections. The *Camera Add On* uses the calibration data to determine how long to move the mount (at whatever guide speed you are using) to make an appropriate autoguider correction. You can perform a single calibration, and *Camera Add On* will adjust the corrections for other declinations. If you choose this method, you should perform the initial calibration near the celestial equator so that the scaling will be most accurate. You can also perform a new calibration whenever you move the telescope to a new declination in order to achieve the highest level of autoguiding accuracy. The longer your focal length, the more you have to gain from performing new calibrations when you change declination.

The basic steps in calibrating the autoguider:

1. Connect the hardware to autoguide. This is typically accomplished by connecting a guider cable from the camera to the mount. Paramount users can configure the *Camera Add On* to autoguide using DirectGuide, which eliminates the need for a guider cable.
2. Move the telescope so that a suitably bright star falls on the autoguider detector.
3. Take a reference image to verify the presence, location, and brightness of the calibration star.
4. Perform the calibration.

How often should you perform a calibration? Calibration frequency depends on your imaging session and your equipment.

If you have a GEM, and “flip” the mount to point on the other side of the meridian, the direction of correction for the x relay changes direction. When *TheSkyX Professional Edition* is controller the telescope, the *Camera Add On* automatically detects the meridian flip and reverses relay direction.

If you are using the *Camera Add On* to autoguide, and the telescope is not controlled by *TheSkyX Professional Edition*, the ***Reverse X*** checkbox on the ***Autoguide*** tab reverses X corrections, and you can manually turn this checkbox on when the mount is on the opposite side of the meridian. But remember, (especially with longer focal lengths), you can always recalibrate the autoguider. The longer your focal length, the greater the sensitivity to changes, and the more likely you are to need to recalibrate whenever you autoguide at a new location.

To calibrate the autoguider, from the ***Autoguider*** tab, click the ***Autoguide*** tab. For an overview of all of the controls on the ***Autoguide*** tab, see "Autoguide Tab" on page 390.

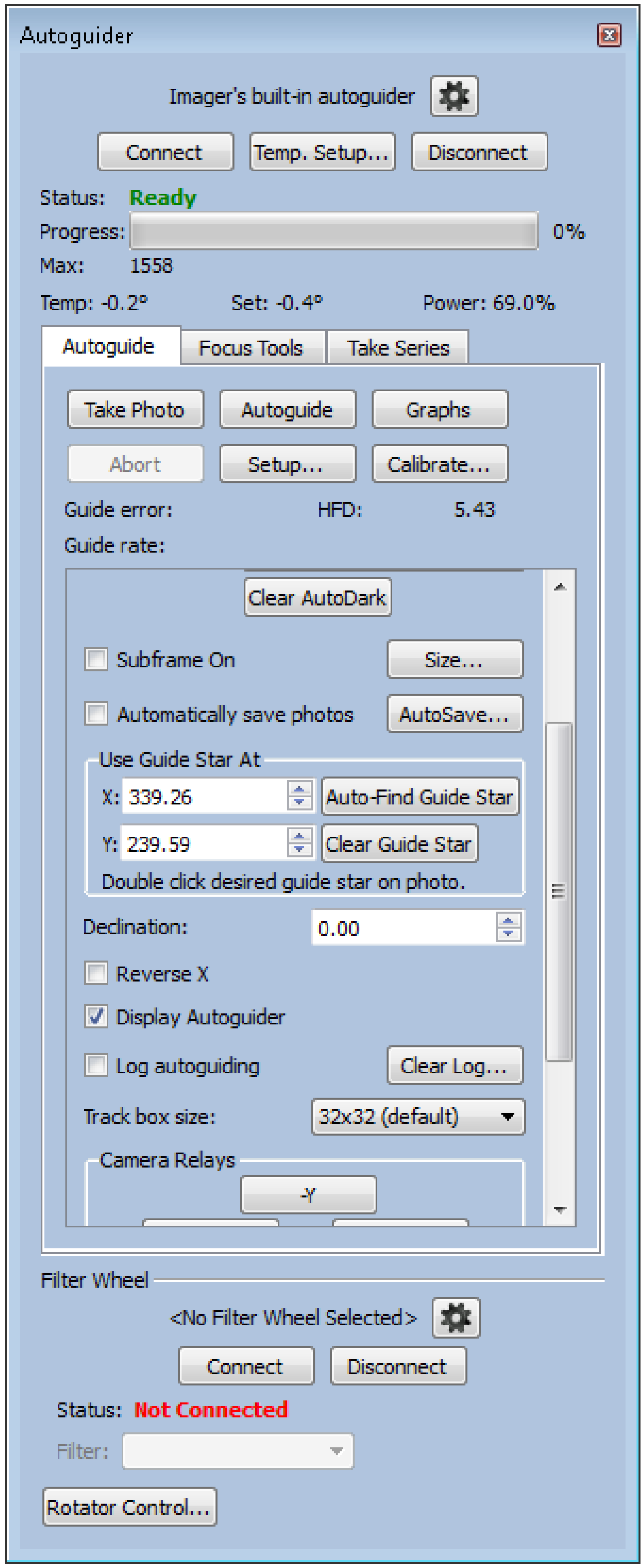


Figure 196: The Autoguide tab.

Make sure the hardware is connected

To autoguide, you need either a camera that will be dedicated to autoguiding, such as a video camera, SBIG ST-i, or an SBIG dual CCD camera that has its own built-in autoguiding detector.

Consult the camera documentation for instructions on how to connect the autoguider cable to the camera. The other end of the autoguide cable attaches to your mount; consult your mount documentation for the location of the autoguider connection.

Not all mounts support input from an autoguider. Contact the mount manufacturer for information on how to build an interface box or cable to fit such a mount. Most cameras come with a standard autoguider cable. If the standard cable doesn't fit your mount (such as for a Takahashi mount, or a Vixen Sky Sensor-equipped mount), consult the mount documentation for information about building or buying a suitable cable. Some mounts require the use of third-party relay hardware to provide appropriate guide signals; read your camera and/or mount documentation for details.

Choosing a Good Autoguider Calibration Star

When calibrating the autoguider, selecting an appropriate calibration star is important. As you will see shortly in the list of possible errors, the brightness and location of the star used for autoguider calibration plays a major role in the success or failure of the calibration. Here are some tips in picking a good autoguider calibration star.

- Don't use a dim, hardly recognizable, calibration star.
    - The calibration star should be bright enough to show clearly against the background. Typically this is achieved if you can visually and easily identify the star on the autoguider photo using the *Camera Add On's* standard auto-contrast routines. In other words, do not try to calibrate the autoguider using a dim, hardly recognizable star. You can run the cursor over the star and the background to see how bright they are; the brightness values appear at the left of the status bar at the bottom left of the photo window. The longer the exposure, the brighter the stars and background, but star brightness will increase faster than background brightness. If you can't find a suitable calibration star for a given exposure, increase the exposure time to see if any good candidates emerge.
- Don't use a saturated calibration star.
    - The calibration stars brightness should not be close to the camera's saturation level. The calibration star brightness will indeed vary and you want make sure it does saturate because saturation can lead to an incorrect star position and thus leading to an incorrect autoguider calibration.
- Don't use a calibration star close to the edge of the CCD.
    - The calibration star should not be near any edge of the autoguider CCD. This is critical when calibrating, since the *Camera Add On* will move the mount during autoguider calibration and you don't want the calibration star to move off the detector. If the calibration star moves within 10 pixels of an edge, calibration will fail with an error stating so. You can use the camera relay buttons, the telescope's motion controls, or the mount's hand controller to move the calibration star more toward the center of the photo.
- During autoguide calibration, the *Camera Add On* finds the autoguide calibration star after each calibration relay adjustment (that moves the mount) by scanning the photo for the brightest light source. Because the *Camera Add On* can autoguide with the camera at any

orientation, the *Camera Add On* does not make any assumptions about which way the calibration star will move with respect to relay activations and instead relies on the convention that the brightest light source on the autoguider photo during autoguide calibration is the calibration star. It is critical that during autoguide calibration the calibration star is significantly brighter than all other stars on the image otherwise the *Camera Add On* might incorrectly choose a different calibration star of similar brightness on a subsequent photo.

- Sometimes an unintended bright star will enter the photo after relay activation and usually results in the calibration error "invalid motion". In this case, pick a different autoguide calibration star in a different area. No other star in the tracking detector's image should be close to the brightness level of the calibration star when calibrating. Otherwise, the *Camera Add On* can get confused about which star is the calibration star. You can use the *Camera Add On* to visually inspect the area around your selected guide star. Check for a distance equal to the 1.5 times the width of the area covered by the autoguiding CCD detector at a minimum. See the section "Select a Guide Star," in this chapter, which can help you select a guide star.
- Accurate focus is required to accurate autoguider calibration. See "Using @Focus2" on page 463 for a reliable, automated focus method.
- Make sure the camera is cooled to the desired temperature setpoint to minimize noise/hot pixels.
- Turn on ***AutoDarks*** so that calibration images do not have as much noise or hot pixels.
- Do not use a long calibration time. The shortest calibration time that results in a successful calibration without a "Motion too small" error is optimal. There is not a lot to gain by having an unnecessarily long calibration time and there are in fact disadvantages; the whole calibration takes longer and the chances of the calibration star moving off the photo increase.

> If you find that calibration repeatedly to fails because the *Camera Add On* finds a different calibration star from photo to photo, use the a subframe to capture less of the photo and aid the *Camera Add On* in finding the same bright, calibration star in photo to photo.
>
> In other words, the subframe applies during autoguide calibration and you can use that to your advantage (and perhaps avoid a say pesky hot pixel in a certain region of the CCD). Avoid making the subframe too small or the calibration might move the guide star off the photo.

Choosing a Good Guide Star

- The *Camera Add On* is able to autoguide with either a dim guide star that is only a few counts above the background, which can be challenging, or a guide star that is bright and easily recognizable to the eye, which is less challenging. Generally speaking, autoguiding will do fine if the guide star is, say, 1,000 or more counts brighter than the background (more if you are doing tricolor imaging, since color filters will reduce the star's brightness, and the brightness of the star will often vary with the filter used).

- If your image composition makes it impossible to put the guide star near the center for autoguiding, you can still get good results as long as the star is at least 10 pixels from an edge. However, you increase the risk of losing the guide star during downloads from the Imager. The *Camera Add On* will automatically reacquire the guide star after Imager download, but cannot do this if the guide star has moved off the detector. The greater the periodic and random errors of your mount, or the poorer the polar alignment, the greater the chances of losing the guide star during Imager download.
- When autoguiding, a star of similar brightness should not be within the autoguider track box, or the *Camera Add On* may jump between the two stars during autoguiding.

Take a Photo as a Reference

Typical autoguide exposures range from 1 to 10 seconds. Shorter and longer exposures can be used, but are not often necessary. Guide exposures shorter than 1-2 seconds can be affected by seeing. When the guide exposure is very short, the autoguiding often winds up measuring and correcting for fluctuations in the atmosphere rather than actual guide star movement that needs to be corrected. If the autoguide exposure time is too long, the guide star could move so much that corrections are not being made when they should be, resulting in an undesirable final image with elongated stars.

The *Camera Add On* automatically accounts for autoguiding at a declination different from where the autoguider was calibrated, provided *TheSkyX Professional Edition* is controlling the mount during autoguider calibration and during autoguiding. If no mount is connected, you must manually enter the declination that the telescope is pointing to in the box labeled **Declination**. An accuracy of one-tenth degree is sufficient if you enter this value manually.

The image you take as a reference image should be long enough to clearly acquire a star suitable for guiding. If you are unsure, start with an exposure of 1 to 10 seconds. You can always adjust the exposure length as needed.

Click ***Take Photo*** on the ***Autoguide*** tab to acquire an autoguider photo. Figure 197 shows the result for the guide detector on an SBIG ST-2000 camera. The guide detector is much smaller than the imaging detector, so download times are short. By default, a dark frame is automatically taken and subtracted from the light frame (reduction is set to ***AutoDark***).

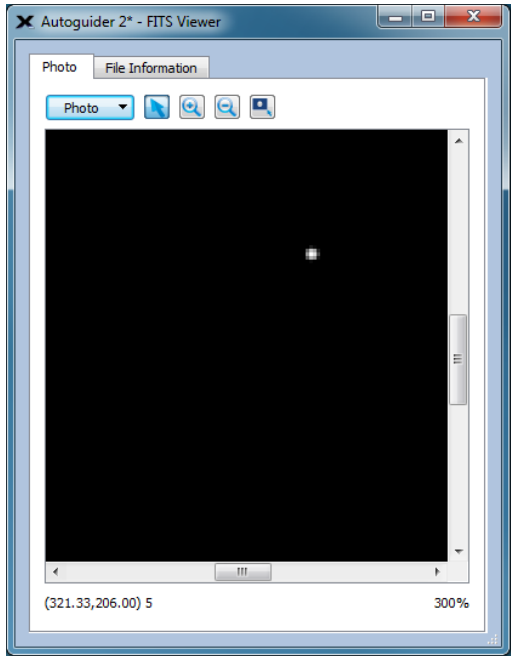


Figure 197: An autoguide image taken for reference. Note that there is an, isolated, bright star which is a good choice for a guide star.

Evaluate the image to determine if the exposure time provides a suitable brightness level for the guide star. As mentioned earlier, a good guide is at least 1,000 units over background level, and not near saturation.

Select a Guide Star

You can either click ***Auto Find Guide Star*** on the ***Autoguide*** tab to have the *Camera Add On* pick the brightest star for the guide star, or you can double click any desired guide star on the photo. A white track box flashes briefly around the star to indicate that it has been selected as the guide star. Also, the coordinates of the selected guider star appear in the ***X*** and ***Y*** boxes of the ***Use Guide Star At*** control.

The *Camera Add On* can display the precise coverage of your CCD detector on the sky display (ST-237 and similar cameras) or both the imaging and tracking CCD detectors (ST-7/8/9/10) on the map of the sky. Figure 198 shows the projection for an ST-8E camera. The inner rectangle is the imaging detector; the small rectangle above it is the tracking detector. The circles show the position of the tracking detector if you rotate the camera. These circles can help you find an alternate guide star just by rotating the camera, instead of moving the mount. The *Camera Add On* does not require that the camera be orthogonal (square) to the mount in order to autoguide. It will calibrate and guide successfully at any camera angle.

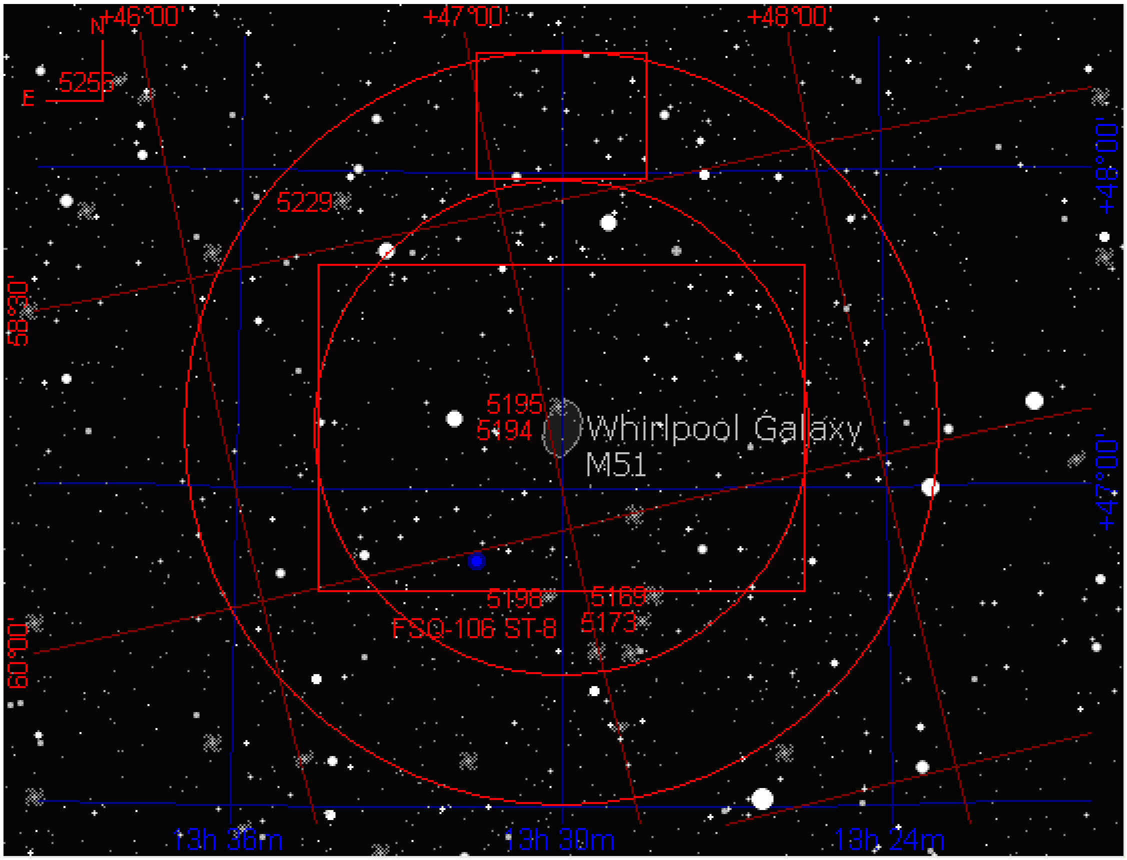


Figure 198: The imager and autoguider detectors of an ST-8E with an ST-237 guider camera.

To set up your camera's field of view indictor, follow these steps in *TheSkyX Professional Edition:*

1. Click Display > Field of View Indicators.
2. Choose your telescope and detector and click ***Create My FOVIs***.
3. Click the ***My FOVIS*** tab, turn on the checkbox next to your FOVI and click ***Center***.

The field of view indicator will only appear when magnifications on the start chart are large enough to see it. Zoom in if necessary to see the field of view indicator (page 93).

In Figure 199, the pair of interacting galaxies known as Messier 51 (M51) is centered on the imaging detector, and celestial north is straight up on the Sky Chart. The box at the top shows that there are a few dim stars on the tracking detector, but none is very bright, and none are near the center. The two galaxies form a nearly vertical line with each other, and several dimmer galaxies are also in the frame. You could try to guide using the star at the eight o'clock position on the tracking detector, but for calibration you should move the mount to bring a brighter star onto the tracking detector.

A brighter guide star allows you to use a shorter guide exposure time. If your mount is very stable and accurate, you can use longer guide exposure times and therefore dimmer guide stars are suitable. If your mount has poor polar alignment, larger periodic error, or suffers from random movements during tracking, brighter guide stars are more important to a nicely autoguided Imager photo.

Figure 200 shows one approach to finding a nice, bright guide star: move the mount so that a bright star falls on the guide detector, while M51 remains in the same orientation. M51 has been moved away from the center of the imaging detector. If you want M51 near the center, you can also rotate the camera to bring a guide star onto the guide detector. If your mount has goto features, you can control it from *TheSkyX Professional Edition*. Changing the camera's rotation requires a trip out to the telescope, unless the *Camera Add On* is connected to the rotator.

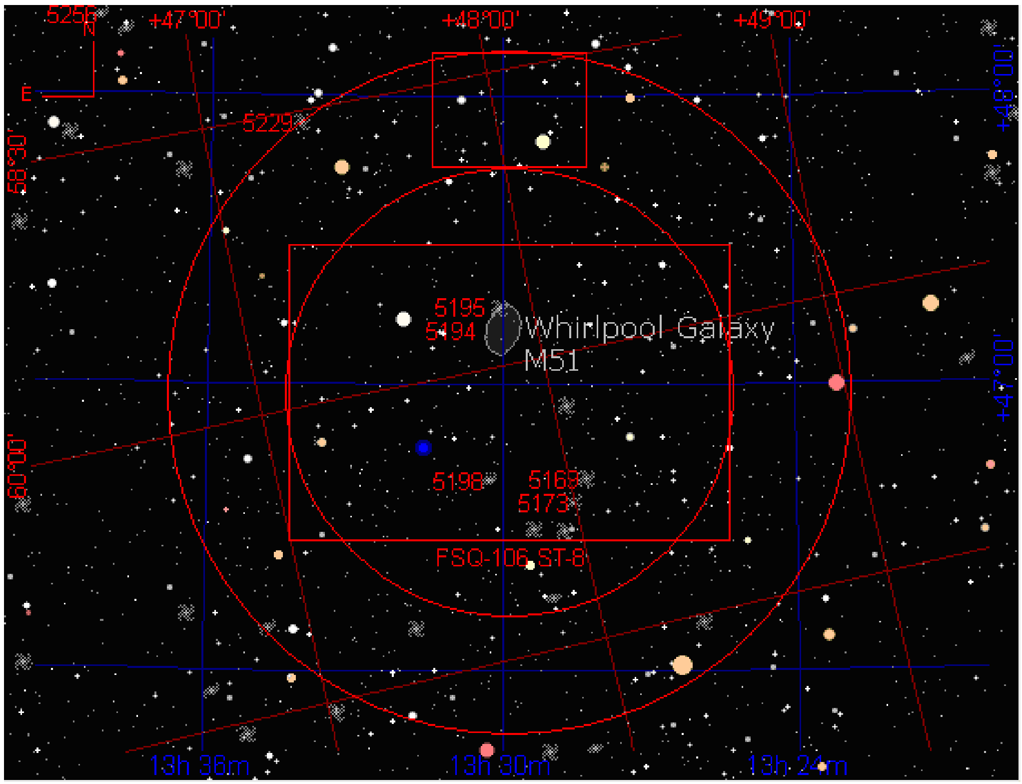


Figure 199: Placing a guide star on the autoguider.

If you were performing a calibration, the bright star in Figure 200 is clearly brighter than others in this field. It is an ideal star for calibration. For this star, use short exposure time; this also will speed up the calibration process. In general, you should expect to move your mount away from the object you intend to image to do a calibration, because putting a bright calibration star near the center of the detector is important to successful autoguider calibration. With the *Camera Add On* available to position the mount, you can move, calibrate, and return to your object very quickly.

If you want to keep M51 at or near the center for taking the actual image, rotating the camera to bring a guide star onto the tracking detector works well. Figure 200 shows that a rotation that puts north at about eight o'clock puts a reasonably bright star on the tracking CCD detector. You can experiment with *TheSkyX Professional Edition* to find the right rotation angle, and then physically adjust the camera to the new orientation. Since the *Camera Add On* can guide accurately at any orientation, even 45 degrees away from orthogonal, you have complete flexibility in framing your images. If the *Camera Add On* is connected to a camera rotator, your FOVI can be linked to the rotator (page 493) so that when you rotate the FOVI on screen, the rotator hardware follows.

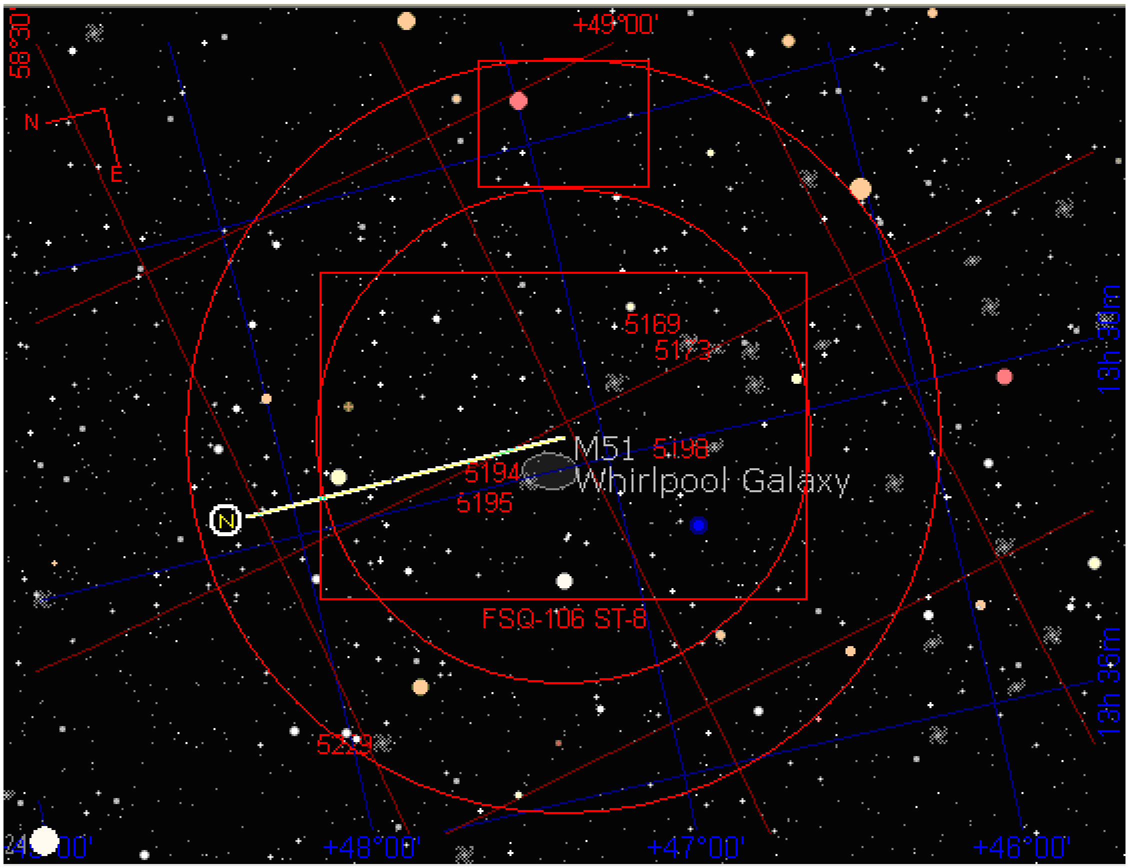


Figure 200: Rotating the view to look for a suitable guide star.

Adjust Calibration Settings

During calibration, the *Camera Add On* will move the mount for a period of time, then take another image and determine the motion of the calibration star (that is, how far the mount has moved). Each photo is displayed along with graphical arrows indicating how the calibration star moved so that you can follow along. These images and arrows (resultant calibration vectors) are a useful for diagnosing common problems that occurs during calibration.

The software measures the amount of movement of the calibration star from one photo to the next. The exact sequence is as follows:

1. Take an initial reference photo.
2. Active the +X relay, take a photo, measure calibration star movement.
3. Active the –X relay, take a photo, measure calibration star movement.
4. Active the +Y relay, take a photo, measure calibration star movement.
5. Active the –Y relay, take a photo, measure calibration star movement.

An ideal mount and imaging system concludes this sequence with the guide star in the exact same position as at the start of the calibration procedure. In most cases, there will be at least a small difference in starting and ending position due to whatever errors accumulated while the mount moved in all four possible directions.

It is fairly intuitive to relate relay activation to calibration star motion when the camera is aligned square to the mount's right ascension and declination axis. For example, when the camera is aligned square to the mount's right ascension and declination axes, X relay activation corresponds to calibration star motion changing in X pixels on the resultant photo and Y relay activation corresponds to calibration star motion changing in Y pixels on the resultant photo. In contrast, if the camera is rotated so that it is not "square" with the right ascension and declination axis, activating, say, the X relay, will produce calibration star motion in both X and Y pixels on the resultant photo. The *Camera Add On* can cope with a completely non-square camera position. This gives a great deal of flexibility in selecting a guide star.

To set the time interval for calibration, as well as other related settings, click ***Setup*** on the ***Autoguide*** tab. See Figure 201 for the default appearance of the ***Autoguide Settings*** dialog box. The calibration time is the length of time in seconds that each relay is activated during the autoguide calibration process.

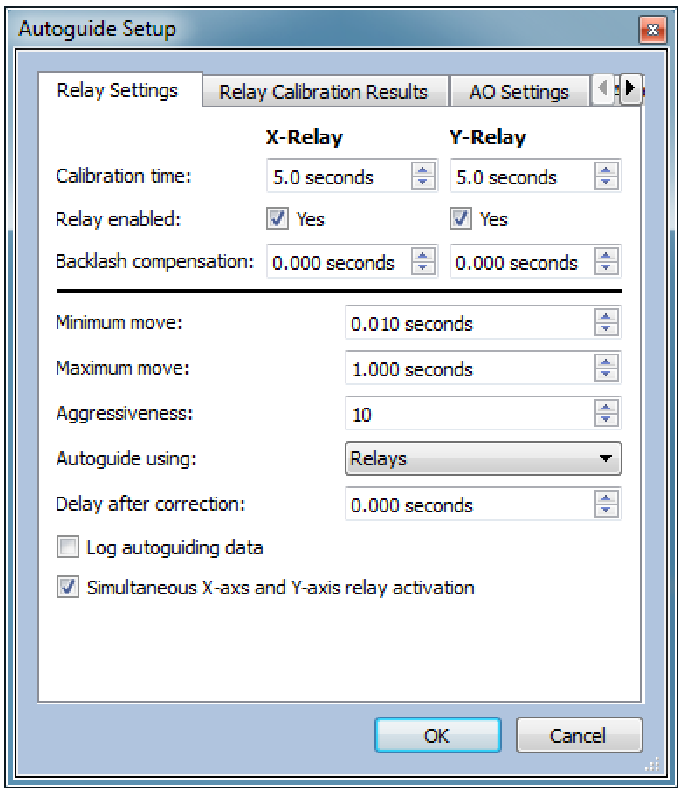


Figure 201: The default Autoguide Setup window.

The calibration time you enter depends on, primarily, the focal length of your telescope, the pixel size of your camera and the bin mode. If the camera is reasonably well matched to the telescope (a camera with anywhere from 1 to 4 arcseconds per pixel), the values shown in the following table are useful starting values for calibration time.

Focal length (mm)	Suggested calibration time (seconds)
100-300 (typically a camera lens)	15
300-500	10
500-1000	5
1000-2000	5
2000-3000	3

Here are the remaining autoguide setup parameters:

Relay Enabled: Determines whether autoguiding corrections are applied to the indicated axis. For example, if the mount's polar alignment is exceptional and exposure duration is under about one hour, you can turn off corrections to the declination axis to avoid spurious corrections that result from atmospheric turbulence. In addition, if you creating a tracking log to determine your mount's periodic error, you want to disable both axes.

Backlash compensation: Backlash exists when the motors on the mount must turn for some period of time after a change of direction before the gears fully engage and actually move the mount. Backlash compensation is the time that the *Camera Add On* should turn the motors to take up backlash when the direction reverses. Since guide speeds in right ascension are typically less than sidereal rate (0.5x is commonly used), no reversal occurs and you should not set a backlash compensation time for right ascension backlash compensation unless you are using a mount autoguide speed of 1x sidereal or faster. You should always slightly under compensate for backlash; over compensation leads to over correction and can make autoguiding impossible.

Minimum move: This specifies the minimum autoguiding correction that the *Camera Add On* will make. If the autoguide correction is less than this amount, no autoguiding correction occurs. When an autoguiding correction is equal to or greater than this amount, the autoguide correction will be made.

Maximum move: The longest time to move the mount during an autoguide correction. If you find that the mount is too active, no matter how you change other settings, this can force the *Camera Add On* to use shorter corrections. However, if at all possible, you should find the source of the problem and fix it instead.

Aggressiveness*:* A number from 1 to 10, indicating the relative aggressiveness of the corrections. With a setting of 10, the *Camera Add On* makes the full, computed correction. With a setting of 5, the *Camera Add On* makes fifty percent of the computed correction. With a setting of 1, ten percent of the indicated correction occurs. If the mount overly responds to corrections, you can reduce the correction with this setting in an effort to smooth guiding. For example, when pointed near the zenith, your mount may be more responsive to corrections due to changes in balance. You can use a lower aggressiveness setting to compensate if your mount behaves in this manner.

Autoguide Using: Determines how the *Camera Add On* should communicate with your mount to make autoguiding corrections. If the camera relay cable is connected directly to the mount (or connected through the SBIG relay box), then use the ***Camera Relays*** setting. If you are using a special, custom arrangement via the serial port of the computer running the *Camera Add On*, then choose ***RelayAPI (serial)***. If your mount supports **DirectGuide**™, that is, the *Camera Add On* communicates directly with the telescope's control system and bypasses the camera's relays, choose this option. Paramount Robotic Telescope Mounts or mounts that employ the Software Bisque Telescope Control System (*Bisque TCS*) support DirectGuide.

Delay After Correction: If your mount tends to vibrate or bounce slightly after a correction is applied (needs a settling time), a delay can help ignore this oscillation. This is usually true only of lighter mounts, but it can also occur with larger mounts that over loaded.

Log Autoguiding Data: When this checkbox is turned on, tracking data is saved to a log data file. The name of the log file is automatically generated so that earlier tracking log data is never overwritten. The filename is in the form *Auguider.001.log* where .001 is incremented each time the **Autoguide** is pressed. The location of this file is determined by the **AutoSave** path. Unlike other settings, this option is immediately applied while autoguiding is in progress so that you can control when logging starts/stop while autoguiding. The **Clear Log** button on the ***Autoguide*** tab applies immediately as well. See the section “Graphically Examining Autoguider Data” on page 401 for information about the tracking log file.

Simultaneous X- and Y-Axis Relay Activation: Turn this option off if your mount is not capable of making an x and y correction at the same time (some older mounts). By default this option is on so that autoguide corrections that involve both an x and y relay activation are applied the mount at the same time. Some much older model Losmandy mounts (Gemini con excluded) cannot perform simultaneous corrections.

Aggressiveness: This is the most frequently used advanced setting. For your first autoguiding efforts, leave the aggressiveness set to 10. If the corrections are too aggressive (the mount is over correcting), try a lower number. It is better to have too low a number than one that is too high, since the nature of autoguiding will eventually catch up and make the necessary corrections if you are reasonably close with your polar alignment. If the aggressiveness is set too low, however, the corrections will not be able to keep up with changes to the position of the guide star and elongated stars will result.

Calibration Procedure

Click ***OK*** to save changes. Click ***Calibrate*** to start the calibration process. You will see information reporting the progress of the calibration in the Autoguide tab, such as “Moving Mount (Plus X).” The calibration procedure starts with a new reference image and dark frame. It then moves plus and minus in the X and Y directions, measuring how the calibration start moves for each relay activation.

If there are any problems during the calibration, an error is reported in the calibration results windows. The following table lists common problems and explains what you can do to try to fix the problem.

Calibration Problem	Solution
Error message: ***"Star too dim. Lost during +X, -X, +Y, or –Y"***	The guide star is too dim, and could not be found on one or more of the photos acquired during calibration. Use a longer exposure, or choose a brighter star. A star is too dim not just when it is too dim to be pulled from the background, but also when the brightest star in a calibration image is less than 25% as bright as in the preceding image.
Error message: ***"Motion too small during +X, -X, +Y, or -Y move. Increase calibration time."***	The calibration time was too short to move the star far enough to get a valid result. The solution is to use a longer calibration time. For a valid calibration, the star must move at least 5 pixels.
Error message: ***"Star too close to edge after +X, -X, +Y, or -Y move."***	The calibration star is too close to the edge of the image after a move. You can reduce the calibration time to cause less movement, and you can also begin calibration with the guide star at the center of the frame. This error will occur when the guide star moves to within 10 pixels of the edge.
Error message: ***"Invalid motion in X- or Y-axis."***	This error typically occurs when: The brightest star in a calibration image is a star other than the original guide star due to random variations in brightness. The guide star should be significantly brighter than any other star in the image. A brighter star moves into the guide frame during calibration. The guide star should be isolated from similarly bright stars by at least 1.5 times the width or height of the guide frame in arcseconds. The mount is very inaccurate, with motion in X resulting in motion in Y, or vice versa. Check the ***Calibration Results*** graph to see if it provides any clues about what kind of invalid motion is contributed by the mount.
Error message: ***"Unable to calibrate, both axes are disabled. At least one axis must be enabled***	With both axes disabled, no calibration is possible. To enable one or both axes, from ***Autoguide*** tab, click ***Settings***, then turn on the ***Enabled*** checkbox for one or both axes.

Calibration Problem	Solution
to calibrate."	
Problem: No calibration in one axis.	If an axis is disabled, no calibration will occur for that axis. To enable one or both axes, from ***Autoguide*** tab, click ***Settings***, then turn on the ***Enabled*** checkbox for one or both axes.
Problem: Calibration star moves out of frame.	This problem can cause several different error messages to appear, depending on what happens when the calibration star moves off of the photo. You might see "Star too dim" if another star winds up being interpreted as the calibration star, or you might see "Star too close to edge" or another message depending on where the brightest star winds up. The *Camera Add On* displays the photos taken at each step in the calibration process; watch these images to see if the guide star is moving out of the frame. Use a shorter calibration time to keep the guide star in the frame, and start with the guide star as close as possible to the center of the frame. Severe mount errors can also move the star out of the frame at longer focal lengths.

Once you have successfully calibrated the autoguider, you are ready to begin autoguiding. If you moved the mount to find a good calibration star, move it back to the object you want to capture.

Autoguiding in Action

Once your system is calibrated, you can start autoguiding. The *Camera Add On* supports autoguiding independent of imaging. This means that you can start an autoguiding session and then take a series of Imager images while the autoguiding continues uninterrupted. If the autoguider is integrated into the camera, as with an SBIG dual CCD's, autoguiding is temporarily paused during the Imager photo download since the shutter must be closed during the Imager download and the autoguider shares the same shutter (and since the shutter is close the autoguider cannot capture photos).

If you have a good polar alignment – which is always a good idea when imaging anyway – the guide star will be more likely to remain within the autoguider track box when autoguiding resumes. If the guide star moves, the *Camera Add On* will perform corrections to move it back to the center of the autoguide window. If this move tends to be large, you can add a delay to your Imager exposures. This will give the *Camera Add On* time to make corrections before the next Imager exposure begins.

The larger the corrections, the longer the delay should be to give the autoguider time to settle down. For most applications, use a delay that is a few seconds longer than two times the autoguide exposure. For example, if your guide exposure is 4 seconds, then use a delay of about 10 seconds. The extra time allows for downloading the autoguider images and processing time. If you find that your particular mount requires shorter or longer delays, adjust accordingly.

Once you have calibrated the autoguider, you can begin autoguiding. A typical autoguiding session includes the following steps:

1. Adjust the position of the mount if necessary to put a suitable guide star on the autoguider detector.
2. Click **Take Image** on the **Autoguide** tab, and verify the location of the guide star using an appropriate exposure length. If you are not sure, try 10 seconds.
3. If the brightness of the guide star is to too high or too low, adjust the exposure time. Aim for a brightness level of about 1000 counts and less than saturation.
4. Enter the current declination of the telescope. If you are using *TheSkyX Professional Edition* to point your telescope, this will be filled in automatically when you click **Autoguide**.
5. Click **Autoguide** to begin guiding.

If you have *TheSkyX Professional Edition* controlling your mount, it will automatically get the current declination of the telescope and use it to scale your calibration. If you move a large distance across the sky, or if you cross the meridian, then you may want to do another calibration. If you are imaging at longer focal lengths (2500mm and larger), you can calibrate before every image if necessary to get the best possible autoguiding out of your system.

During autoguiding, the *Camera Add On* continuously updates the autoguider photo (see Figure 202) with the latest position of the guide star. The current autoguide error appears near the top of the ***Autoguide*** tab, showing the number of pixels that the guide star has moved from the original position (X Error and Y Error). These numbers may be positive or negative, and are reported for both X and Y directions to the nearest hundredth of a pixel. Each photo captured for autoguiding shows a progress bar in the line for the autoguider at the ***Autoguider*** tab.

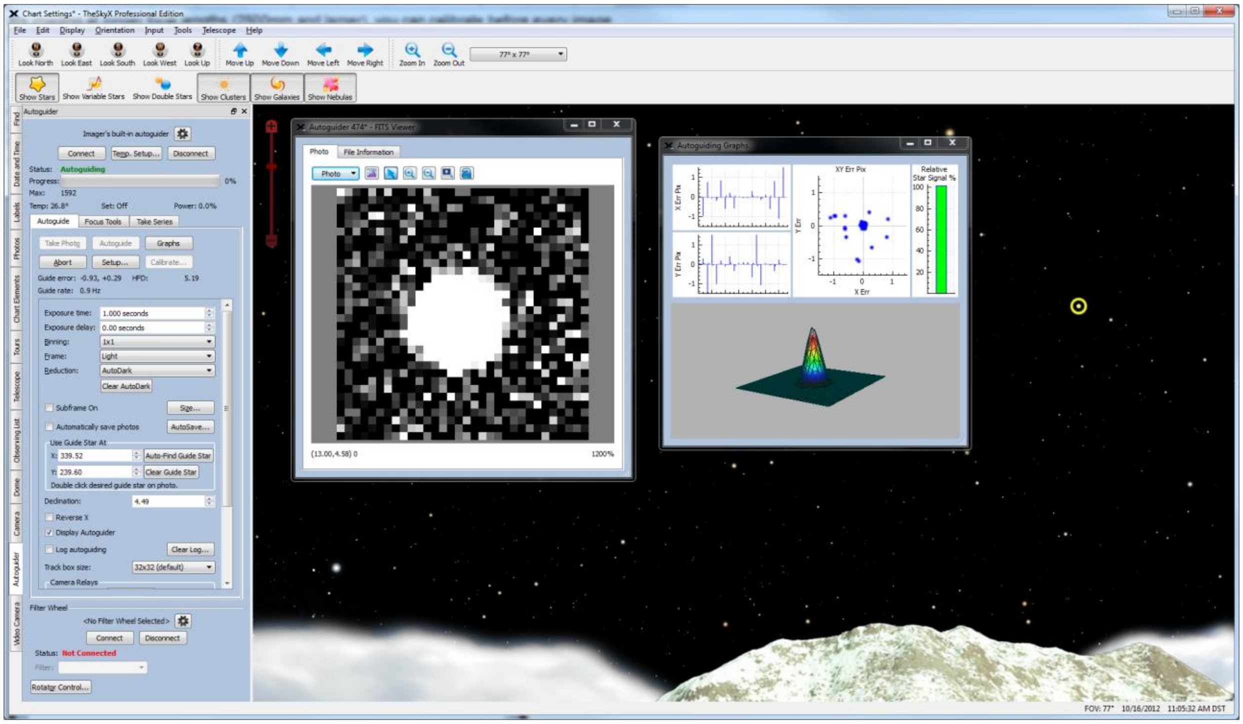


Figure 202: The appearance of the Camera Add On when autoguiding is active.

Autoguiding will continue until the **Abort** button is clicked. If there is an error during autoguiding, autoguiding will continue when possible, for instance if the guide stars brightness falls drastically due to clouds, autoguiding corrections are not made and autoguiding continues until the guide star brightness returns. If the guide star is lost and will not return (such as when the telescope is bumped), abort autoguiding and start over.

When using an SBIG dual CCD, the shutter will be closed when the Imager photo is being downloaded from the camera. Autoguiding is suspended while the shutter is closed, and will resume after the Imager download is complete. If the mount's polar alignment is good, the guide star will still be visible, and autoguiding will resume. You can enter an exposure delay in your Imager exposure(s) to allow for guiding corrections to settle right after the guide star is reacquired.

Recalibration

When should you recalibrate? The simplest way to tell is to start an autoguiding session and observe what happens. Start autoguiding after the telescope moves to a new position. Observe what happens to the X error and Y error numbers. If the both stay within +/- 1.0 pixel, you will likely have good results. If both stay within +/- 0.5 pixel, then the seeing is very good, and you should get excellent results. If one or both shows values greater than +/- 1.0, either the seeing is poor, or you may need to recalibrate for the new position. The need to recalibrate varies greatly from mount to mount, your image scale, and only experience will show you what works best for your particular mount.

Sometimes, autoguiding will not work as expected. Common problems, and possible solutions, include:

Autoguiding Problem	Suggested Solution
No corrections occur, and the X and/or Y Error numbers continue to increase	Most likely, autoguiding corrections are not getting to the mount, check the cable between the camera and the mount. Make sure that corrections are enabled for the appropriate axes. Verify that the guide speed is set to an appropriate value (usually 0.5x sidereal) for the mount. You can test connections by pressing the relay buttons on the Autoguider tab and verifying if the stars in the photo move accordingly or worst case see if the mounts coordinates change (warning you will have to press a relay button a long time before seeing a change in mount the position reported by the mount.
Corrections tend to oscillate between positive and negative values (for example, +1.3 and –0.9)	If the load on your mount is too carefully balanced, the mount will be unusually sensitive to guide corrections, and may overshoot. You want a slight but definite excess of weight on the east side. This keeps the gears meshed, and reduces the tendency of the mount to over-react to corrections. Oscillations can also occur when working near the zenith. You can also simply reduce the aggressiveness setting to see if that will eliminate the oscillation. Sometimes the mount will simply have a resonant period similar to the exposure duration and certain correction speeds; try a shorter or longer guide exposure length to see if it will eliminate the oscillation.
The mount suddenly makes large movements, and then comes back to zero.	A “large movement” is any sudden movement of two pixels or more. This usually results from irregularities in the mount's bearings or gears, and may limit the success you will be able to achieve with autoguiding. Shorter exposures can help by allowing you to complete an image before you hit one of the large movements. Contact your manufacturer to see if you might need to replace a worn or damaged part. Dirt or grit in the gears can also cause this problem. Another possibility: wind gusts. If it's very windy, you may not be able to guide or track successfully, as the mount will bounce around. The larger and/or longer your telescope, the more likely it is to catch wind and cause deflections that will show up as guiding errors. In some cases, if the movements are not extreme, you may be able to guide successfully by shortening the guide exposure so that the *Camera Add On* can detect these movements sooner and correct for them more often. Guide exposures of 1-3 seconds can give you better results on less-expensive mounts, but not all objects will have a sufficiently bright guide star for you to try this option.
The guide star suddenly disappears	The most common cause for this is simply clouds. Guide exposures are short enough that many stars will simply disappear if even a thin cloud moves through that part of the sky. If your mount is well aligned to the pole, and tracks accurately, you can sometimes simply wait out the cloud

Autoguiding Problem	Suggested Solution
	and guiding will resume when it passes. Any exposure you were taking during the time the cloud was in the way may or may not be salvageable. The guide star can also disappear if the mount is disturbed, in which case you probably have also lost your polar alignment. You might have touched your mount accidentally, but even a stray cat rubbing against a tripod leg has been known to cause trouble!
Corrections occur, but the X and Y errors are large and random	This could be a sign of over correction. Try recalibrating and see if that happens smoothly. Another option is to lower aggressiveness setting. Try lowering the aggressiveness one unit at a time and see if you get any improvement. Stop lowering the aggressiveness when you get into the range of +/- 1.0 pixels (average seeing) to +/- 0.5 pixel (good seeing). Problems with your mount's bearings or gears are another potential source of trouble; consider tuning your mount if you get wild changes in the X and Y errors . For any given mount, there is a limit to how accurately it will track and autoguide; if tuning and/or service won't improve your results, you may need to upgrade your mount to work at a given focal length.
The guide star keeps trying to move in a specific direction.	If the move is always in declination, this is most likely the result of a polar misalignment that is fairly large (more than 0.5 degree). If the autoguider is able to handle the movement in declination and keep it within a trouble-free range, the only concern is field rotation for long (one hour or more) photos or series of photos. If the autoguider fails to make the corrections and keep the error in a reasonable range, you can usually solve this problem by refining your polar alignment. See "Camera-Assisted Drift Alignment," later in this chapter.
The guide star wanders slowly back and forth.	Typically, this happens in right ascension, and you are seeing the periodic error of your mount. If your camera is oriented with north up, this will be a side-to-side (x pixels) motion in the autoguider photo. If the camera is turned 90 degrees (east or west up), then the motion will be up and down (y pixels). Periodic error usually results in slow, steady changes that go back and forth, so it is relatively easy for the autoguider to compensate. If your mount has the ability to record periodic error and then compensate for it (usually called PEC, for periodic error correction), you can use it or not, as you wish. It will not harm the performance of the autoguider if PEC and the autoguider are operating at the same time. However, the autoguiding is usually able to compensate for periodic error on its own, and you do not need to engage your PEC feature to get accurate guiding. You can also use the autoguider to log guide star motion which is sufficient to create PEC for capable mounts.

Autoguide Tab

The table below lists the controls in the ***Autoguide*** tab.

Control	Description
Take Photo	Click this button to take a photo using the current ***Exposure Time***, ***Exposure Delay*** and other settings.
Autoguide	Click this button to initiate autoguiding.
Graphs	Click this button to display the *Autoguiding Graphs* window.
Abort	Click this button to abort the camera operation in progress.
Setup	Displays the Autoguide Setup window.
Calibrate	Start the autoguider calibration process.
Exposure Time	Enter the exposure time, in seconds, for the autoguider photo.
Exposure Delay	Enter a pre-exposure delay in seconds.
Binning	Enter the camera binning.
Frame	The type of photo to be acquired: Light Dark Bias Flat
Reduction	Choose the type of reduction that is applied to each image acquired. None AutoDark Full Calibration
Clear AutoDark	Clears the AutoDark frame causing the *Camera Add On* to acquire a new dark frame on the next photo (when *Reduction* is set to *AutoDark*).
Sub-frame On	When checked, only a portion of the CCD is acquired with *Take Photo*. The sub-frame size is set by either dragging a sub-frame on the photo or by typing in the size after clicking the *Size* button.
Size...	Type in the size of the desired sub-frame.

Control	Description
Automatically Save Photos	When checked, every Take Photo is saved to the hard drive.
AutoSave...	Click to display the AutoSave setup window.
Use Guide Star At X, Y	The x and y pixel coordinate of the guide star.
Auto-Find Guide Star	Scans the photo for the brightest guide star and sets Guide Star XY accordingly.
Clear Guide Star	Removes any selected guide and sets guide star's X,Y position to 0,0.
Declination	The telescope's declination.
Reverse X	Allows reusing of autoguide calibration results after flipping a GEM even though initial calibration happened on the other side. Note that the Camera Add On, when used with a TheSkyX Professional Edition-controlled mounts, automatically reverses the X direction.
Display Autoguider	This checkbox is on by default, and forces every autoguider photo acquired to be displayed. On slower computers, turn this checkbox off so that autoguider photos are not displayed and increase the photo throughput.
Log Autoguiding	Generate a tracking log for periodic error correction.
Clear Log...	Delete the existing autoguider log file.
Track Box Size	Choose the size of the track box, in pixels.
Camera Relays	Click or click and hold one of the *+X*, *+Y*, *–X*, *-Y* buttons to activate the camera relays in that direction.
Auto Contrast Setup…	Click this button to show the *Auto Contrast* window and choose the desired method to adjust the contrast method to apply to subsequent photos. Auto Contrast options: SBIG: Use Santa Barbara Instrument Group's autocontrast algorithm to compute the photo's black and white points. Bjorn: Use the proprietary algorithm, along with the selected *Background*

Control	Description
	and *Highlight* options to compute the photo’s white and black points.
Simulate Photo Using DSS	Turn on the *Simulate Photo Using DSS* checkbox to take photos of Digitized Sky Survey objects, instead of collecting “actual” photons with the camera’s detector and a telescope.
Screen Shutter	Turn this checkbox on to show a completely black computer during exposures. This can minimize “light leak” from your monitor.

Assessing Autoguiding Possibilities

Once you have mastered enough CCD imaging skills to take focused photos, the next step is to lengthen your exposures so you can take deeper, more detailed, and cleaner photos of your favorite celestial objects. The accuracy of your mount determines how deep you can go. The more accurate your mount, the easier it will be to take long exposures.

Some mount manufacturers specify the accuracy of their mounts. This accuracy is expressed in arcseconds. An exceptional mount can guide with accuracy of 2-3 arcseconds or less. A very good mount can guide to about 5-6 arcseconds. The average low-cost mount guides to within 15-20 arcseconds. Mounts with even less accuracy are less suitable for CCD imaging unless the focal length of the telescope or lens is exceptionally short.

Whatever the accuracy of your mount, the key to success is matching the focal length of your telescope or camera lens to the abilities of the mount. For example, consider a CCD detector with pixels that are 9 microns square, such as the ST-7E. The angle on the sky covered by each pixel varies with the focal length of your telescope:

ST-7E (9-micron pixels)	
Focal Length of the Telescope (mm)	**Angle of Sky (arcseconds)**
300	6.2
500	3.7
700	2.6
900	2.1
1100	1.7

For example, imaging with a 300mm camera lens, at least 6 arcseconds of error are tolerable because a single pixel covers just over 6 arcseconds. Imaging with a refractor that has 1100mm focal length, a single pixel covers only 1.7 arcseconds, and the need for tracking accuracy is almost four times higher.

In practice, star images cover more than one pixel due to atmospheric scattering, the same process that causes stars to twinkle, so you would have more leeway than shown here. The important concept is that the shorter your focal length, the less the need for tracking accuracy in your mount.

A short focal length alone won't necessarily solve the problem, however. Smaller or larger pixels on your CCD detector alter the numbers. As shown in the following table, large pixels cover more sky for a given focal length, and smaller pixels cover less sky:

ST-9E (20-micron pixels)		ST-237 (6.8-micron pixels)	
Focal Length of Telescope (mm)	**Angle of Sky, (arcseconds)**	**Focal Length of Telescope (mm)**	**Angle of Sky, (arcseconds)**
800	5.1	300	4.7
1000	4.1	500	2.8
1200	3.4	700	2.0
1500	2.7	900	1.5
2000	2.0	1100	1.3

For best results, match the focal length of your telescope to both your CCD camera and your mount. Most CCD imagers aim for a camera/telescope combination that yields from 1.5 to 4 arcseconds per pixel. Your choice of mount should match the capabilities of whatever combination you select. You can calculate the arcseconds per pixel of your camera/telescope combination using the following formula:

(<pixel size in microns> / <focal length in mm>) * 206

Experience shows that, to get good results, your mount error should be no more than +/- 2 pixels. For high-quality images, one and a half times the arcseconds per pixel value is a safer limit. Very high precision results demand a value of a single pixel. For very long focal lengths (2500mm and up), local seeing and other conditions becomes more important and the calculations are not so straightforward; experience of local conditions is needed to assess the requirements for the mount.

In general, then, for high-quality images, a mount should be able to guide to within 2.25 and 6 arcseconds, depending on the pixel size of the CCD camera in relation to the focal length of the telescope.

> If your mount isn't providing the pointing accuracy needed by your telescope, you can either use a focal reducer to shorten the focal length of your telescope, or take steps to increase the pointing accuracy of your mount, or both.

If you already own a mount, and want to assess its approximate pointing accuracy, you can follow this procedure.

Adjusting and Tuning Your Mount

Mounts come in a variety of designs. Most mounts intended for use CCD cameras involve a worm and worm gear, as shown in Figure 203. There is normally one pair for right ascension, and another pair for declination, but some mounts are only driven in right ascension.

A motor drives the worm gear, and there will usually be gears between the motor and the worm to reduce the speed of rotation at the worm. The worm in turn drives the worm gear, which is attached to the shaft. The right ascension shaft turns at sidereal rate, which is the rate stars appear to move across the sky (approximately one revolution per day). The motor speed and gear ratios are set to track accurately at the sidereal rate. Some mounts provide a way to adjust the tracking rate for the highest possible accuracy, but most do not.

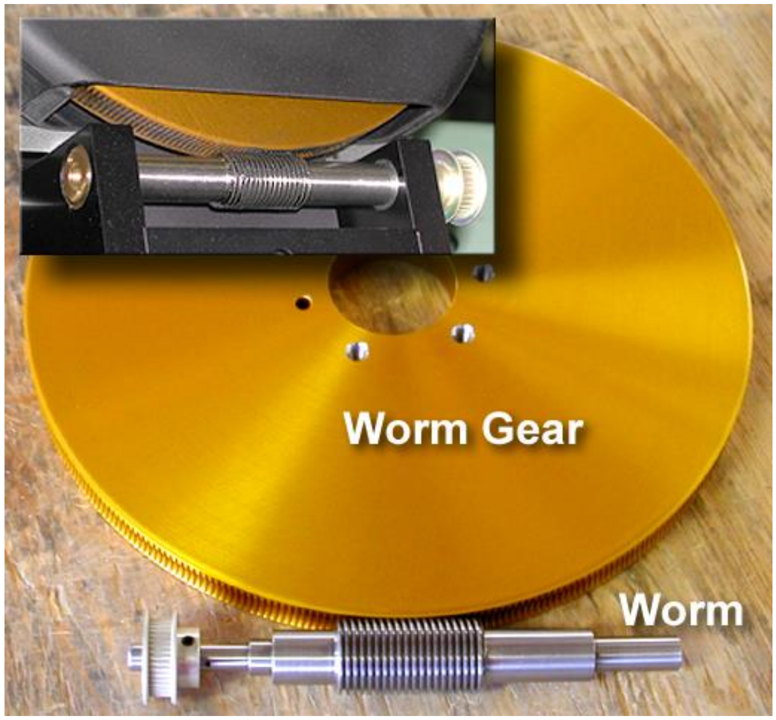


Figure 203: A precision worm and worm gear.

To track and autoguide accurately, a worm-driven mount must often be adjusted or tuned in several ways. Before using a mount for autoguiding, we suggest the following; please consult your mount's documentation or the manufacturer for specific procedures on making these adjustments:

- Verify that the worm and worm gear are properly seated. If the end bearings of the worm are too tight, the worm will bind and could be damaged. If the worm is too loose between its end bearings (end play), reversals of direction will be erratic. Endplay in the worm gear is the usual cause if you observe that the mount initially and briefly moves in the wrong direction when reversing directions.
- Verify that the mesh between worm and worm gear is appropriate. Some mounts are made from harder materials and to closer tolerances, and these will typically require a very tight mesh between the worm and worm gear. Other mounts are made of softer metals, or to looser tolerances, and will require a looser mesh. If the mesh is too tight for the design, the gears will bind and could overheat or be damaged. If the mesh is too loose, there will be excessive backlash. Some mounts have built-in backlash compensation that allows you to keep the gears appropriately loose; the *Camera Add On* provides software backlash compensation that serves the same purpose. During backlash compensation, the motor is

run at a higher speed to take up slack in the gears. Too much compensation will result in a jerky movement; too little compensation will result in a delay before a guiding correction is effective. It is always better to have too little rather than too much backlash compensation. If in doubt about how tight to mesh the gears, err on the side of being too loose. See the section "Assessing Mount Accuracy" on how to measure backlash.

- A slow-turning motor usually has less torque (that is, less force available to move the mount). This means that a slowly turning motor is more likely to stall than one that is turning quickly. If the worm and worm gear are too tightly meshed, the slowdown to 0.5x sidereal that occurs during autoguiding could cause the mount to stall, or move at the wrong speed.
- Cold conditions can cause some lubricants to become stiff, and this can alter the behavior of your mount. If you need to operate your mount in very cold conditions, or if you observe increased stiffness in cold weather, check with the manufacturer to find out whether you will need to use different lubrication for cold conditions.
- Some mounts, after tuning and adjustment, will have a large enough residual error that it will limit the focal length telescope you can use successfully. The larger the error (from periodic and non-periodic sources), the shorter the focal length of the telescope you can use for imaging. The actual limit depends on the weight of your telescope and its overall physical length as well as its focal length. Long, heavy telescopes require more careful balancing and tuning for successful guiding. Focal reducers are available to help with this situation. Otherwise, you will need to use a telescope with a shorter focal length.
- Test the balance of your mount in various positions . Off-center equipment, such as a finder offset from the centerline of your telescope, or a camera attached piggyback fashion onto your telescope, can dynamically alter the balance of your mount as you point at different areas of the sky. A mount should always be loaded so that there is slightly more weight on the east side of the mount. This keeps the right ascension axis loaded at all times, eliminating backlash as a factor in right ascension autoguiding (as long as the correction speed is less than sidereal rate). If off-center equipment does cause the balance to change at different pointing angles, you can either rearrange equipment and/or counterweights after pointing to a new area of the sky, or you can incorporate sliding weights or some other weight-shifting system into the design of your setup. An out of balance mount can oscillate or wander unpredictably, or require a new calibration when pointing to different parts of the sky even if the declination remains similar.
- You can calibrate your setup at a higher correction speed than you use when autoguiding. This tends to mask some errors, but it isn't a cure-all. It slows down the correction process, and if your mount tends to be over-responsive, it can eliminate unnecessary corrections and provide smoother autoguiding.

More than any other single factor, the ability of your mount to track accurately and to respond quickly and smoothly to guiding corrections determines the success of your imaging. It is well worth measuring the accuracy of your mount, and tuning and adjusting it to improve that accuracy to the greatest degree possible.

Polar Alignment

In order to track accurately, your mount needs to be aligned close to the celestial pole. Many mounts include a polar telescope (also called a bore telescope or bore sight) to help you polar align. There are many different kinds of polar telescopes, but most contain some kind of reticle that allows you to point the mount at specific stars to achieve alignment. Most mounts also contain provisions for aligning in either the northern or southern hemispheres.

Although you do not need perfect polar alignment for autoguiding, there are some issues to be aware of with respect to polar alignment. If you are taking single images of less than five minutes, even a rough polar alignment will be satisfactory if you are autoguiding. The lack of a perfect alignment will cause the field of view to drift and rotate slowly during the exposure, but the autoguider will detect the drift and correct for it. The field will rotate a small amount during the exposure, but if the exposure is short enough rotation will not be a problem.

Autoguiding can correct for small misalignments to the celestial pole. If the misalignment is too large, however, the autoguider will have to make large, frequent corrections making the autoguider work very hard and only high quality mounts will respond accordingly. The larger the misalignment, the shorter your guide exposures must be in order to make corrections before they become too significant and pollute the Imager photo (stars not round).

If your exposures are longer than five minutes, rotation of the field over time becomes a more important issue. If you are combining short-duration images for better signal-to-noise ratio or for color, the routine must also rotate the photos before combining.

Very short focal lengths are more sensitive to field rotation because the image covers a larger area of the sky. You can minimize field rotation by taking the time to polar align your mount very carefully. Use the polar telescope for rough alignment, and then use drift alignment to refine alignment. You can do drift alignment manually, or you can use the CCD camera to assist. You can also use the TPoint Add On, a Software Bisque software tool that increases telescope-pointing accuracy, to achieve extremely accurate polar alignment.

Manual Drift Alignment

1. Level the base of the mount if possible. A level mount is not required, but it makes adjust easier by reducing interplay between altitude and azimuth adjustments.
2. Locate a bright star near the celestial equator and near the meridian (the midpoint between east and west). Center the star in the crosshairs of an illuminated reticle eyepiece.
3. Observe the star until it drifts north or south; ignore drift to the east or west. If the star drifts north, adjust azimuth so the mount points more to the east. If the star drifts south, adjust azimuth so the mount points more to the west. Repeat until north/south drift becomes negligible over a 5-minute observing period.
4. Locate a bright star near the celestial equator and near either the east or west horizon. Center it in the crosshairs of an illuminated reticle eyepiece.
5. Observe the star until it drifts north or south; ignore drift to the east or west.

If you are looking **east:**

- If and the star drifts north, adjust altitude downward.
- If the star drifts south, adjust altitude upward.

If you are looking **west:**

- If and the star drifts north, adjust altitude upward.
- If the star drifts south, adjust altitude downward.

Repeat until north/south drift becomes negligible over a 5-minute observing period.

	To determine which way is north in the eyepiece, move the telescope toward the south and note the direction the stars move; they are moving toward the north.

Camera-Assisted Drift Alignment

Calibrate your autoguider as described earlier in this chapter.

1. See if the camera is currently orthogonal (square) to the mount. If you have performed a calibration, you can use the *Camera Add On* to tell you how close the camera is to orthogonal. On the ***Autoguide*** tab for the ***Autoguider***, click ***Setup***. This opens the ***Autoguide Setup*** window. Click the ***Relay Calibration Results*** tab. This displays a graph showing how the camera is oriented with respect to the right ascension and declination axes of the mount. Ideally, the X- and Y- relay vectors will line up closely with the X- and Y-axis of the photo/CCD (Figure 204). Ideally, but not necessarily, the angle of the +X vector should be close to zero, and the +Y axis vector should be nearly perpendicular to the +X vector. If your camera is rotated with respect to the mount axes (Figure 205), you will not get accurate readings for camera-assisted drift alignment.

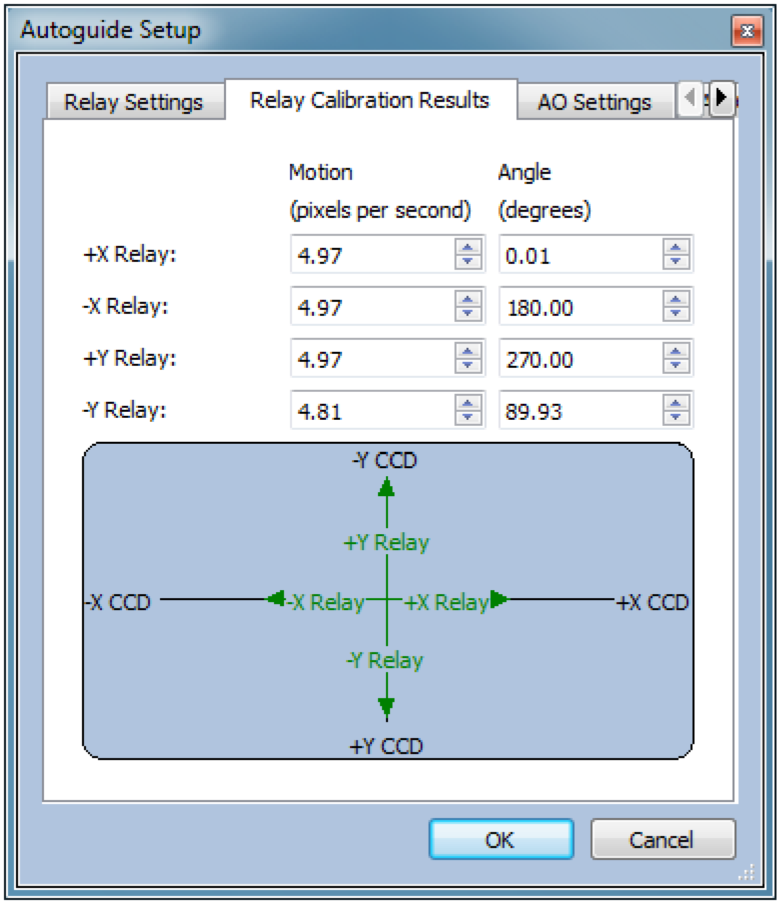


Figure 204: Relay calibration results that show the camera is ready to assist with drift alignment.

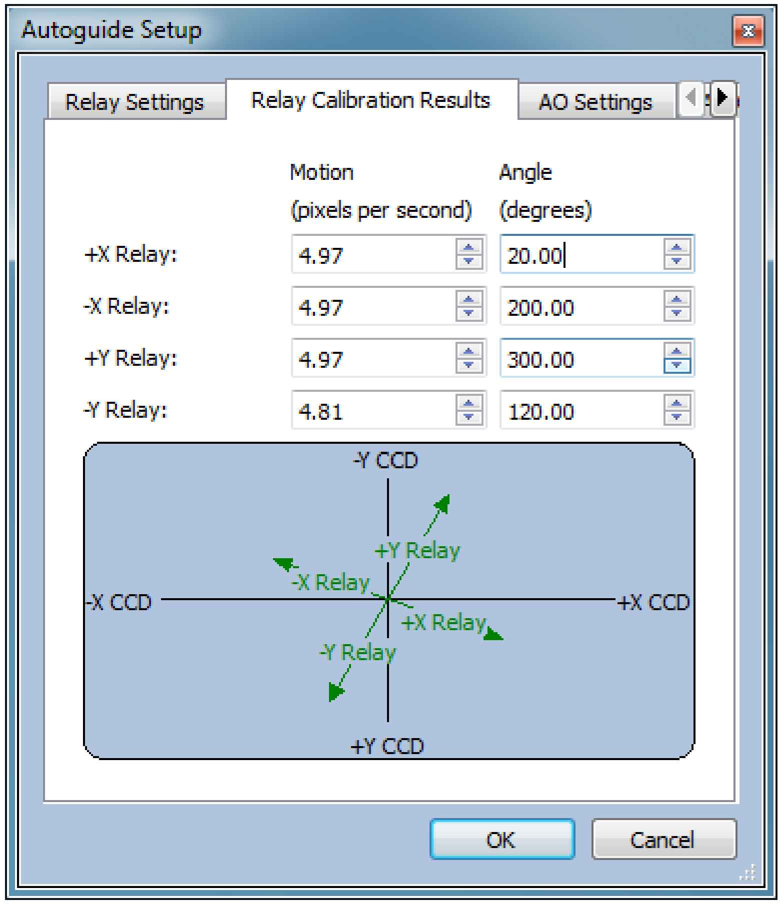


Figure 205: The camera axes are not square to the mount axes. The camera rotation is not well situated for assisting with drift alignment.

2. If the camera isn't square with the mount, adjust the camera so that the top of the CCD detector points toward north. For the greatest accuracy, repeat calibration to verify alignment of the camera. Repeat until you've got everything lined up to your satisfaction.
3. Using the ***Autoguide*** tab, set an appropriate exposure time (for example, 5-10 seconds), and then click ***Take Photo***. Check your results, and adjust the exposure time as needed. Double click on a suitable guide star.
4. Click ***Log Autoguiding***. This allows you to examine your data later if you have any questions about the progress you are making toward polar alignment. The log file is named `autoguider.XXX.log`, and can be found under the camera's autosave folder. See the next section, "Autoguider and Tracking Log," for a list of the fields contained in the log file.
5. To measure drift, you need to turn off corrections. From the ***Relay Settings*** tab, uncheck the ***Relay Enabled*** checkboxes for X-and Y-relay. Note: Remember to re-enable corrections when you are done.
6. Click ***OK*** to close the Autoguide setup window.
7. Click the ***Autoguide*** button on the ***Autoguide*** tab. You can now observe the Y (declination) error to measure drift very accurately and very quickly. You can examine the log file at any time to determine the total amount of drift versus elapsed time. Positive Y error values are northward drift; negative Y error values indicate a drift to the south.
8. Once you have a measurement of the current amount of drift north (+Y) or south (-Y), adjust the mount as for manual drift alignment and repeat the autoguiding process.

9. For optimal results, continue drift aligning until you can autoguide for several minutes with a Y error no larger than +/- 1.0. For critical applications, continue until you can autoguide for five minutes with a Y error no larger than +/- 0.5.

Autoguider and Tracking Logs

You can turn on logging of autoguider operation using the either the ***Log Autoguiding Data*** checkbox on the ***Autoguide*** tab or the same checkbox under the **Setup** button on the ***Autoguider*** tab. Turn the checkbox on to collect autoguiding data. New autoguiding data is always automatically saved to a new file per autoguiding session. To clear the log file, click the ***Clear Log*** button.

A sample `autoguider.log` file is shown below. The lines are wrapped because the data content is too long to fit on a single line here. In the file itself, each line of data is a single line.

```
TheSkyX Camera Add On Autoguiding Log
Camera = Imager's built-in autoguider
X Axis = Enabled
Y Axis = Enabled
ExposureTime = 0.10
Aggressiveness Factor = 10
Calibration Time X = 4.00
Calibration Time Y = 4.00
Calibration declination = 0.00
Declination now = 0.00
Minimum Move = 0.01
Maximum Move = 1.00
Backlash X = 0.00
Backlash Y = 0.00
Delay After Move = 0.00
Autoguide using Relays

Calibration Determined Velocity Vectors (pixels/sec)
 XPlus  Speed=     5.00106 (XPlus  X=     5.00076, XPlus  Y=     0.05490) Angle=     0.00000
 XMinus Speed=     5.00016 (XMinus X=    -4.99985, XMinus Y=    -0.05594) Angle=     0.00000
 YPlus  Speed=     4.99963 (YPlus  X=    -0.00182, YPlus  Y=    -4.99963) Angle=     0.00000
 YMinus Speed=     4.81357 (YMinus X=     0.05687, YMinus Y=     4.81323) Angle=     0.00000

|Elapsed Secs|RefCentroidX|RefCentroidY|CurCentroidX|CurCentroidY|GuideErrX   |GuideErrY   |TotGuideErr
|XPlusRelay  |XMinusRelay |YPlusRelay  |YMinusRelay |PECIndex RA |PECIndex Dec|
|      0.0000|     49.8300|     49.0000|     49.7707|     48.9768|     -0.0593|     -0.0232|      0.0637|
1|          0|           0|           0|           0|           0|
|      2.4020|     49.8300|     49.0000|     49.8054|     48.9818|     -0.0246|     -0.0182|      0.0306|
0|          0|           0|           0|           0|           0|
|      3.3230|     49.8300|     49.0000|     49.8077|     48.9778|     -0.0223|     -0.0222|      0.0314|
0|          0|           0|           0|           0|           0|
|      4.2590|     49.8300|     49.0000|     49.8038|     48.9827|     -0.0262|     -0.0173|      0.0314|
1|          0|           0|           0|           0|           0|
|      5.1950|     49.8300|     49.0000|     49.9322|     48.3956|      0.1022|     -0.6044|      0.6130|
0|          2|           0|          13|           0|           0|
|      6.1310|     49.8300|     49.0000|     49.8545|     48.8989|      0.0245|     -0.1011|      0.1040|
0|          0|           0|           2|           0|           0|
|      7.0670|     49.8300|     49.0000|     49.8569|     48.9807|      0.0269|     -0.0193|      0.0331|
0|          1|           0|           0|           0|           0|
|      7.9870|     49.8300|     49.0000|     49.8139|     48.9820|     -0.0161|     -0.0180|      0.0241|
0|          0|           0|           0|           0|           0|
|      8.9080|     49.8300|     49.0000|     49.8128|     48.9798|     -0.0172|     -0.0202|      0.0265|
0|          0|           0|           0|           0|           0|
0.0000|          0|           0|           0|           0|
```

The top portion of the file record the camera used, as well as which axes are enabled. The exposure time and the aggressiveness setting are also recorded.

The next section lists the calibration details. This is a text version of the information you see in the ***Relay Calibration Results*** window (Figure 204).

The bottom section contains a record of all guiding corrections. The example above shows only a few lines. You could have hundreds of correction entries for a long exposure. The following data is included for each correction; for X/Y coordinates, the origin is the upper left corner of the detector:

Heading	Description
Elapsed Secs	Total number of seconds that have elapsed since the start of the current autoguiding session.
RefCentroidX	The X coordinate of the starting position of the guide star centroid.
RefCentroidY	The Y coordinate of the starting position of the guide star centroid.
CurCentroidX	The current X coordinate of the guide star, in pixels.
CurCentroidY	The current Y coordinate of the guide star, in pixels.
GuideErrX	The number of pixels the guide star has moved from the starting position along the X-axis. Equal to $(CurCentroidX - RefCentroidX)$
GuideErrY	The number of pixels the guide star has moved from the starting position along the Y-axis. Equal to $(CurCentroidY - RefCentroidY)$
TotGuideErr	The total current guide error in pixels, measured in a straight line from the origin. Equal to $\sqrt{(GuideErrX^2 + GuideErrY^2)}$
XplusRelay	Time in one-hundredths seconds that the X-plus relay was on to make the correction.
XminusRelay	Time in one-hundredths seconds that the X-minus relay was on to make the correction.
YplusRelay	Time in one-hundredths seconds that the Y-plus relay was on to make the correction.
YminusRelay	Time in one-hundredths seconds that the Y-minus relay was on to make the correction.

Heads up, the deciphering the autoguiding log is not intuitive when the camera is rotated with respect to right ascension and declination since an x pixel error may manifest itself to both an X and Y relay adjustment. Another potential point of confusion: resultant autoguiding corrections account for autoguiding at a declination different from the declination at calibration time so they may be bigger or smaller than what you might expect at first glance.

Graphically Examining Autoguider Data

If you logged autoguiding information, you can open the log file from the **Autoguiding Graphs** window to see the data graphically. Press the **Graphs** button on the Autoguiding sub tab and from the Autoguiding Graphs window, right click the "X Pix Error" graph (or the "Y Pix Error" or "XY Err Pix" graph) and choose **Open Autoguiding Log**.

	If you turn off corrections during autoguiding, the log file will contain a record of the periodic error of your mount. Let autoguiding proceed for one full revolution of the right ascension worm. This is usually in the range of four to seven minutes. Consult your mount documentation if you aren't sure, or contact the mount manufacturer. To turn off corrections, click **Setup** on the ***Autoguide*** tab. Turn off the ***Relay Enabled*** checkboxes to disable the X- and Y relays.

Autoguider Graphs Window

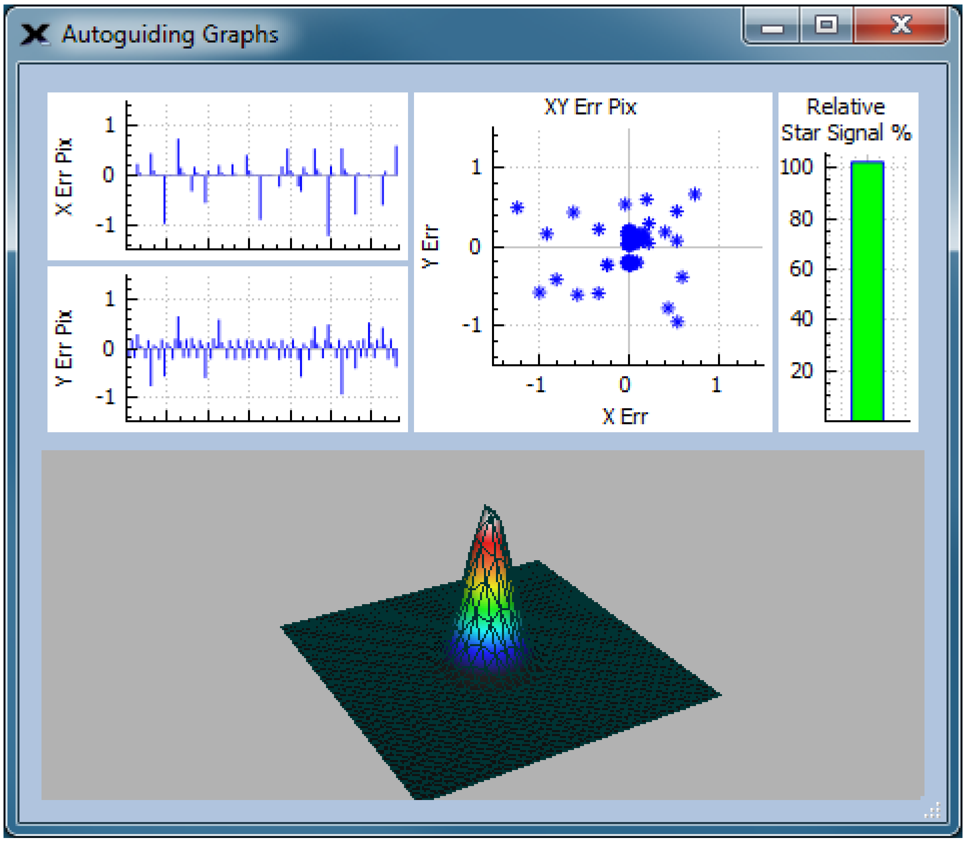


Figure 206: Sample autoguider graphs.

While autoguiding, press the ***Graphs*** button to display the ***Autoguiding Graphs*** window. These graphs give great insight into autoguiding performance at a glance.

The graphs show the X error in pixels, the Y error in pixels, the XY error as a scatter graph, the guide stars relative signal and a three dimensional plot of the guide star.

The XY error graphs show the error for the last 100 autoguiding cycles. You can zoom in/out on the XY error graphs by holding your mouse over the graph and using the mouse wheel. Click and drag the graphs to scroll left or right. The graphs window is also sizable allowing it to be viewed “full screen” on a second monitor, for example.

You can change the viewing angle of the three dimensional guide star by clicking and dragging within this window. Right click and choose properties to change the appearance of the three dimensional star (these settings are not saved and the three dimensional star will return to its default settings on exit and restart).

Autoguide Using Adaptive Optics

There are three types of autoguiding available in the *Camera Add On*:

- Self-guiding with an autoguiding CCD built into an SBIG dual camera.
- Autoguiding with a separate autoguiding camera (in a guide scope or using an off-axis splitter).
- Autoguiding with adaptive optics (using the SBIG AO).

At the time of this documentation, TheSkyX Camera Add On does NOT yet support autoguiding with an SBIG AO attached to the newer model SBIG STTs.

The first two methods work similarly: the guide corrections are calculated and TheSkyX Camera Add On makes corrections by activating a camera relay which in turn moves the mount. This section assumes you are familiar with conventional, relay-based, autoguiding, and that you understand the concepts covered in the section "*Autoguiding*" above.

With the SBIG AO, an internal mirror tilts rapidly to make the autoguide corrections. When using the SBIG AO, you have to calibrate using relays so the TheSkyX Camera Add On knows how to move the guide star by moving the mount *and* calibrate using AO tip/tilt so that the *Camera Add On* knows how to move the guide star by tip/tilting the AO mirror.

Guide corrections to the mount (via camera relays) may still occur when using the SBIG AO. The mirror tilt of the AO has of course has a limited range of motion. By default, if the mirror reaches 50% of maximum tilt in any direction, *Camera Add On* will "bump" the mount using the camera relays to bring mirror tilt back within range. Typically, polar misalignment causes drift that requires periodic mount "bumps."

Since guiding with the AO still involves use of the camera relays to bump the mount when necessary, you should always confirm that you are able to successfully autoguide using the camera relays stand alone. Verify that the mount moves via the camera relays, and that guiding is accurate and satisfactory. Otherwise, when the SBIG AO "bumps" the mount, you may lose your guide star and not get the result you want.

Quick Start

If you are familiar with the *Camera Add On* and the SBIG AO, follow these steps to start autoguiding with the SBIG AO. This section assumes that you are familiar with conventional autoguiding (see "*Autoguiding*") For details, please read *"Autoguiding with the SBIG AO*" below.

The AO quick start instructions above perform both calibrations using the autoguider, you could also perform both calibrations using the Imager. The Camera Add On will automatically calibrate the Imager upon successful autoguider calibration and vice versa. Since the Imager CCD is always bigger than the built-in autoguider, it is easier to place stars on the Camera. You will have to turn on the ***Advanced Camera User Interface*** checkbox (page 185) to enable the ***Autoguide*** tab on the ***Camera*** window.

The SBIG AO must be connected to the camera and all cabling in place between the computer, camera, and SBIG AO before you start.

1. Choose ***SBIG with AO...*** for the camera and ***Imager's Built-In Autoguider*** as the autoguider.
    a. Go to Telescope, Telescope Setup and from the Imaging System window, Open Imaging System and highlight Camera. Click ***Camera Setup***, **S**elect ***SBIG with AO…*** from the ***Camera*** list.
    b. Click Imaging System, Autoguider and highlight Camera.
    c. On the Camera Setup pop-up menu, click Choose and select Imager's Built-In Autoguider.
2. Place an appropriate calibration star on the autoguider photo.
    a. Click ***Take Photo*** to take an autoguider photo. Adjust telescope pointing and exposure time until you have a suitable star for calibration. A good calibration star must be the brightest star in the field of view, and there must not be similar bright stars nearby that will move into the field of view during calibration. Use the *Camera Add On* to help locate suitable calibration stars.
3. Calibrate the autoguider using relays.
    a. From the Autoguider tab, Autoguide sub tab, perform an autoguider calibration using relays as you normally would when autoguiding without the AO. You do not have to uncheck ***AO Enabled***. To use relay calibration, click ***Calibrate*** on, then click the ***Calibrate Using Relays*** option.

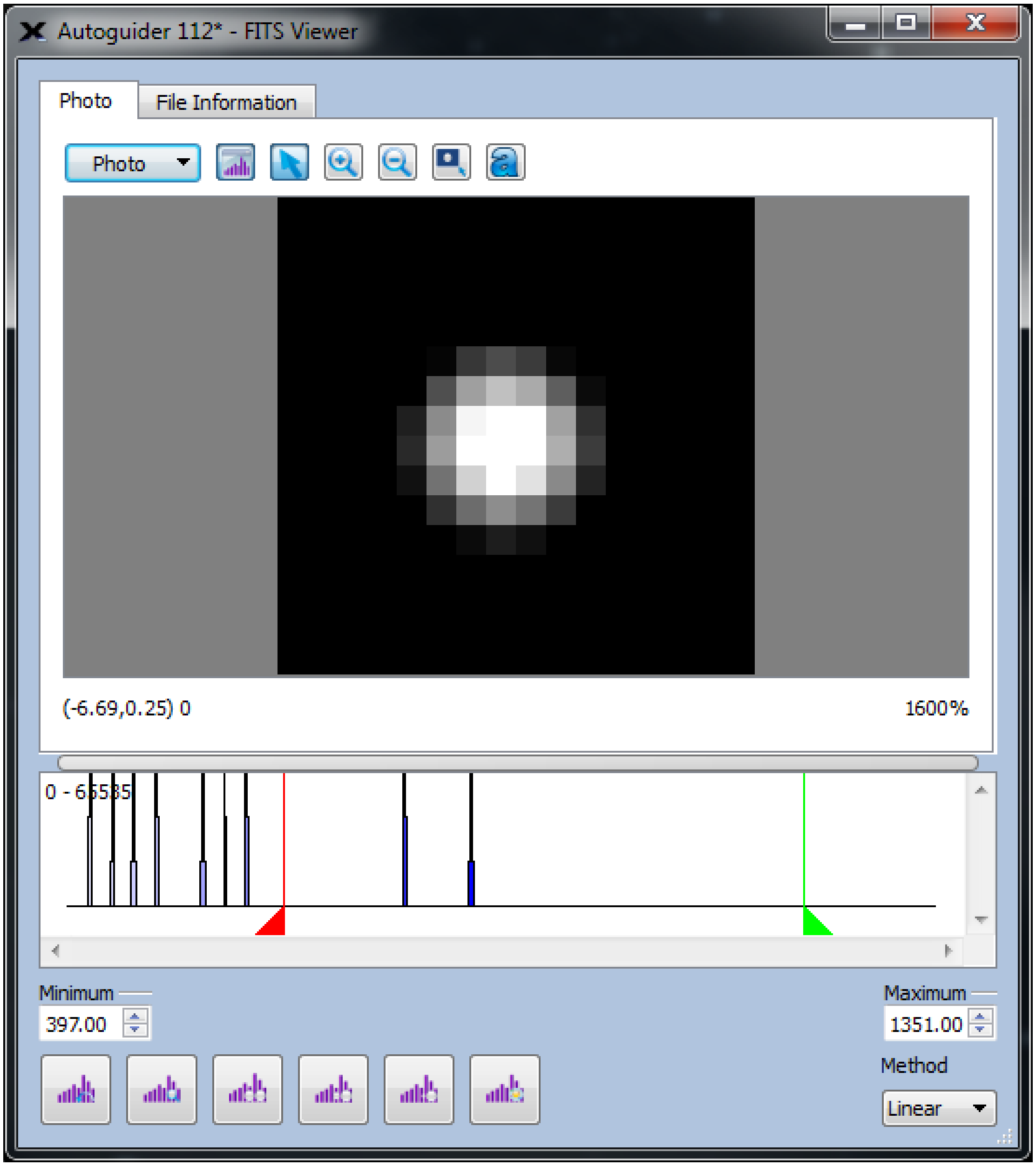


Figure 207: You may need to adjust the contrast to see dim guide stars while autoguiding.

4. Set the AO settings to their default values.
   a. Click the ***AO Settings*** tab. Click the ***AO Default Settings*** button to set the default values for the parameters. For fine-tuning the device, see the section "*SBIG AO Settings*" on page 410. Click **OK**.
5. Calibrate the autoguider using the AO.
   a. Click **Calibrate…** and then click **Calibrate using AO**. Verify that the **AO deflection…** setting is 100%. Click **Calibrate**. The SBIG AO will move its mirror, take exposures of the calibration star, and measure the movement in each direction.
6. Start autoguiding.
   a. Click **Take Photo** to download an image using the guide chip. Adjust telescope pointing and exposure time until you have a suitable guide star. See "Autoguiding" on page 367 for information about what makes a star suitable for guiding.

b. Double click the desired guide star in the photo to select it as the guide star, or click the ***Auto Find Guide Star*** button to have the *Camera Add On* select the guide star for you.
c. Click ***Autoguide*** to start autoguiding. You can monitor progress using the information on the ***Autoguide*** tab, including X/Y tilt, wander, etc. See following sections for details.

Autoguiding with the SBIG AO

Once the SBIG AO is installed and connected according to the instructions from SBIG, you must do the following before you can start using the AO device:

- Make the correct camera choices for the ***Camera*** and ***Autoguider***.
- Verify that the SBIG AO is enabled on the ***Autoguide*** window.
- Calibrate using the SBIG AO *and* calibrate using relays.

You must choose the ***SBIG with AO...*** as the camera and the ***Imager's Built-In Autoguider*** as the autoguider before autoguiding with the AO is possible. Figure 1 shows the correct camera choices for using the SBIG AO: If you choose any of the other individual cameras instead, the SBIG AO will not be active or available.

If you have been using another autoguider, take a moment to verify that the Autoguider selection is correct. From the Imaging System Setup window, open Autoguider and highlight Camera. Choose **Camera Setup**, Choose and select **Imager's built-in autoguider** as the selected Autoguider camera (see Figure 209).

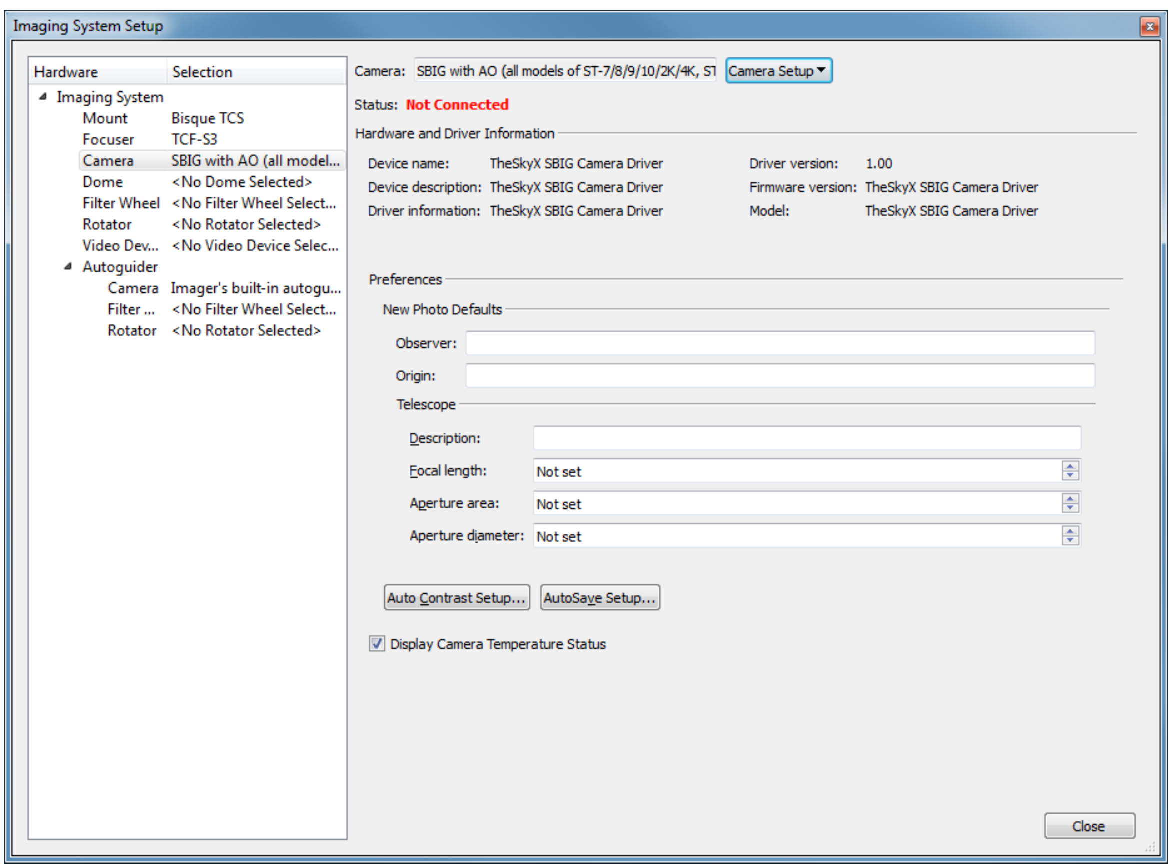


Figure 208: Make sure the Camera is *SBIG with AO...* and the Autoguider camera is *Imager's built in autoguider*.

If you are having trouble seeing the guide star, try to adjust the photo's contrast settings (click the ***Show Histogram*** button on the ***FITS Viewer*** window). When using the SBIG AO, dim guide stars and/or short exposures are common and can be difficult for auto contrast algorithms to get right. By trying different contrast algorithms, you should be able to "see" the guide star. The underlining autoguide algorithm doesn't care about the contrast setting—it will pick out the guide star if it is bright enough, only a few counts above the background, even if you can't see it. A good measure of how well the SBIG AO is autoguiding is to monitor the ***Wander*** (see section "SBIG AO Settings" for details).

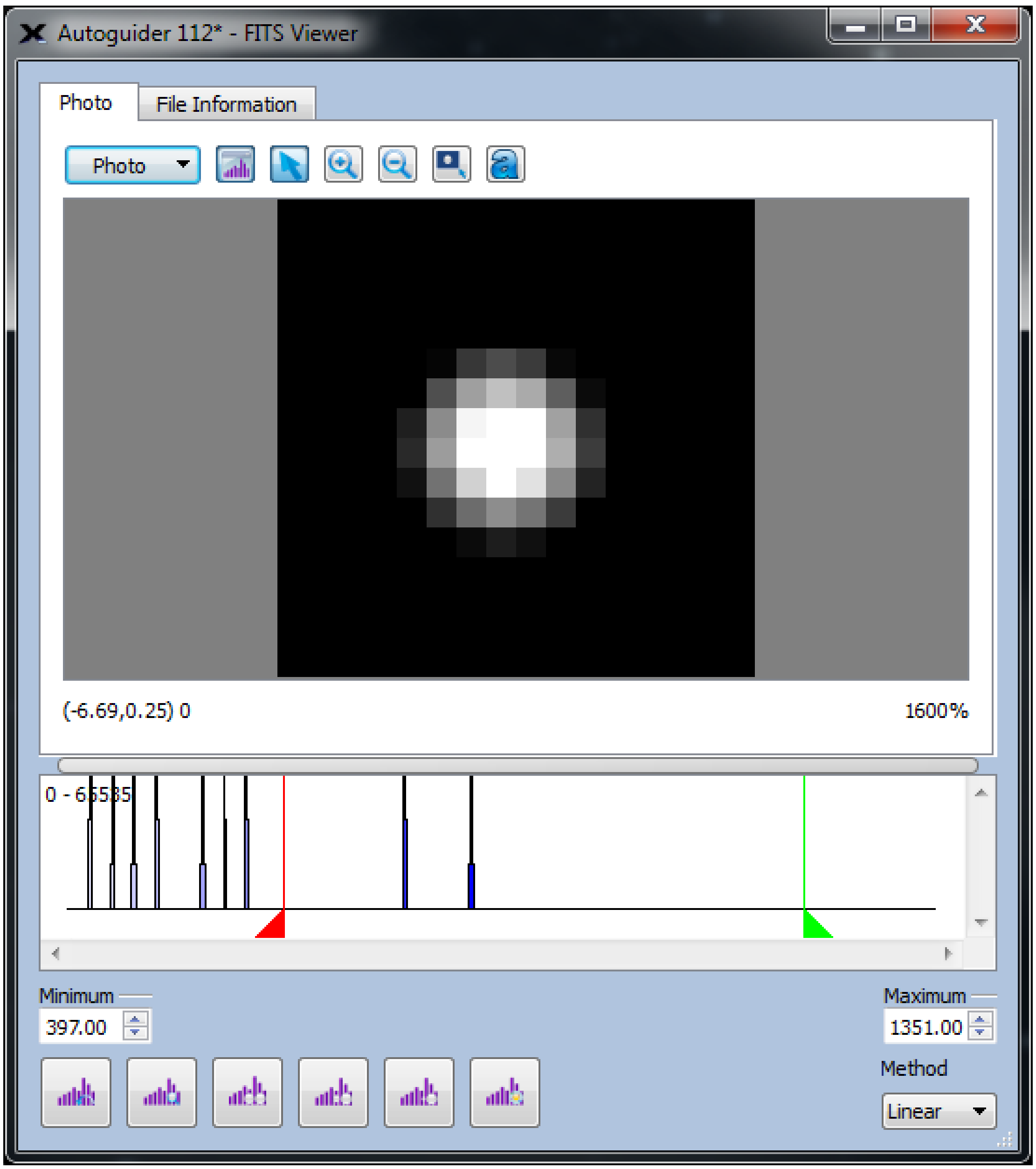


Figure 209 You may need to adjust the contrast to see dim guide stars while autoguiding.

SBIG AO Settings

To access the *Camera Add On's* SBIG AO controls, see the **Autoguide** tab on the ***Autoguider*** window (Figure 210).

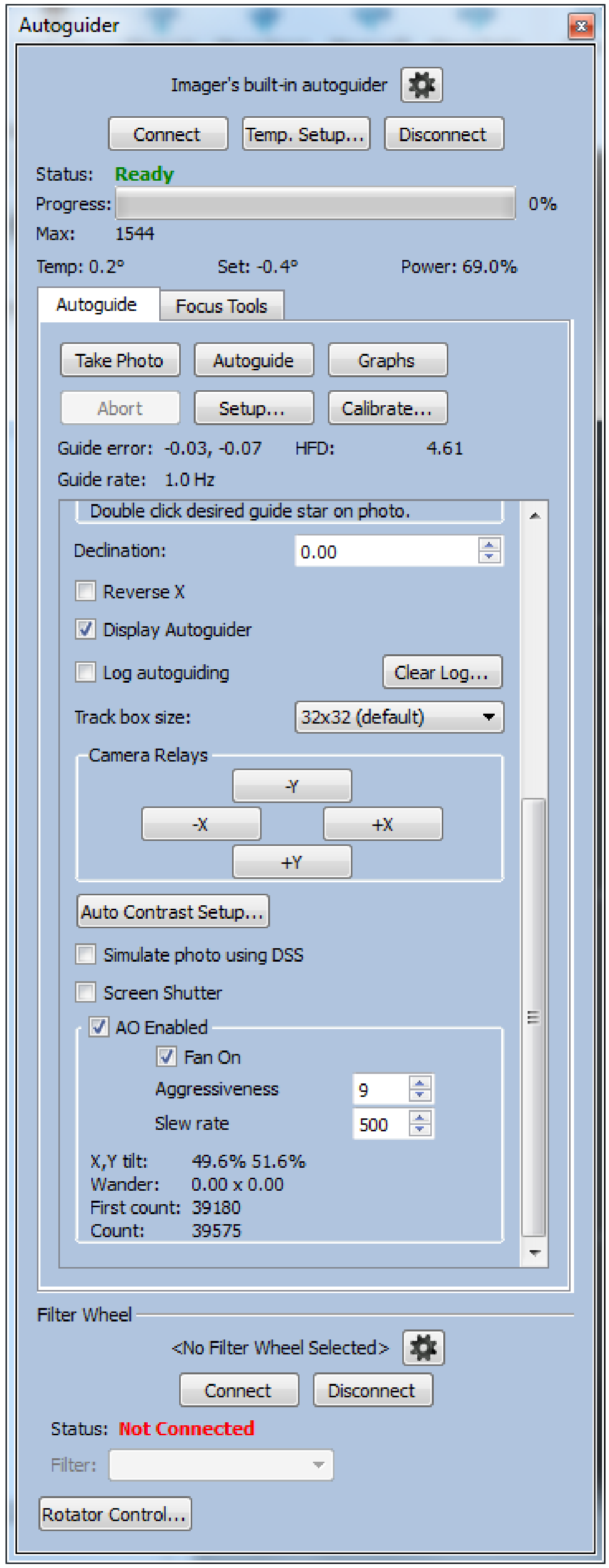


Figure 210: The Autoguide tab showing AO-related controls.

The most frequently used AO settings are found at the bottom of the scrolling controls on the ***Autoguide*** tab. Check ***AO Enabled*** to turn on the SBIG AO for autoguiding. Unlike most other controls of the *Camera Add On*, ***AO Enabled*** (and ***Fan On, Aggressiveness*** and ***Slew Rate***) are real-time controls in that they apply immediately when you change them. This allows you to turn on AO guiding, camera fan, aggressiveness and slew rate while autoguiding is in progress. The following list explains all of the AO features found in this window.

If you have the **AO Enabled** checkbox turned on and checked the AO will "do its thing" and tip/tilt the AO mirror to guide *and* if necessary the relays will bump the mount to bring the AO mirror near center. If you do not have **AO enabled** checked, the AO will not perform any corrections *and* no relay bumps will occur. In other words, when **AO enabled** is not checked, no guiding of any kind occurs. If you want to do normal guiding, disconnect and switch to your regular camera setting (for example, a specific SBIG camera by name).

Control	Description
AO enabled	When this checkbox is turned on, the SBIG AO will operate during autoguiding. This checkbox can be toggled during autoguiding. Unlike most other *Camera Add On* controls, this control remains active in real time during autoguiding. When turned off, no guiding occurs (no SBIG AO mirror tilt and no "bumping" of the mount with the camera relays occurs).
Fan on	This checkbox turns the camera fan on and off and can be toggled during autoguiding. Note that the fan may introduce a small vibration that can affect the quality of the photo; turning it off may improve your image sharpness at long focal lengths and high magnifications. Unlike most other *Camera Add On* controls, this control remains active in real time during autoguiding. Your camera cooler may have to work harder to maintain its temperature if you shut off the fan. Keep an eye on the ***Power*** text at the top of the ***Autoguide*** tab and monitor the percentage of cooling capacity in use. It should stay below 90% for effective cooling.
Center button	Click this button to center the SBIG AO's mirror. The center position is at the middle of the range of motion for both X- and Y- axes. A warning message is displayed when this button is clicked since centering will change the field of view, so you should re-take any reference image before proceeding after centering the mirror. Otherwise, a guide star currently in the field of view could move out of the field of view, or be at a slightly different position.
Aggressiveness	This functions like the aggressiveness setting when guiding with camera relays. A value of 10 means that 100% of a correction (mirror tilt) will be made. A value of 5 means that 50% of the indicated correction will be made, and so on.
Slew rate	Controls how the AO reacts to large error corrections. The units are arcseconds/second. If a correction would exceed this value, it is limited to this value. In order for this option to work correctly, you must enter your telescope

Control	Description
	focal length by clicking ***Telescope > Telescope Setup***, then highlight ***Camera*** and click ***New Photo Defaults***. For example, a slew rate of 250 arcseconds per second at 5 Hz would result in a maximum 50 arcsecond correction.
X tilt	The current tilt of the mirror in the X-axis (left to right with respect to the camera, if the SBIG AO is mounted to the camera according to the instructions from SBIG). The mirror tilts in the X-axis from 0% to 100%, with 50% being the middle position.
Y tilt	The current tilt of the mirror in the Y-axis (top to bottom with respect to the camera, if the SBIG AO is mounted to the camera according to the instructions from SBIG). The mirror tilts in the Y-axis from 0% to 100%, with 50% being the middle position.
Wander	The amount of guide star position error left ***after*** the AO makes a correction. In other words, this is the amount of error that the AO cannot correct. It will be higher if the seeing is bad, the guide rate is too low, or when the AO is oscillating from over-correction. It may be helpful to compare the ***Wander*** value with and without the SBIG AO enabled: the ***Wander*** value without the SBIG AO is controlled by the seeing; the ***Wander*** value with the SBIG AO shows the improvement obtained using the SBIG AO. You can tune the ***Slew Rate*** and ***Aggressiveness*** settings to minimize ***Wander*** with the AO enabled.
First count	The flux (total brightness above the background) of the guide star. All the pixel values in the star above the background are summed to find the star's flux.
Count	The current flux (total brightness) of the guide star. Compare this to the ***First Count*** value during guiding. If this value changes by a large amount following a download, the current guide star might not be the same as the original. If the value drops slowly over time, focus may be shifting. If this value jumps erratically, seeing may be poor, or clouds may be passing through.
Guide rate	The rate at which the SBIG AO is guiding. This will sometimes be slower than the actual exposure time suggests. For example, if you are using an exposure time of 0.25 seconds, you might expect a guide rate of 4 Hz (4 times per second). However, the download time, display time, and computer processing time slow this down. A very fast computer could hit a maximum guide rate as high as 60Hz with a sufficiently bright guide star and a small track box. Dimmer stars and slower computers will achieve lower rates. As a point of comparison, a 300 MHz laptop can achieve a guide rate of 8 Hz.

Autoguide Calibration Using Relays

When autoguiding with the SBIG AO, there are actually *two types* of autoguiding taking place. The SBIG AO tips and tilts its mirror to make rapid, precise guide corrections. Over time, the guide star may drift and the AO will accommodate this drift as it continues to guide. If the star's drift is large enough, the mirror will have a larger base tilt. When the base tilt reaches a certain value, the *Camera Add On* will move the mount in the opposite direction using the camera relays. This puts the AO mirror back closer to the center of its range of motion.

These two types of guiding (mirror tip/tilt and camera relays) are the reason that you must have both the autoguider calibrated using relays and autoguider calibrated using the SBIG AO before you can successfully autoguide using the SBIG AO.

If you have a Paramount mount and you have the ProTrack™ enabled, the *Camera Add On* will probably never need to bump the relays to keep the AO within its range of motion as ProTrack adjusts for nearly all of the stellar drift.

The aggressiveness setting for the mount applies when using the SBIG AO. A lower aggressiveness setting on the ***Relay Settings*** tab results in smaller (but more frequent) mount movements.

A higher aggressiveness setting results in larger (and less frequent) mount movements. Too frequent mount movements can reduce the effectiveness of the SBIG AO. Too large mount movements can result in elongated stars. Find a mount aggressiveness setting that balances these two extremes.

For details on relay calibration for autoguiding, please see "Autoguider Calibration" on page 367.

Additional AO Settings

Figure 210 shows the basic AO settings available on the ***Autoguide*** tab. In most cases, you will not need to adjust any other settings to get good results with the SBIG AO. However, additional AO parameters are available on the ***Autoguide Settings*** window's ***AO Settings*** tab (Figure 211). You can use these settings to refine the accuracy and performance of the SBIG AO. To access this dialog box, click ***Setup*** on the ***Autoguide*** tab of the ***Autoguider*** window (refer to Figure 210).

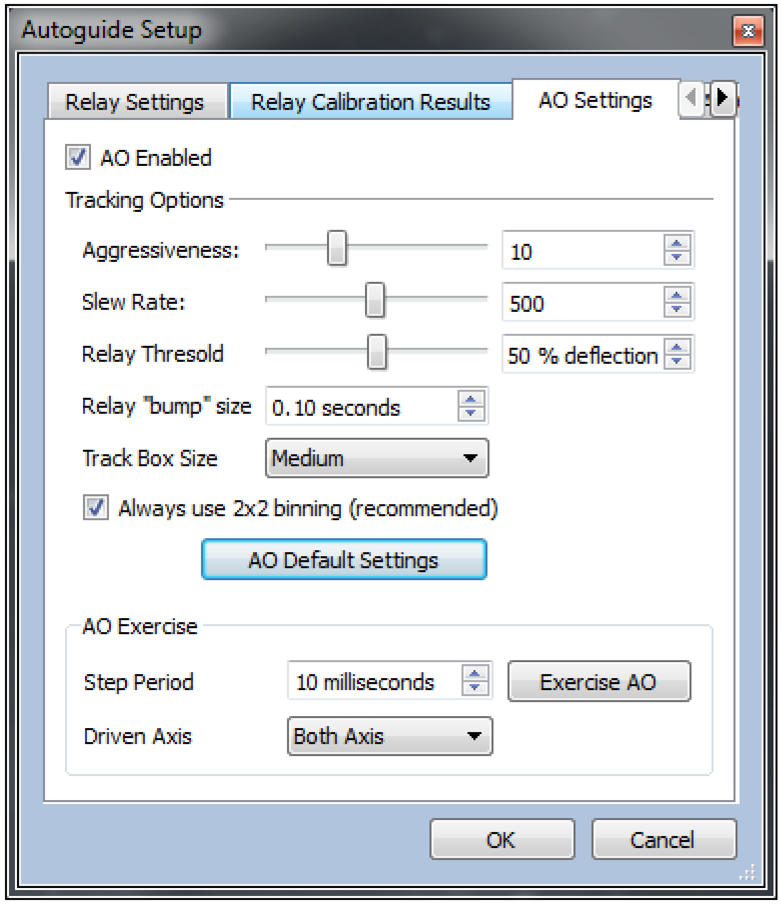


Figure 211: The AO Settings tab on the Autoguide Setup window.

The ***Tracking Options*** section of the ***AO Settings*** tab contains the following settings:

Control	Description
Aggressiveness	This is the same as the aggressiveness setting for the SBIG AO on the ***Autoguide*** tab.
Slew Rate	This is the same as the slew rate setting for the SBIG AO on the ***Autoguide*** tab.
Relay Threshold	The amount of mirror tilt that must occur before the mount is "bumped" with the camera relays. The default value is 50%, and this will work for most situations. If the seeing is very steady, and you would like to see less frequent mount movement, set this to a higher number. Never set the number so high as to cause the mirror to reach the end of its travel; the mirror cannot make corrections beyond 100% movement. Always leave a margin of safety. If seeing is poor, you can increase the safety margin by lowering this value.
Track Box	The size of the subframe used for autoguiding with the AO. Available

Control	Description
	values are small (4x4 pixels), medium (8x8) and large (16x16). A smaller track box allows for faster downloads and thus faster guiding. However, if the track box is too small, seeing-induced movement may cause the star to be lost, resulting in poor guiding. On any given night, the seeing will limit the size of the track box you can use.
Always Use 2x2	Binning the guide chip 2x2 increases its sensitivity. For a given star, the guide rate will be slower with 1x1 binning than with 2x2 binning. Since AO corrections are limited by exposure length, the shorter exposures possible with 2x2 binning allow you to use faster guide rates. A faster guide rate means the AO can work more effectively. The increased sensitivity for 2x2 binning comes from an increase in signal to noise ratio. Signal increases 4 times (2^2), and noise only increases ~1.4 times (square root of 2). Therefore the best possible signal to noise increase is from x to (4x/1.4) or 2.85x.
Use AO Defaults	Click this button to restore the default settings.

The ***Exercise AO*** group of controls allows you to test the movement of the AO mirror. You should remove the AO from the telescope when testing and observe whether the motion actually occurs. The AO device will make a light vibrating sound while it is being exercised.

The ***Exercise AO*** section contains the following settings:

Setting	Description
Step period	How long to move the SBIG AO for each step. The default value is 10 milliseconds.
Driven axes	You can test the X- or Y-axis alone or both axes together.
Exercise	Click this button to begin exercising the SBIG AO. A window appears during exercising to show the current X and Y position of the mirror. Click ***Cancel*** to stop the exercise process.

When you are finished making changes to the ***AO Settings*** tab, click ***OK*** save them, or ***Cancel***.

AO Calibration

	Even if you are using the SBIG AO for guiding, you must still calibrate the autoguider using relays as well. See the section, "Autoguide Calibration," for information. The relay calibration must be done prior to guiding with the SBIG

AO. If mount calibration fails, the SBIG AO may be unable to guide accurately, because movement of the mount via camera relays during guiding will be incorrect and the guide star will be lost.

During drive calibration, the *Camera Add On* takes a photo, moves the mount in a given direction, and then takes another photo. The difference in the calibration star's position between the two photos tells the Camera Add On how fast the mount moves in each of the four directions. Once calibrated, the *Camera Add On* can issue guide corrections that are as accurate as the mount will allow. Various factors, such as backlash and rough gear surfaces, can reduce the accuracy of mount-based guiding.

With the SBIG AO, corrections are made by tipping and tilting a small, lightweight mirror. There are no gears to worry about, and the mass of the mirror is tiny compared to the mass of a mount. In addition to its adaptive optics capabilities, the SBIG AO provides very accurate guiding and can compensate, up to a point, for an inaccurate mount. The mount must be accurate enough to move reliably with the camera relays. You can use a larger track box (see preceding section) to compensate for some of the mount's inaccuracies—a larger track box makes it less likely that a mount error will push the star out of the track box.

As with any calibration, the key to success is finding a suitable star for calibration. A good calibration star must be the brightest star in the field of view, and there must not be similar bright stars nearby that will move into the field of view during calibration. You can use stars the simulated stars on the Sky Chart to help locate suitable calibration stars. For more information about selecting stars for calibration, please see the section "*Choosing a Good Autoguider Calibration Star*" on page 374.

Adjust the telescope position to put the calibration star roughly in the center of the photo. This will prevent it from moving out of the field of view during calibration. Next, click ***Calibrate*** on the ***Autoguider*** tab of the ***Autoguider*** window to show the ***Calibration Autoguider*** window (Figure 210).

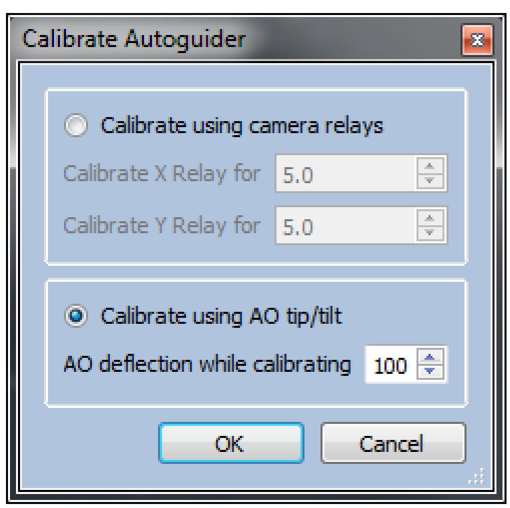


Figure 212: Calibrating the SBIG AO.

Click the ***Calibrate Using AO Tip/Tilt*** radio button to use this calibration method. For most applications, use 100% as the ***AO Deflection While Calibrating***. You can reduce this number to see if it improves the perpendicularity of calibration. Use the ***AO Calibration Results*** tab of the ***Autoguide Settings*** dialog box to evaluate AO calibration (Figure 213).

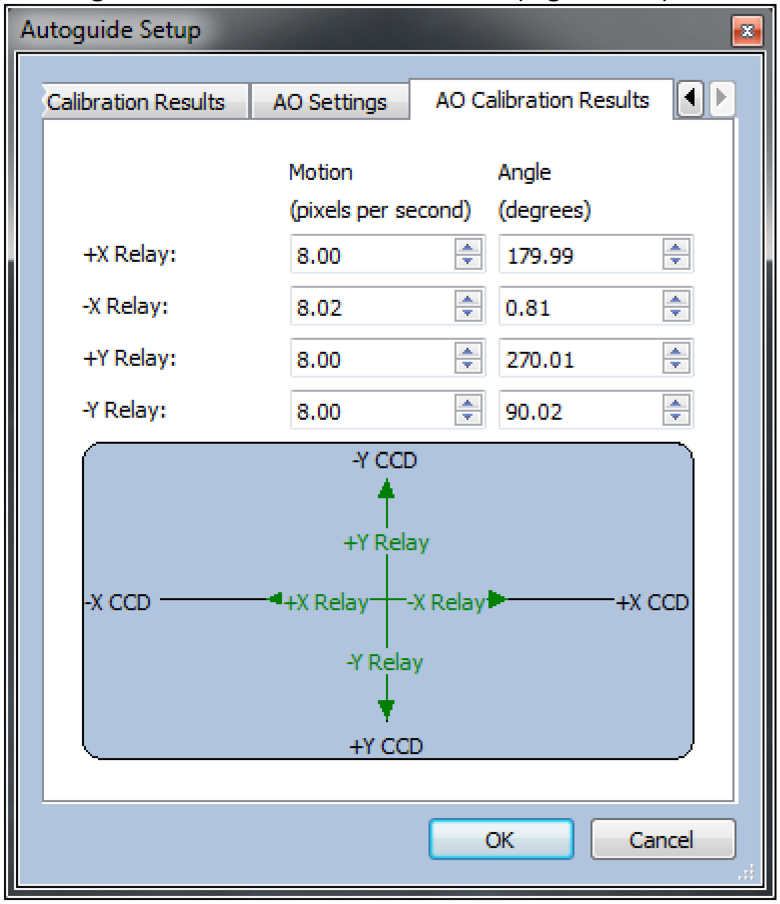


Figure 213: AO calibration results.

Note that the X/Y axes of the calibration results (green arrows) are not necessarily perpendicular to the reference X/Y axes. This is normal. Even if the camera and SBIG AO are installed exactly orthogonal to the mount's axes, the vector showing AO movement may be slightly non-orthogonal because of how the mirror moves. The *Camera Add On* takes this into account and will guide accurately with the SBIG AO.

AO-Assisted Autoguiding

Once you have calibrated the autoguider using both relays and the SBIG AO, you can use the SBIG AO for guiding. Start by clicking ***Take Photo*** from the ***Autoguide*** tab of the ***Autoguide*** window.

As with calibration, the key to successful autoguiding is finding a suitable guide star. The guide star should be away from the edges of the chip, and if you are using color filters it should be bright enough to remain visible through all filters. The brighter the guide star, the faster the guide rate you can use. Since the SBIG AO works best with the brightest available guide star, it's usually worthwhile to find the brightest one you can.

You can use *TheSkyX* to help locate suitable guide stars, adjust the framing of your photo, or rotate the camera to find the best available guide star. For more information about selecting stars for guiding, please see the section "Select a Guide Star" on page 377.

Adjust the telescope position to put the guide star at least 10 pixels away from the edges of the guide window. This will make it less likely that the guide star will move off of the guide chip during guiding. You can adjust the guide star's position using the mount's hand paddle; *TheSkyX* mount controls; or using the ***NSEW*** buttons on the ***Autoguide*** tab. The ***NSEW*** buttons move the telescope at the current guide rate using the camera relays, and you can use them to make very small adjustments to position.

Before you start autoguiding, you can make final adjustments to guide parameters. Settings for ***Aggressiveness*** and ***Slew Rate*** can be made right on the ***Autoguide*** tab. You may also need to adjust the ***Track Box Size*** to adjust for seeing conditions. The better the seeing conditions, the smaller the track box you can use. Figure 214 shows the appearance of the three track box sizes. Note that different zoom levels are used for the track boxes, so the track box stays the same size, but the relative size of the star changes. From left to right, they are Small, Medium, and Large. The Small track box requires very good seeing (steady skies), or the star will move out of the track box. The Medium setting is good for more typical seeing conditions, and the Large track box allows you to use the SBIG AO on nights when the seeing is below average.

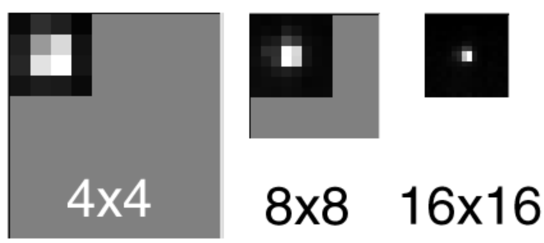


Figure 214: Different sizes of the AO track box. From left: Small, Medium, and Large.

Once the guide star is properly positioned, click ***Autoguide*** to begin guiding. The *Camera Add On* takes multiple dark frames and averages them to reduce noise in the dark frame. This master dark is subtracted from all light frames to provide as clean an image as possible during guiding. If your exposure time is relatively long (for example, 5 seconds), it will take longer to capture the multiple dark frames before the start of guiding. A 5-second exposure will not give you any benefits of the adaptive optics, but could be used instead of conventional guiding if your mount does not handle guide corrections effectively.

During guiding, you can monitor the effectiveness of guiding by watching the values in the ***AO Enabled*** section of the ***Autoguide*** tab. The ***X*** and ***Y Tilt*** values show the current tilt of the SBIG AO mirror. These values should change over time as the mirror tilts to accommodate drift. When tilt reaches the maximum value allowed (default is less than 25% or greater than 50%), The *Camera Add On* will bump the mount and the tilt should return closer to 50% for both axis.

The amount it will go down depends on the aggressiveness setting of the mount. With low aggressiveness settings on the mount, smaller bumps will occur, and the bumps will therefore be more frequent.

Wander indicates how accurately the SBIG AO is guiding. If the SBIG AO aggressiveness is too low, wander will be high because the SBIG AO will under correct. If the SBIG AO aggressiveness is too high, over-correction may occur and this will also increase the ***Wander*** value. Adjust ***Aggressiveness*** and the ***Slew Rate*** to obtain the optimal ***Wander*** value.

Note: Local seeing conditions also affect ***Wander***. Compare the ***Wander*** value with and without SBIG AO guiding so that you know the contribution to ***Wander*** from seeing.

A good measure of the optimal tuning of the aggressiveness, guide rate, etc. is the RMS wander. This wants to be a small as possible and ideally will not degrade when the AO is turned off momentarily.

Ideally an AO guided image will have 30% lower stellar half-width and 50% to 100% better peak brightness.

You can also use ***First Count*** and ***Count*** to monitor guiding. If the ***Count*** value drops, you may have clouds moving in or a focus shift. Focus can shift from changes in temperature, or from a physical slippage of the focuser.

The ***Guide Rate*** may be lower than you expect, depending on the processing speed of your computer's processor. For example, if you are using an exposure of 0.02 seconds, you might expect a guide rate of 50 Hz (50 exposures per second). However, it takes time to download and display images, and it takes additional time to perform calculations on your computer. This time is added to each exposure, resulting in the actual guide rate. In this example, the guide rate might be anywhere from 6 to 40 Hz depending on your equipment.

Autoguiding will automatically suspend during downloads from the main imaging chip. Autoguiding will resume when the download is complete. If you are using a Small or Medium track box, the guide star may have drifted out of the field of view during the download. Cameras with USB download are much faster, and it is more likely that you will retain your guide star using a USB-equipped camera. An extremely accurate polar alignment will also help you retain your guide star following a download.

If the guide star is lost, or if a different guide star is found, you can ***Abort*** the guiding and restart it with the desired star. Re-center the mirror if tilt is large. Click ***Take Photo*** to get a new image using the guide star, click to select the guide star, and then click ***Autoguide*** to begin again. If you are taking a sequence of images, you may need to monitor the downloaded images and the guide star window to determine if the guide star is still available.

Taking Series of Photos

The *Camera Add On* gives you the ability to acquire multiple photos, in sequence, using the ***Take Series*** tab on the ***Camera*** window.

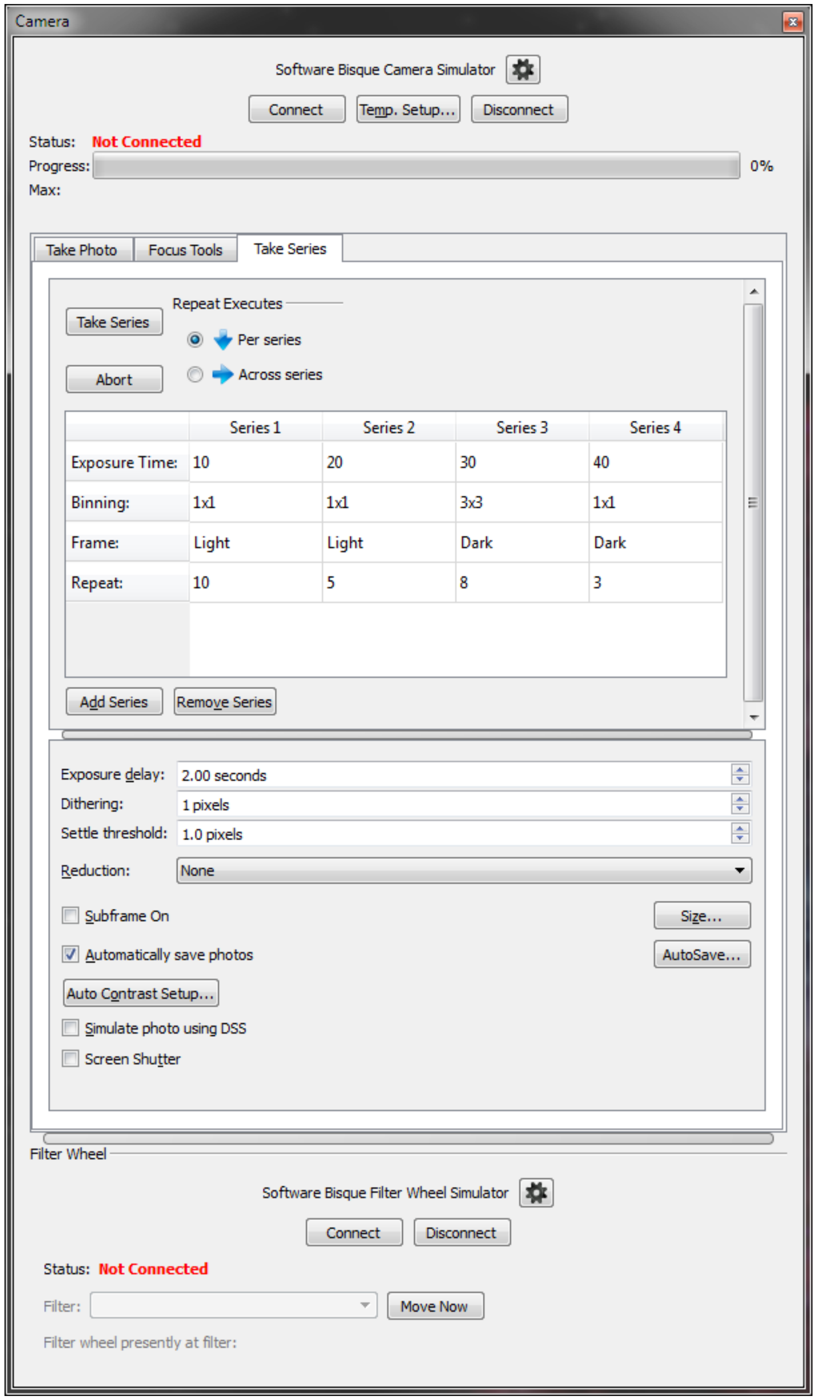


Figure 215: The *Take Series* tab on the *Camera* window.

Take Series Button

Click this button to begin the process of taking photos based on the settings in the ***Series*** table.

Repeat Executes Options

These two options permit a flexible means to control how individual series are executed.

Per Series

When this option is selected, ***Series 1*** is repeated based on the ***Series 1 Repeat*** value, followed by ***Series 2***, which is repeated based on the ***Series 2 Repeat*** value, and so on until the series is completed.

For the series defined in Figure 215, ***Series 1*** is repeated 10 times, followed by ***Series 2***, which is repeated five times, followed by ***Series 3***, eight times, followed by ***Series 4***, three times.

Across Series

When this option is selected, ***Series 1*** is executed first, and once, regardless of the ***Repeat*** value, then ***Series 2*** is executed once, regardless of the ***Repeat*** value, and so on until the end of the series. The series execution continues for each series that has a ***Repeat*** value greater than one.

For the series defined in Figure 215, ***Series 1-4*** are each executed three times, then series 1-3 are executed two more times (since the ***Repeat*** count of ***Series 2*** is 5, and that makes five repeats), then Series 1 and 3 are each executed three more times, and Series 1 repeats to more times for a total of ten repeats.

Abort

Click this button to stop taking a series of photos.

Series Table

The top row of the ***Series Table*** lists each series, starting with ***Series 1***.

The left-most column of the ***Series Table*** lists the camera settings (and filter settings, if a filter wheel has been selected) that will be applied to each series. To edit any one of the series parameters, double-click the appropriate table entry. For example, double-clicking on the number *10* next to ***Exposure Time*** shows the spin box that lets you enter a different value.

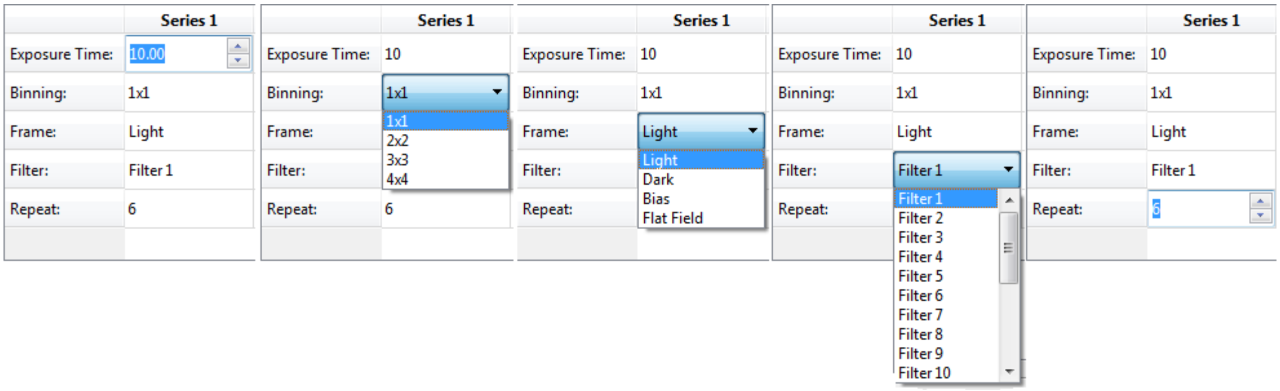


Figure 216: To change a camera or filter setting for a particular series, double-click the appropriate table entry.

Exposure Time

Enter the length of the exposure, in seconds, for this series. See "Select Exposure Length (Exposure Length)" on page 356 for details about this camera setting.

Binning

Choose the binning for this series. See "Select Bin Mode (Binning pop-up)" on page 357 for details about this setting.

Frame

Choose the type of frame (***Light***, ***Bias***, ***Dark***, ***Flat Field***) to capture for this series. See "Set Frame Type to Light" on page 360 for details about this camera setting.

Filter

Select the desired filter for this series. Note that the ***Filter*** option is displayed only if an appropriate filter wheel is selected on the Imaging System Setup window.

Repeat

Enter the number of times to repeat this series.

Add Series

Click this button to add a new series to the ***Series Table***.

Remove Series

Click this button to remove the selected series from the ***Series Table***.

The following "global" series options apply to each series.

Exposure Delay

Enter the delay between each exposure in the series to allow for telescope settling.

Dithering

Enter the number of pixels to move the guide star (specifically, the telescope) between successive photos in the series.

Settle Threshold

Enter the maximum deviation, in pixels, of the guide star after the telescope's position has been adjusted during dithering process.

Reduction

Choose the image reduction to apply to each photo in the series.

- ***None***: do not apply any reduction to the photo.
- ***AutoDark***: apply a dark frame to the photo.
- ***Full Calibration***: apply a calibrated photo to the photo.

The following options appear when the ***Full Calibration Reduction*** option is selected.

Group Pop-up Menu

Choose either ***Imager*** to apply a calibrated photo from ***Image Calibration Library*** for the imager, or ***Autoguider*** to apply a photo for the autoguider.

Image Calibration Library Button

Click this button to show the ***Image Calibration Library*** window. See "Taking Reduction Frames" on page 428 for more information about image reduction and calibration.

Subframe On

Turn this option on to show and use a portion or subframe of the photo instead of the full frame.

Size Button

Click this button to define the size of the subframe.

Automatically Save Photos

Turn this checkbox on to automatically save photo acquired during the series.

AutoSave Button

Click this button to show the ***AutoSave Setup*** window to configure the AutoSave settings (page 361).

Image Reduction

Image reduction allows you to clean up images to better reveal the data in them. You can in effect take pictures of some of the noise in your imaging equipment, and then use those pictures to remove much of the noise.

Noise is the error in the brightness levels in an image. Noise can occur from a variety of sources. Some noise is random and unpredictable. Such noise can be limited, but never removed. This type of noise is defined as the level of uncertainty in brightness levels. For example, if you took four images of an object, you might see brightness levels of 98, 97, 103, and 102. That variation in brightness reflects the error level.

Other types of noise are inherent to the imaging equipment, and this type of noise is called system noise. System noise can be subtracted from your images to clean them up. It builds up while you are taking your image, and while reading the image off of the CCD detector. By taking steps to limit noise in the camera (mainly by cooling the detector), and by removing the repeatable noise that is left, you can achieve very high-quality images. Image reduction, however, can only clean up an image so far. The quality of the image itself determines that limit. Longer exposures, or combined exposures, when reduced properly, will give you the highest level of quality possible.

All noise by nature creates uncertainty in the brightness levels of the pixels in your image. If a picture has a lot of noise in it, you can see this visually. There will be variations in brightness in areas that you expect to have a more uniform brightness. Words commonly used to describe this effect are “grainy” and “gritty.”

Some common sources of system noise in CCD imaging include:

- **Readout noise** results from collecting, amplifying, and converting pixel data to electrons inside the camera.
- **Dark current** results from electrons accumulating in pixels even in the absence of light.
- **Optical dust** is debris and bits of dust in the optical path that cast shadows on the CCD detector.
- **Background noise** results from sky glow.
- **Reflections** are the effects of light that reflects off of various surfaces in the telescope, focuser, or CCD camera, and falls on the CCD detector.
- **Image processing noise** results from processing the image using various techniques.

Removing the system noise from your images is a form of **data reduction.** The term “calibration” is sometimes used to refer to this process, but data reduction is a more accurate description of the procedures involved. Calibration involves comparing values to a known accurate reference, such as calibrating the brightness of a star in an image using its known magnitude, or determining how far your mount moves in 10 seconds (autoguider calibration).

Even when you take steps to remove noise, you also add some noise back into the image at the same time. For example, when you subtract a dark frame (see section "ERROR" later in this chapter), you add the dark frame's noise to the image. You are usually removing much more noise than you add, providing a net gain from this and most other noise reduction processes. Thus, there is no way to remove all of the noise from an image. You can remove a lot of noise with careful technique, however. Figure 1 shows two halves of an image. The top half shows the original image; the bottom half shows the same image after data reduction.

Figure 217: The benefits of data reduction on an image of Stephan's Quintet.

This chapter describes how to use TheSkyX Camera Add On to remove noise from your images, leaving them cleaner and ready for further processing. In this chapter, you will learn how to:

- Acquire bias frames.
- Acquire and apply dark frames.
- Acquire and apply flat-field frames.
- Create and manage groups of bias, dark, and flat-field frames.
- Manually and automatically apply data reduction to images.

Quick Start for Experienced Users

For this section, an experienced user is someone who has experience creating and applying bias frames, dark frames, and flat field frames to CCD images.

The most powerful way to apply reduction is to create **reduction groups,** consisting of any number of bias, dark, and flat-field frames. You can apply reduction groups to individual images, to a folder of images, or automatically to each image as you acquire it.

1. Create a reduction group, and add images to it. To begin, you must have appropriate bias, dark, and flat-field images to add to the group. Follow accepted guidelines for optimal creation of these files:
   - Bias and dark frames should be taken at the same temperature as the light frames.
   - Bias frames should be taken using the shortest possible exposure time.
   - Dark frames should be taken with same exposure as the light frames.
   - If matching exposure temperature and duration is not practical, the *Camera Add On* can be set to compensate for these differences.
   - Flat fields can be taken at different times and temperatures than light and dark frames. If appropriate, you can use separate dark frames for flat fields.
2. Click ***Input > Image Calibration Library*** to open the ***Image Calibration Library*** window. Click ***Add Group*** to create a new group. Try using a name that includes the date, detector temperature, and/or other items that can help you with later re-use of the group.
3. The new group will have placeholders for bias frames, dark frames, dark frames for flats only, and flat frames. Click on the placeholder, and then click ***Add Frames***. Navigate to the folder with the files you want to add. Highlight the frames you want to add (use Ctrl and Shift keys to select more than one), and then click ***Open***.
4. Continue until you have added all of the images you desire to any or all of the four placeholders.

You now have several options for using the newly created reduction group:

- If you have one or more images open that you want to reduce, click ***Reduce***, select the images to reduce and click ***OK***.
- If you have a folder of images you would like to reduce, click ***Reduce Folder*** and navigate to that folder. Then select the output folder and click ***Reduce***. This is a powerful feature that can save you hours of effort. For example, in just a few minutes you could apply bias, dark, and flat frames to hundreds of images. Note: every file in the folder must be an appropriate image for the reduction group. For best results, copy images with the same reduction characteristics into a folder.
- If you are taking new images, and want to apply the reduction group to each image as it is acquired, start by making sure to save your photos by turning on the ***Automatically Save Photos*** checkbox on the Camera window. Next, select ***Full Calibration*** as the ***Reduction*** option. Then select the desired group from the Group option just below the Reduction option. Note: The Group option isn't active unless you choose the appropriate Reduction option. The group you select will automatically be applied to each image. The original image and the reduced image are both saved to the ***AutoSave*** folder. The reduced image will have the keyword "REDUCED" added to the filename.

Principles of Image Reduction

There are many sources of noise in the data collection process. There are three things you can do that will remove the majority of the noise from most images, and they all involve taking a picture that captures the noise you want to remove. These are bias, flat-field, and dark frames. Figure 2 shows an example of each type of frame.

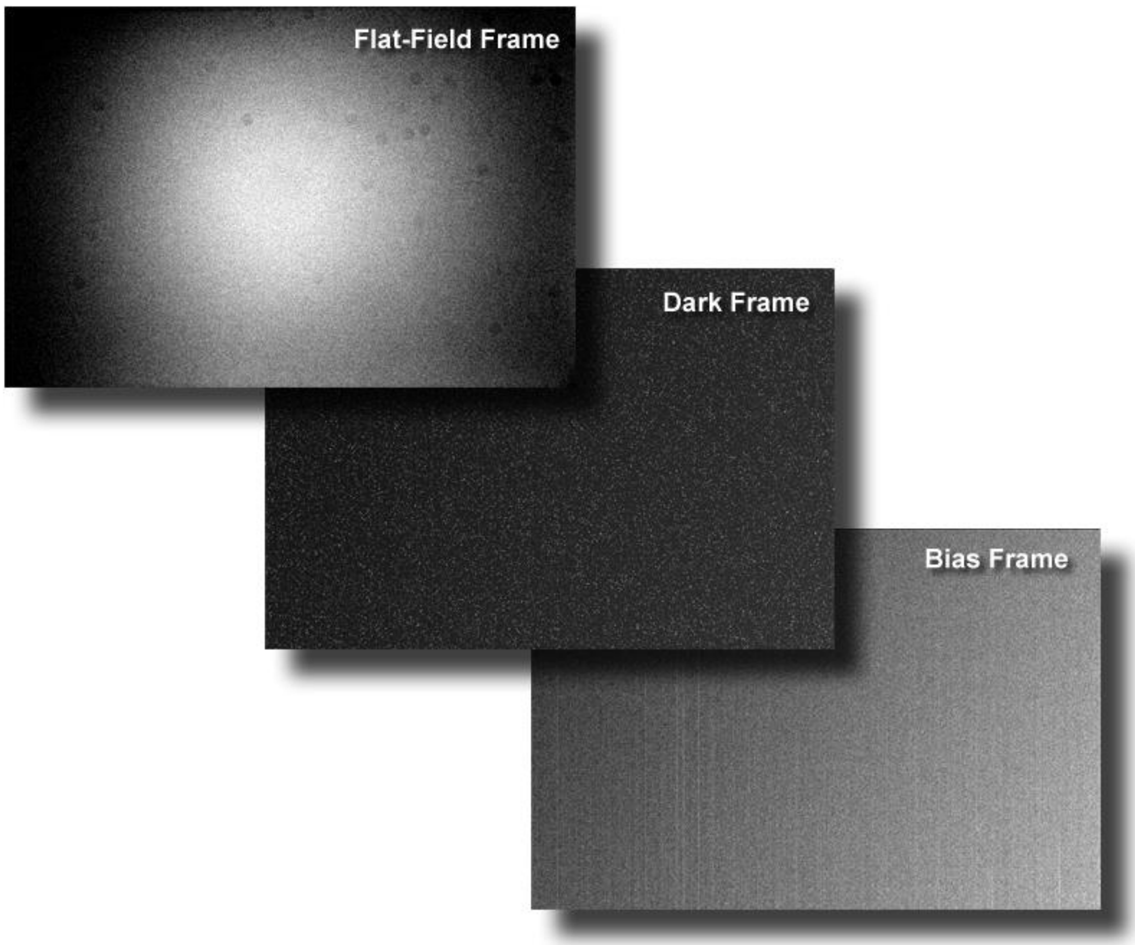


Figure 218: Samples of bias, flat-field, and dark frames.

Bias Frames: Bias represents pixel values that occur on your CCD detector even if the exposure time is zero (or as close to zero as possible). In other words, even a zero-length exposure still delivers non-zero brightness values. This means that pixels do not necessarily start with a zero value at the beginning of an exposure. Note: SBIG cameras include a 100-unit pedestal (that is, 100 units are added to the value of every pixel). This is true not just of bias frames, but of all frames (bias, dark, flat-field, and light). TheSkyX Camera Add On appropriately subtracts the pedestal during data reduction. You will find instructions for taking bias (and other types of data reduction frames) in later sections of this chapter.

Dark Frames: Even if no light strikes the CCD detector, the individual pixels change value over time, building up an electrical charge consisting of electrons that accumulate in the pixels.

Most of this energy comes from heat, and it is called thermal noise or dark current. Most CCD detectors are cooled to reduce this type of noise, but there will always be some level of dark current. The greater the cooling, the lower the dark current will be. Each pixel responds to dark current differently. Some are more sensitive, and will be brighter as a result of dark current. Others are less sensitive, and may change very little. The top half of figure 1 shows many hot pixels from dark current. Dark current varies slightly from image to image, but it is highly consistent. Thus, as with a bias frame, you can take an image with the shutter closed (or your hat over the front of the telescope if your camera has no shutter) to create a dark frame. TheSkyX Camera Add On subtracts dark frames from light frames to remove most of the effects of dark current.

Flat Field Frames: As light comes through the telescope and CCD camera, several things can happen. Under the best of circumstances, the light will come through unobstructed and perfectly distributed. This ideal situation is seldom the case, however. For example, the center of the focal plane is often brighter than the edges. Also, dust can get on the optical surfaces, casting shadows that affect the amount of light reaching each pixel. In addition, internal reflections can cause unwanted light to fall on the CCD detector. A flat-field frame records these variations in brightness. To create a flat-field frame, take an image of an evenly illuminated surface. Various parts of the optical path add or subtract light from the evenly illuminated surface, and the flat field records the variations.

Taking Reduction Frames

Bias frames are easy to take, and require no special technique. You simply take the shortest possible exposure that your camera provides. Dark frames are also relatively simple, though you should match the temperature and exposure length of the light frame(s) reasonably well. Flat-field frames are the trickiest to master. It’s not as easy as it sounds to create an evenly illuminated surface. You’ll learn some useful techniques for creating good flat fields later in this chapter. The

Bias Frames

Figure 3 shows the Take Series tab set up to take a series of three, one-minute light exposures. ***Binning*** is ***1x1***, and no image reduction will occur because the ***Reduction*** option is set to ***None***. See the section “Automatic Reduction” later in this chapter for information about automatic image reduction.

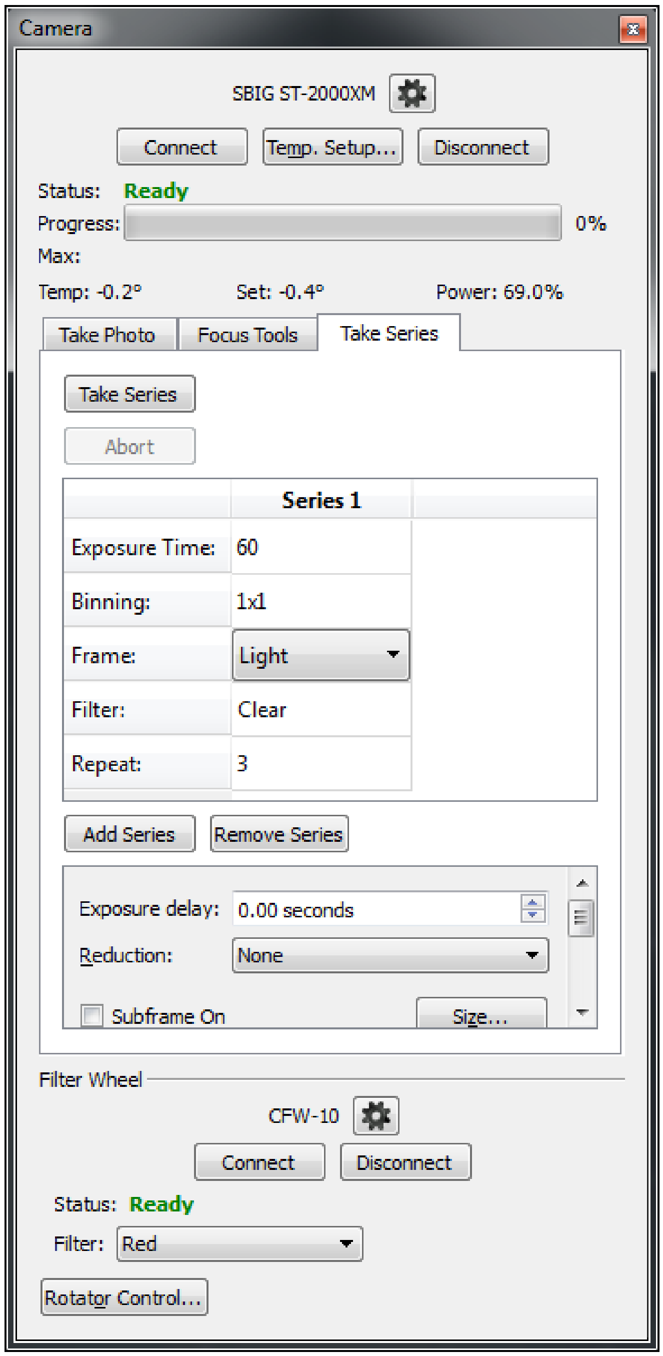


Figure 219: The light frame to which the sample bias, dark, and flat-field frames will be later applied. The filter row is only shown when there is a connection to a filter wheel.

To take a bias frames for this photo, simply double click Light and instead choose Bias. Since the bias frame is the shortest possible exposure, the Exposure Time settings is ignored. TheSkyX Camera Add On will automatically use the shortest possible exposure for your camera when it exposes a bias frame.

Note that the ***Repeat*** setting is set to 3. We recommend taking at least three bias frames. These can be averaged to reduce noise. The images you take for image reduction have their own levels of random noise. Combining images is one of the most effective ways of reducing the random noise in your reduction frames and your images. This occurs automatically when you use reduction groups with multiple frames. See the section "Using Groups for Reduction" later in this chapter for details.

When you are ready to take your bias frames, click ***Take Series***. If you have set ***AutoSave*** on, the filename will contain the word BIAS in it so you can readily distinguish your bias frames. For most situations, we recommend leaving ***AutoSave*** on to make sure that no images or reduction frames are accidentally lost. As with any image, you can cancel the bias frame or its download by clicking ***Abort***.

Bias frames can only be applied as part of a group; there is no command for applying only a bias frame to an image.

The Take Series tab allows for taking multiple series of a single target. For the example at hand, we could have taken three lights, three bias and three darks like this by simply clicking Add Series.
When you press Take Series photos would have been acquired in just that order, three lights, three darks, and three bias frames.

If instead you wanted to take one light, one bias, one dark, three times, simply set Repeat to one, then copy all three columns and paste to the end twice. There is really no limit to the number of series and the ability to copy and paste a series makes it fairly easy to get most any combination of frames.

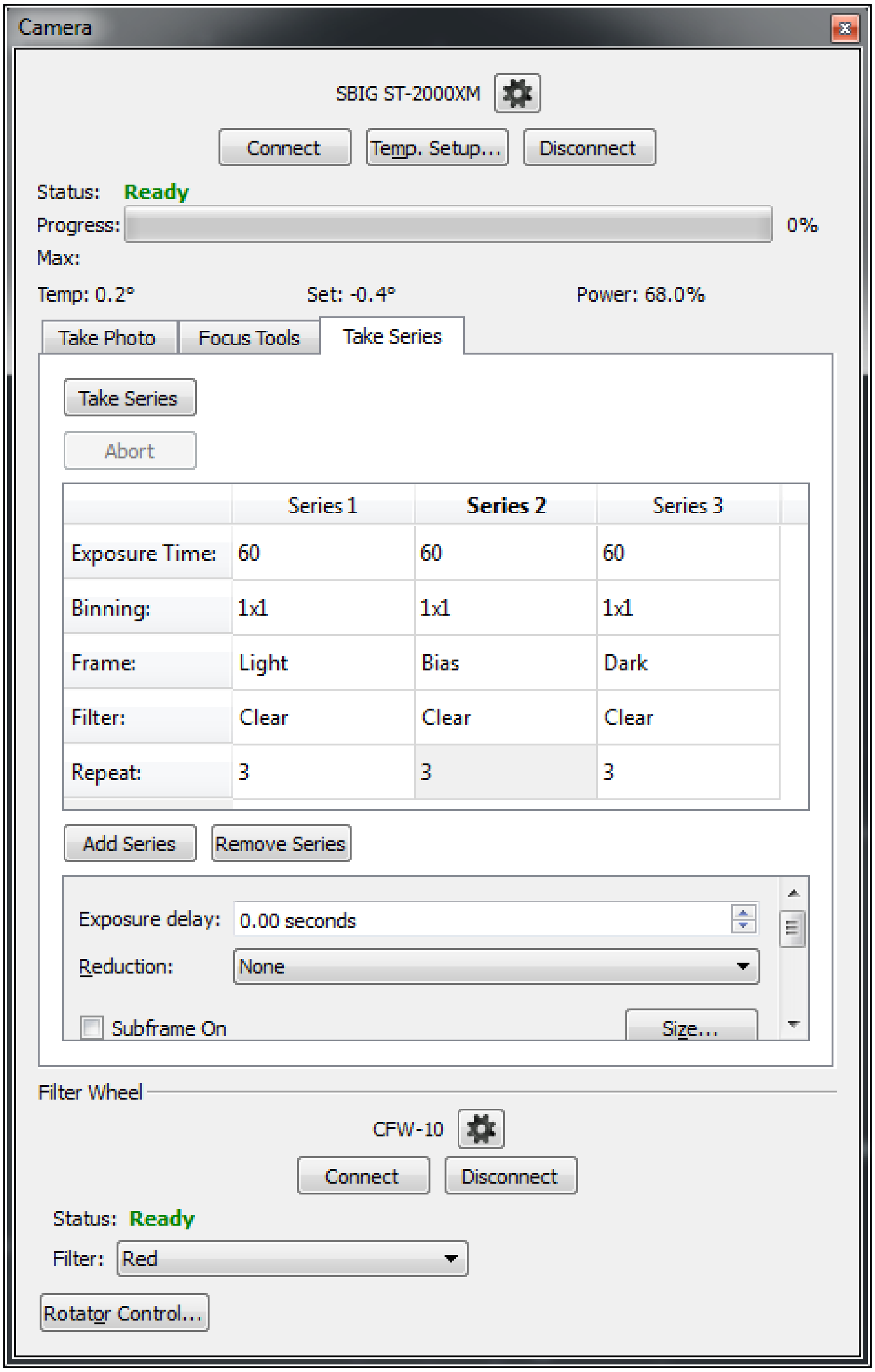


Figure 220: Take Series tab on the Camera window.

Dark Frames

Dark frames are an important tool for image reduction. Dark current varies with the temperature of the CCD detector. Most CCD cameras cool the detector, some by as much as 35 degrees Celsius or more. The warmer the CCD detector, the greater the dark current and the greater the need for dark frames. For optimal noise reduction, take at least three dark frames and use them in a reduction group.

Each CCD detector has a pattern of hot and cold pixels that varies minimally from image to image. The intensity of the hot pixels varies with exposure length and temperature, however. For this reason, you should, whenever possible, take dark frames that have the same temperature and exposure length as your light frames. If you are unable to do so, TheSkyX Camera Add On will scale dark frames to fit the exposure of a light frame. The results will not be quite as good as when you match temperature and exposure length precisely. The greater the difference in exposure time, the less likely this compensation will be effective. For example, if you have a light frame with a two-minute exposure, a dark frame of 90 seconds or three minutes will be reasonably effective. A ten-minute dark frame, however, will probably add substantial noise to the image. The colder the CCD, the less of a problem this will be, since the total noise in the image will be less.

To take a series of three dark frames matching the light frame from figure 3, simply change Frame to Dark. Note that the exposure time matches that of the light frame, and that the temperature is the same. There will often be small fluctuations in CCD detector temperature (less than a quarter degree, typically), and these can be safely ignored. The Frame has been set to ***Dark***. Note that the Reduction drop-down list is disabled, since there can be no reduction of a dark frame.

When you are ready to take your dark frame(s), click ***Take Series***. If you have turned ***AutoSave*** on, the filename will contain the word DARK so you can readily distinguish your dark frames. For most situations, we recommend leaving ***AutoSave*** on to make sure that no images or reduction frames are lost accidentally. As with any image, you can cancel the image or the download by clicking ***Abort***, which is only active when imaging or downloading.

You may notice on some cameras that one side of the dark frame is a little brighter than the other. This is normal. It may take as much as a minute or more to download the data from cameras with very large pixel arrays, and during this time dark current continues to build up on the CCD detector. Since this gradient occurs in both the light frame and the dark frame, it is automatically removed during image reduction. Cameras that transfer the image instantly via frame buffers will not show this effect.

You can apply a single dark frame to an image, or you can apply multiple dark frames as part of a group. Since the thermal noise (dark current) in dark frames is also present in the light frame, the idea is to simply subtract the dark frame from the light frame, leaving a clean record of the light that struck the CCD detector. TheSkyX Camera Add On automatically handles the 100-count pedestal that is added to images acquired with SBIG cameras (see bias frame section above for details).

Flat-Field Frames

Like dark frames, flat fields can make a big difference in the appearance of your images. Flat, in this case, means "evenly illuminated." Unlike dark frames, which simply require you to take an image to record the dark current, taking a good flat field requires much more operator involvement. You should expect to spend some time perfecting your technique in making high-quality flat-field frames. It's not as easy as it might seem to evenly illuminate a surface. Stray light and reflections outside the optical tube are a challenge to control.

The flat-field frame is a record of the optical path's characteristics (see figure 14 for an example of a flat field). Anything that casts a shadow or causes a reflection leaves its imprint on the flat-field image. This includes dust on any of the optical surfaces; lint hanging from the inside of the tube into the optical path; light reflecting off of any surfaces within the tube, focuser, filter wheel, and/or camera, etc.

If you rotate your camera, change filters, use a different dew shield, or make any other changes to your system, you'll probably need a new flat field. You'll also want to take new flat fields periodically to account for any new dust that settles on the optical surfaces, or that moves or falls out of the system.

Quality Issues for Flat Fields

The best way to judge the quality of a flat field is to apply it to a test image. The ideal test image is of a sparse star field unaffected by light pollution, without any large galaxies or nebulas in the field of view. This allows you to examine the effects of the flat field on the entire background of the image. If applying the flat field removes shadows from dust particles, and provides a flat, even background in your images, then it is an effective flat field. If you do not have an area of sky unaffected by light pollution, you may have to use your best judgment on the quality of your flat field.

Several things can get in the way of this simple test of a flat field, however:

- If there is a moon or other bright light source, the sky background may not be flat. It will be brighter on the side toward the light source, and darker away from the light source. This gradient may be very small, but after you apply a flat field the gradient will be much more visible. A bright full moon, a nearby streetlight, or lights from an urban area near the horizon can all create severe problems that are a major challenge to solve. It's difficult to test a flat field when such a gradient is present, and the flat field won't solve this type of gradient problem because the source is outside the optical system. In some cases, such as when the light is very bright or the dynamic range of your CCD detector is small, the gradient will overwhelm the image completely.
- Off-axis light sources can pollute a flat field. For example, suppose you are using a dew shield and that there is a neighbor's security light to the left of the telescope's optical axis. If that light reflects off of the dew shield, it could make it down the optical tube and hit the CCD detector. As a result, one side of the flat field image will be brighter than the other. The off-axis light source prevents you from getting even illumination.

Similarly, if you are using a translucent panel to create the even illumination, an off-axis light source could reflect preferentially at some angles and create bright spots in the flat field.

All of these obstacles can be overcome. You need to invest some time to discover the ways in which undesired light is interfering with even illumination. Once you eliminate the extraneous light sources, you wind up with a very high quality flat field that will give you much better looking images.

Flat fields have particular value for scientific research. A properly executed flat field will remove distortions in brightness levels from an image, and allow you to make accurate measurements of the relative brightness of objects in the image. Without a good flat field, your calculations will contain a larger amount of error.

But flat fields are also important for taking “pretty pictures,” too. It is difficult – sometimes impossible – to process an image that has variable levels in the background. Dim areas of an image get lost in the brighter portions of the background. A properly executed flat field can completely solve such problems. Getting to a flat, even background is very important no matter what kind of images you take.

A good flat field will correct for any shadows and reflections in your optical system. Any gradient in the background that remains after a good flat field is either caused by brightness in the sky itself, as from the moon or a bright planet; light pollution; or by off-axis light sources that cause additional internal reflections. Creating a counter gradient and subtracting it can remove gradients, but you will almost always loose some image quality in the process.

Flat Fields

Figure 221 shows the settings to use for taking a flat field. The exposure time need not (and mostly will not) match the exposure time of the original image. Likewise, the temperature need not be the same. You will need to take a separate dark frame (or set of dark frames) that match the temperature and exposure time of your flat field frames. If you apply a flat field individually to an image, apply the flat’s dark frame first. If you use reduction groups, the dark frames for the flat field frames are part of the group, and will be applied to the flat frame automatically. In Figure 221, the ***Frame*** type has been set to ***Flat Field***, and the ***Reduction*** is set to ***None***.

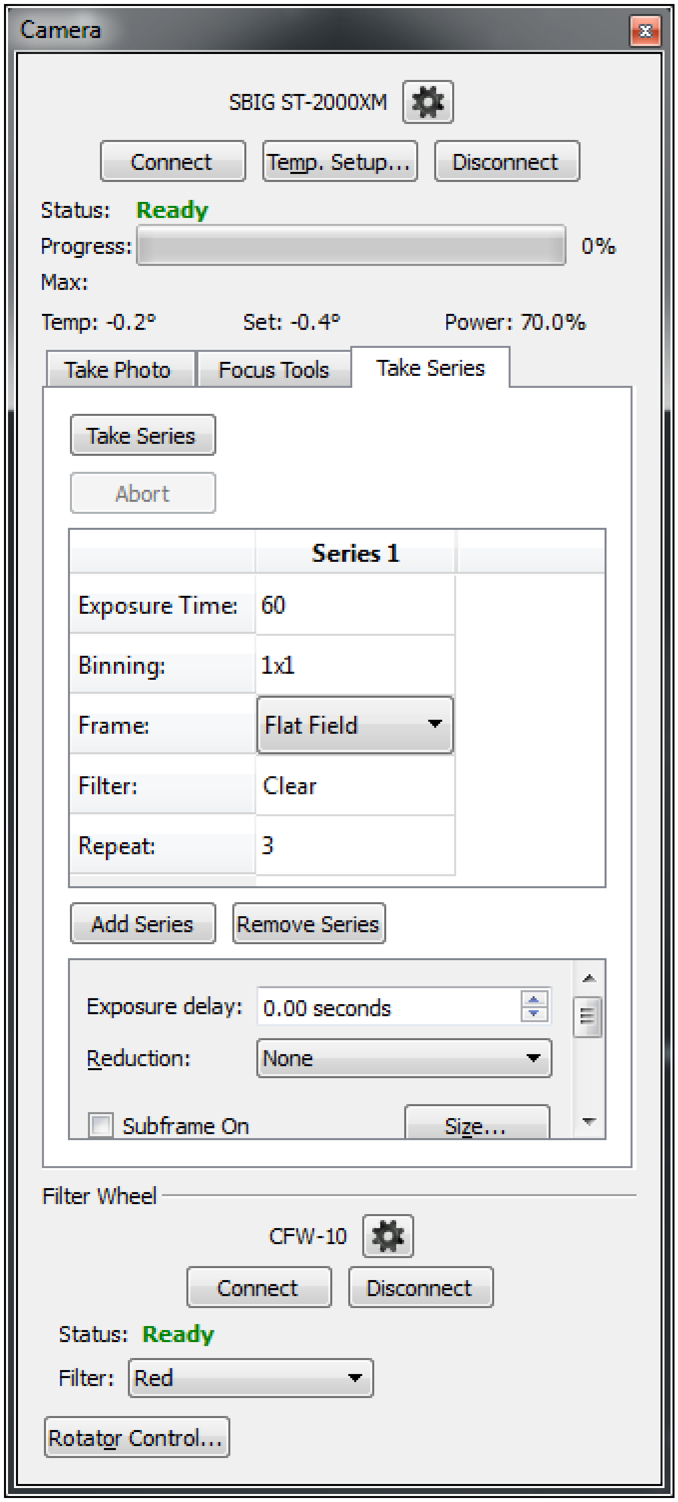


Figure 221: Settings for taking a series of flat-fields.

The obvious question about a flat field is how to long to expose. The goal is to have a flat-field image with an average value that is about 33-50% of the CCD detector's saturation level. The table below summarizes the ideal range for flat-field images for various SBIG cameras binned 1x1. For other camera brands, or for binned images, you will need to calculate the saturation level yourself, using the following formula:

$$\frac{full\ well\ capacity}{electrons\ \ per\ \ ADU}$$

The full-well capacity is the largest number of electrons that a pixel can hold, and is normally available in the technical specifications for the CCD detector. “Electrons per ADU” is called the gain of the camera. “ADU” stands for Analog to Digital Unit, and is a single brightness level.

Each camera also has a certain number of bits that are used to perform the analog to digital conversion. The ST-7E, for example, uses 16 bits, which provide a maximum value of about 65,500 units. The ST-237 uses 12 bits, with a maximum value of 4096. If the saturation level is greater than the maximum value based on the number of bits, use the number based on the number of bits.

Table: Saturation values for flat-field frames

Average value of the brightest area should fall between 33% and 50% of saturation.

Camera/ Guider	Full Well Capacity	Gain *	Calculated Saturation	Effective Saturation	33% *** Saturation	50% *** Saturation
ST-4 8 bits	80,000	150	533	533	175	250
STV 10 bits **	20,000	4.0	5,000	1024	350	500
ST-5C 16 bits	50,000	2.0	25,000	25,000	8,500	12,500
ST-237 12 bits	20,000	4.0	5,000	4.096	1350	2000
ST-6B 16 bits	400,000	6.7	59,700	59,700	20,000	30,000
ST-7E ABG 16 bits	50,000	2.3	21,740	21,740	7,250	11,000
ST-7E NABG 16 bits	100,000	2.3	43,500	43,500	14,500	21,750
ST-8E ABG 16 bits	50,000	2.3	21,740	21,740	7,250	11,000
ST-8E NABG 16 bits	100,000	2.3	43,500	43,500	14,500	21,750
ST-9E 16 bits	200,000	2.8	71,400	65,000	21,600	32,500
ST-10E 16 bits	77,000	1.5	51,000	51,000	17,000	25,500

* Electrons per ADU

** Varies with binning mode; see SBIG documentation.

*** Rounded values for easy memorization

Note: CCD detectors and CCD cameras have natural variations in their full-well capacity and gain settings. The numbers shown in the table for saturation are only approximate.

Note: When measuring brightness of a flat-field image, be sure to average a small group of pixels so that a single bright pixel won't throw off the reading. To find the value of a pixel in TheSkyX Camera Add On, pass the mouse cursor over the image. The coordinates and brightness value appear on the status bar at the bottom of the TheSkyX Camera Add On window.

The best way to take a flat field depends on your telescope and overall optical configuration. Here are some suggestions for different ways to take a flat field; you can try them to see which provides the best results for you.

Taking a Flat Field Image

The idea behind a flat field is simple: Using the same focus position you use for taking light images, take an image of an evenly illuminated surface so that you achieve approximately one-third to one-half the saturation level of the CCD chip. Here are some things to keep in mind when taking a flat field:

Same Focus Position: The flat field is a snapshot of your optical system in a particular arrangement. If you change the focus position, the relative positions of the optical elements change, and any dirt or dust will cast different shadows, and reflections will change as well. To get a useful flat field, the optical system must be in the same position as when used for astronomical imaging.

Take An Image: The flat field is an image of something. That means that it must be treated like any other image: it will need a dark frame, for example.

Evenly Illuminated Surface: Whatever it is that you are taking a picture of when you take a flat-field image, the surface needs to be evenly illuminated. Otherwise, the flat field isn't really flat. The flat field represents the variations from flat illumination caused by your optical system. If the surface you are imaging is not evenly illuminated, then the flat field is only an approximation, not a true flat field. You can get away with some unevenness at times, but the more even your illumination, the better your flat field will work.

If you normally use a dew shield when imaging, make sure you also use it when you take the flat. Otherwise, off-axis illumination can cause internal reflections that vary from those that occur when you image.

Here are some things you can try for making flat field images.

- The ***Two-Surface Flat*** (Figure 222) involves shining a light on a flat object so that it reflects off of another flat object and into the front of the telescope. The main disadvantage to this method is that it frequently takes two people to get enough distance between the two diffusing surfaces.

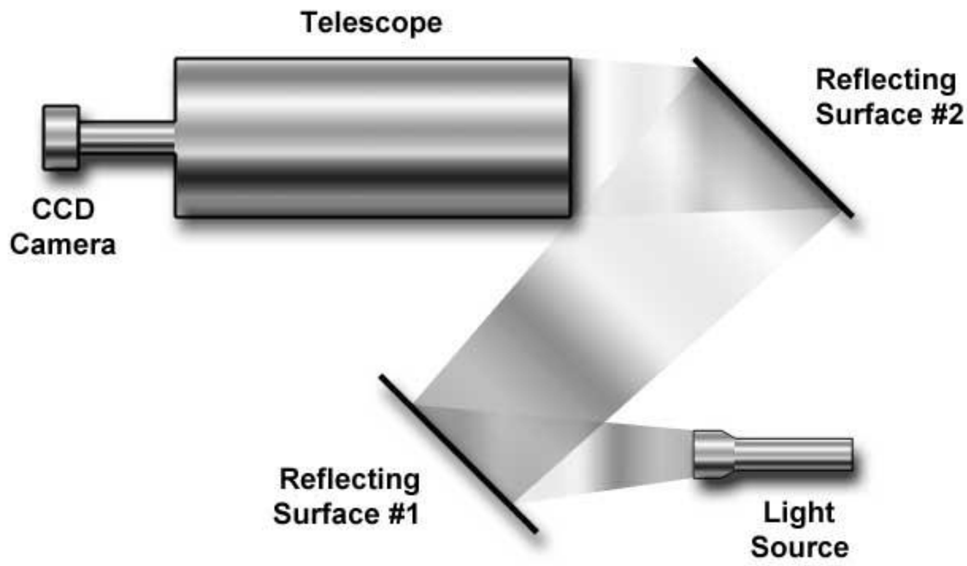


Figure 222: Taking a flat using two surfaces to diffuse light to create even illumination.

- The ***Dome Flat*** involves imaging the inside of an observatory or the wall of a nearby house, shed, or fence. You can use any evenly lit surface to take this kind of flat, but getting even illumination can be tricky. Try moving the scope slightly between images, and average multiple images to improve evenness.
- The ***Sky Flat*** involves taking many images of the sky at twilight, and averaging them to create a flat field. You may get some dim stars, but taking 8 or 12 or even 16 images, and moving the mount between images, will allow you to combine the images by averaging to remove the stars. Figure 223 shows a typical twilight flat; Figure 224 shows how averaging a dozen such images can remove any trace of stars.

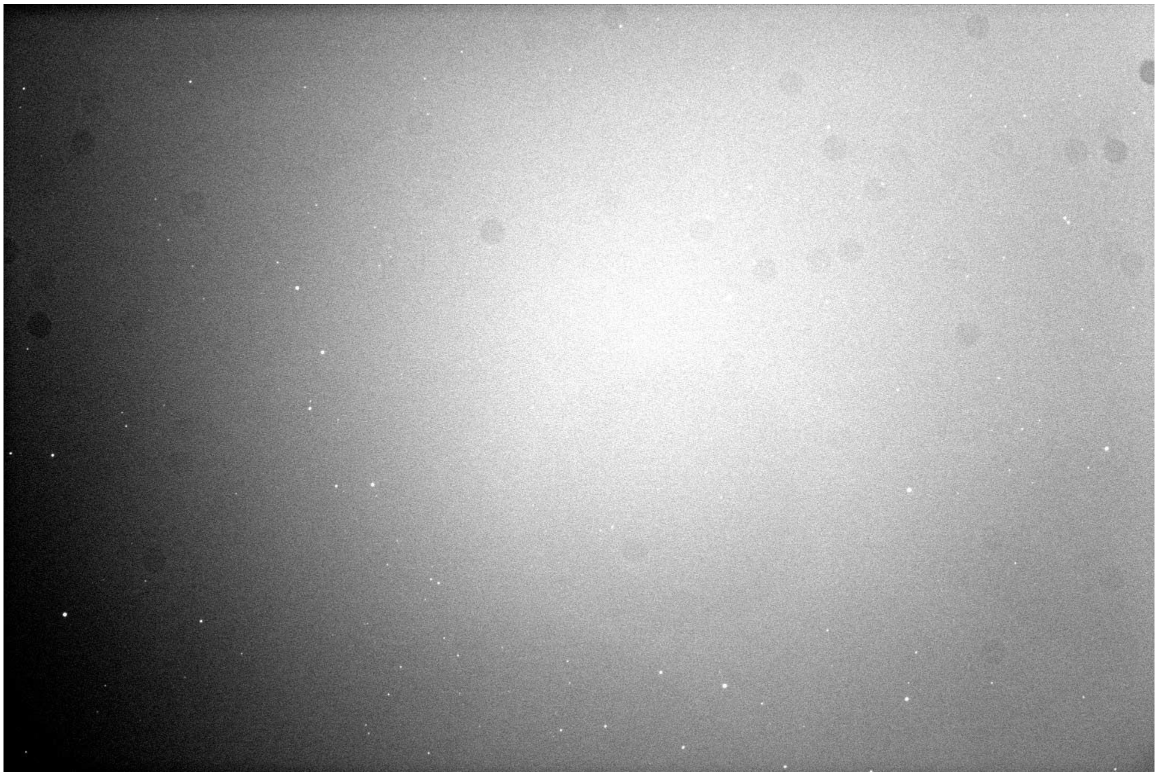


Figure 223: A single sky flat taken at twilight.

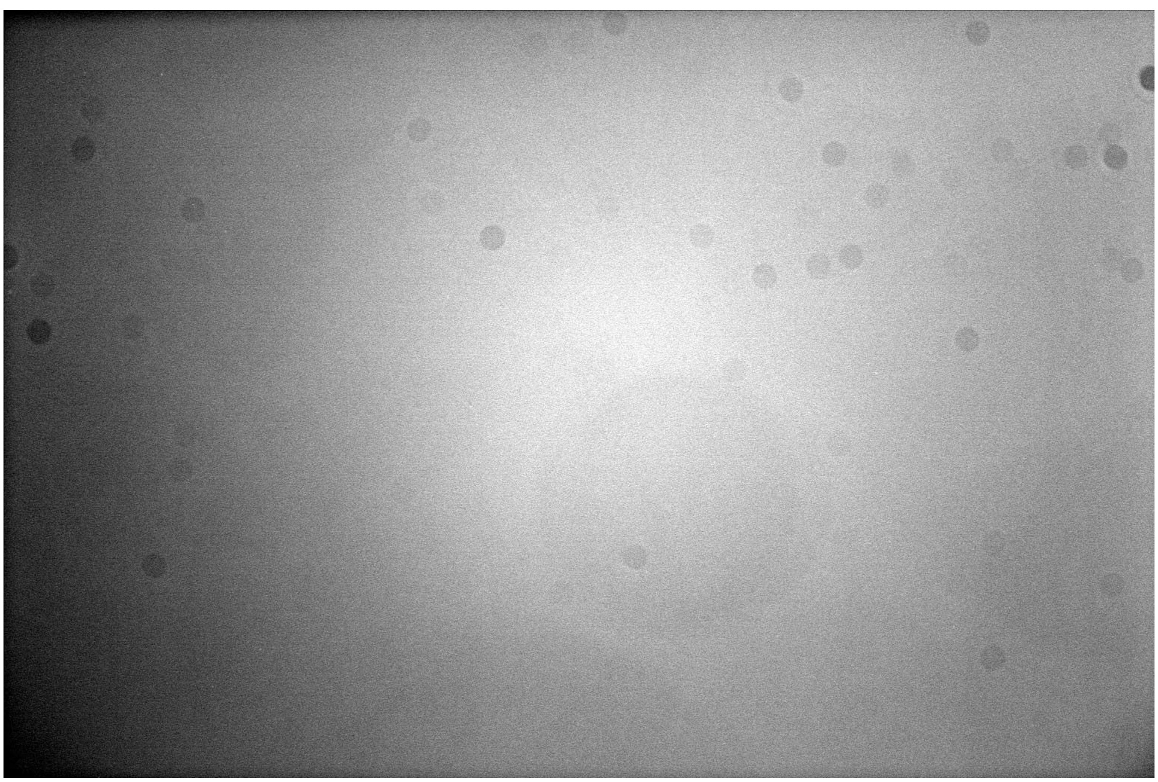


Figure 224: An average of 20 twilight flats.

- The **Light Box Flat** involves a box with a light source and a diffuser, which is placed on the end of the telescope. These are available commercially, or you can build your own. Numerous plans for light boxes can be found on the web.
- The **T-Shirt Flat** uses a T-shirt or other white cloth over the front of the telescope. Figure 225 shows this in operation. It may not be pretty, but if you are very careful about off-axis light sources, this method can generate very high-quality flat field frames. Make sure the cloth is stretched as flat as possible across the aperture. Point the telescope away from bright lights (toward the ground in daylight) to get the most even illumination possible. The goal is to get a perfectly even, indirect light falling on the cloth. If you use a dew shield, attach the cloth, and then put the dew shield on before you take your flat field.

Figure 225: Using a T-shirt to take a flat in daylight. Be sure to point the scope away from bright sources of light.

Figure 226 shows a comparison between a good flat and a great flat. The important point is that the difference is actually very small. The sky flat in Figure 226 has a brighter right edge. The T-shirt flat has a distinctly darker right edge. How do you determine which is the “better” flat field image? You apply each to a test image as described earlier in this chapter. The sky flat created a gradient in the test image, while the T-shirt flat left an even background. It is important to make sure that your flat-field setup doesn't allow any off-axis light into the telescope. Off-axis light can reflect off of the flat surface and/or interior surfaces of the optical system and make a mess of a flat field. A dew shield can help prevent off-axis light from being a problem. If you use a dew shield for imaging, be sure to also use it for creating your flat fields.

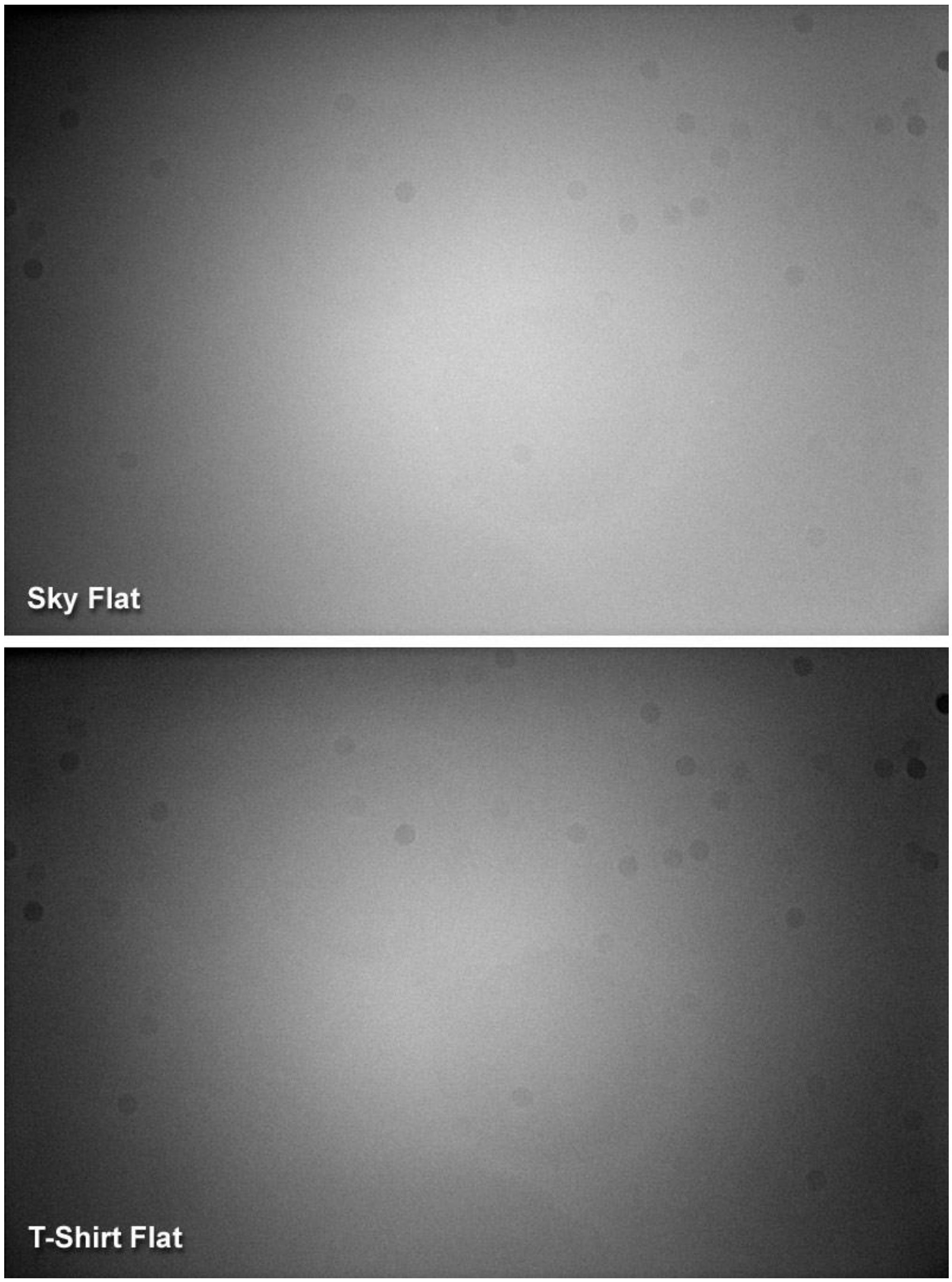


Figure 226: Comparing the results from two types of flat fields.

Figure 227 shows some examples of evaluating the quality of flat fields. Take an image that is near the zenith on a night with good transparency and minimal sky glow. Now apply your dark frame(s) to the light image. Measure the variations in the background levels. If the levels vary by only a small amount, then you have a good test image for your flat field. If you are having trouble evaluating the quality of the background numerically, you can also adjust the background and range to give you useful visual feedback. Set a low background and a very small range. This will reveal variations in the background clearly. Adjust the black and white point settings (click the ***Histogram*** button on the ***FITS Viewer*** window, page 84) to provide a fairly bright background, and then reduce the range until it is grainy and any brightness variations present show up clearly.

Figure 227 shows the differences between the results obtained with the two flat fields. The upper left image is the raw image. The upper right image had the sky flat applied to it. Note that the right side of the upper right image is darker, which indicates that the bright right edge of the sky flat was probably the result of some off-axis illumination. To get a good sky flat, the off-axis source would have to be identified and removed. If it was a streetlight, for example, putting a stepladder with a tarp over it between the telescope and the streetlight should solve the problem.

The lower left image shows the results of using the T-shirt flat. The background is almost completely even, so the T-shirt flat does a better job, and was the more accurate flat field of the two. The "optimized" version of the T-shirt flat at lower right has had the background and range adjusted for best results. The T-shirt flat in this case is the better flat because it does a better job. But with appropriate adjustments during exposure, a sky flat or any other type of flat could do just as well.

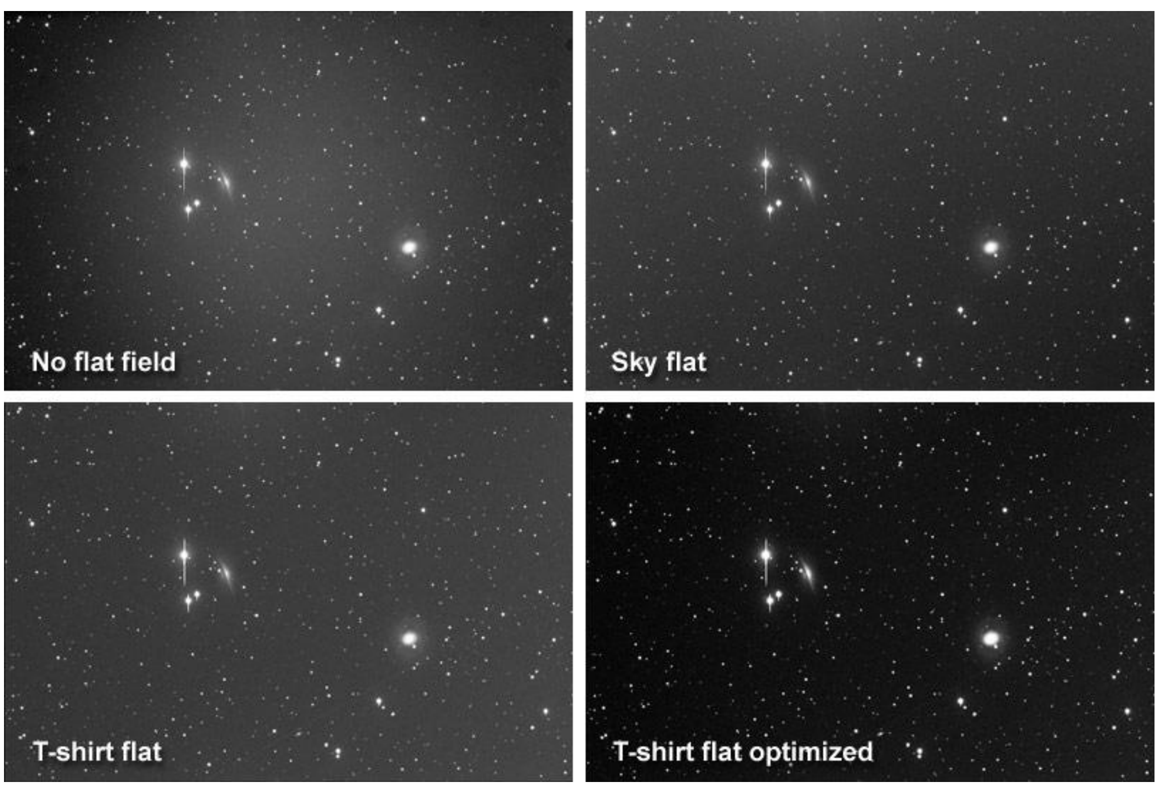


Figure 227: A comparison of results from applying two different flat fields.

Ultimately, it's a good idea to take lots and lots of flats using different methods and different equipment attached to your telescope. There is no substitute for having a deep knowledge of how light passes through your telescope. For example, the telescope used for this example does not have one edge brighter than the other; any such variation is due to off-axis light. Typically, off-axis sources are well off-axis, and it's easy to miss them, yet they can have a noticeable effect on your results. The more flat fields you take under different conditions using different techniques, the sooner you will develop the skills you need to take and apply flat-fields to your images effectively.

You can apply a single flat-field frame to an image, or you can apply multiple flat-field frames as part of a group. Unlike a dark frame, which is simply subtracted from a light frame, the flat-field frame is applied to the light frame in a more complex manner. A dark frame represents simple offsets from the accurate value, and is therefore simply subtracted from the light frame. For example, if a light frame pixel has a value of 800, and that same pixel in the dark frame has a value of 500, then the corrected value of the pixel after dark frame subtraction is 300.

For a flat field, the pixel values in the light image are adjusted using a more complex formula based on the average brightness level and the corresponding pixel in the flat-field frame. There isn't a simple relationship between the pixels in the light frame and the pixels in the flat-field frame; the entire image is used to effectively apply the flat field.

Using Reduction Groups

A single bias, dark, or flat-field frame helps considerably in improving your images. But the improvements come at a cost. Everything you do to the original image adds noise even as it removes various system effects. The ideal situation would be to take bias, dark, and flat-field frames that have as little noise as possible.

You can accomplish this by taking multiple bias, dark, and flat-field images. TheSkyX Camera Add On can combine these images in ways that reduce overall noise. It can even apply the combined images automatically when you are taking images with the camera (see the next section).

Creating Reduction Groups

Before you can create a group, you must take the bias, dark, and flat-field frames you plan to include in the group. To build the group, click ***Input > Image Calibration Library***. Figure 230 shows the Image Calibration Library window. By default, there are two groups: Imager and Autoguider. You can add bias, dark, flat-field, and darks for flat-field frames to these groups, or create your own groups.

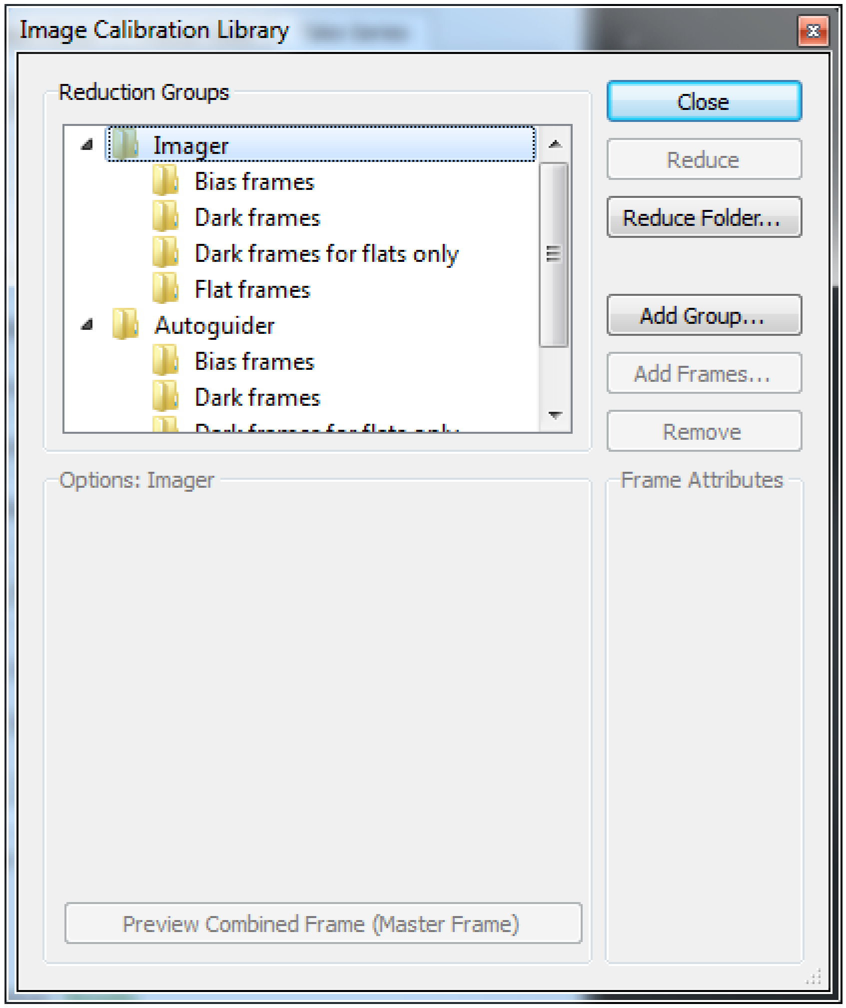


Figure 228: The Image Calibration Library window.

To create a new group, click ***Add Group***. This displays the Add Group dialog box (see figure 25). Type in the new group name, and click ***OK*** to add the group to the list. The new group will automatically contain sub folders for bias frames, dark frames, dark frames for flats only, and flat frames.

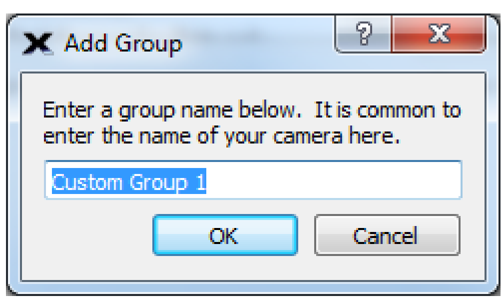


Figure 229: Adding a new group.

To add individual images to your group, click on the sub-group name (***Bias Frames***, ***Dark Frames***, ***Flat Frames***) to highlight it, and click ***Add Frames***. This opens the appropriate Select Frames dialog box. Navigate to the folder that contains the desired files, and click to highlight them. You can add more than one frame at a time; use `Shift+Click` and/or

`Control+Click` to select multiple images. Click ***Open*** to add the files. Figure 230 shows multiple files added to all four sub-groups. You can resize the ***Image Reduction*** window to see long filenames, or you can hold the mouse cursor over a specific file to view the entire name.

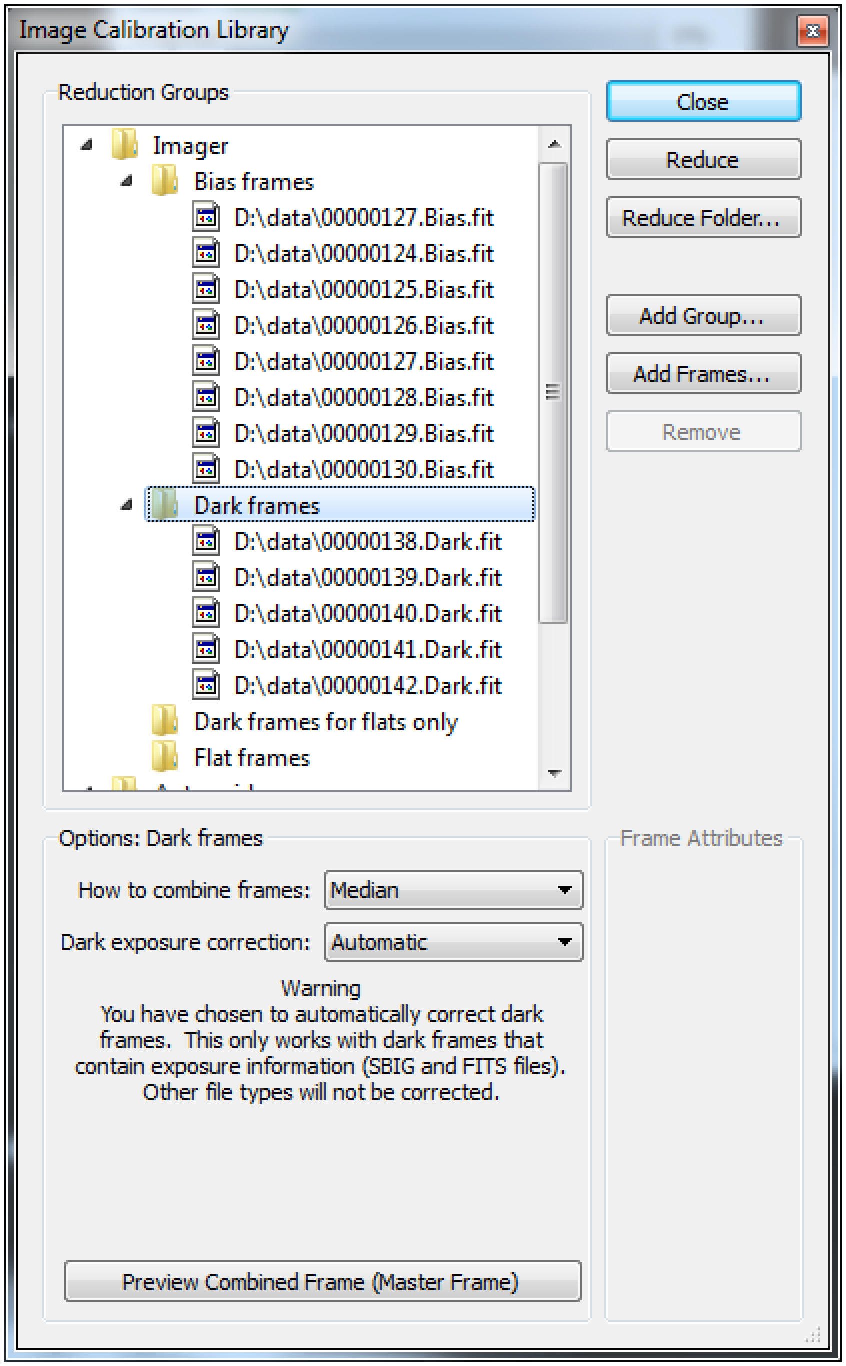


Figure 230: Files added to the bias, dark, sub-groups.

When you apply a reduction group to an image or a folder of images, the *Camera Add On* will create master frames by combining the images. A master frame is the result of combining all of the frames of a given type. There is a master frame for the bias frames, a master frame for the dark frames, etc. The master frames are created automatically the first time you use a reduction group. The master frames are also updated automatically the first time you use a reduction group after adding, deleting, or otherwise changing the frames in a reduction group.

You can create a copy of the master frame for any one sub-group at any time by clicking ***Preview Combined Frames (Master Frame)*** near the bottom of the Image Reduction window. A copy of the master frame appears in a window, and you can examine it to make sure it meets your requirements.

The ***Remove*** button acts differently depending on what you highlight in the Image Reduction window:

- If a single frame is highlighted, the frame is removed from the group.
- If a sub-group is highlighted, the frames in the sub-group are removed. The sub-group itself remains.
- If a group name is highlighted, the frames in all sub-groups of the group are removed. If the group is a default group (Imager and Autoguider are the default groups), the empty group remains. If the group is one you created, the group is also removed.

If you double-click on a file in a sub-group, the file opens in a new window.

Setting Reduction Group Properties

You can specify how TheSkyX Camera Add On should combine frames in a sub-group. For example, if your sub-group contains 4 dark frames, you can choose how to combine them: average or median.

Average – The brightness of each pixel in the combined image is the average of the values in the same pixel in all of the images in the group. Summing the pixel values, and dividing by the number of images in the sub-group calculate the average.

Median – The brightness of each pixel in the combined image is the median of the values in the same pixel in all of the images in the group. The median is the value in the middle of the distribution of brightness levels. There are equally many values larger than the medium as there are smaller.

In addition, the ***Image Reduction*** window contains options for how dark frames are applied to your light images and flat frames:

Option	Values/Description
Dark Exposure Correction	***None*** – No exposure correction occurs. The dark frame is simply subtracted from the light frame. It's up to you to make sure that the exposure times for light and dark frames are the same. ***Automatic*** – TheSkyX Camera Add On reads the file header to obtain exposure and temperature information, and uses this information to scale the dark frame before applying it to the light frame. Only file types that contain header information, such as FITS and SBIG files, work with this option.

Option	Values/Description
	Manual – The dark frame is scaled using numeric values that you supply, using either duration or a multiplier.

To set the options for Bias, Dark, and Flat Frames, click to highlight the group or any file in the group; the options appear in the area below the list of files in the group (Figure 230). Note that, when an individual filename is highlighted, the attributes for the file appear in the Frame Attributes area at lower right. The attributes can help you identify which file is which, and can help you determine whether you have the correct files included in the group. The Frame Attributes are especially helpful long after you take images or create reduction groups.

Note: the dark frames you add to a group should all have approximately the same exposure duration. If you try to combine dark frames with very different exposure durations, you will add a lot of noise to your images. For the cleanest, lowest-noise reduction, use dark frames with identical exposures.

Reducing a Single Image

To reduce a single image, open the image in the *Camera Add On* and then open the *Image Reduction* window (***Input > Image Calibration Library***). Click ***Reduce*** to open the ***Reduce Now*** window (Figure 231). If this is the first time you have used the group for reduction, there will be a delay while the Camera Add On builds the master bias, dark, dark for flat, and flat-field frames.

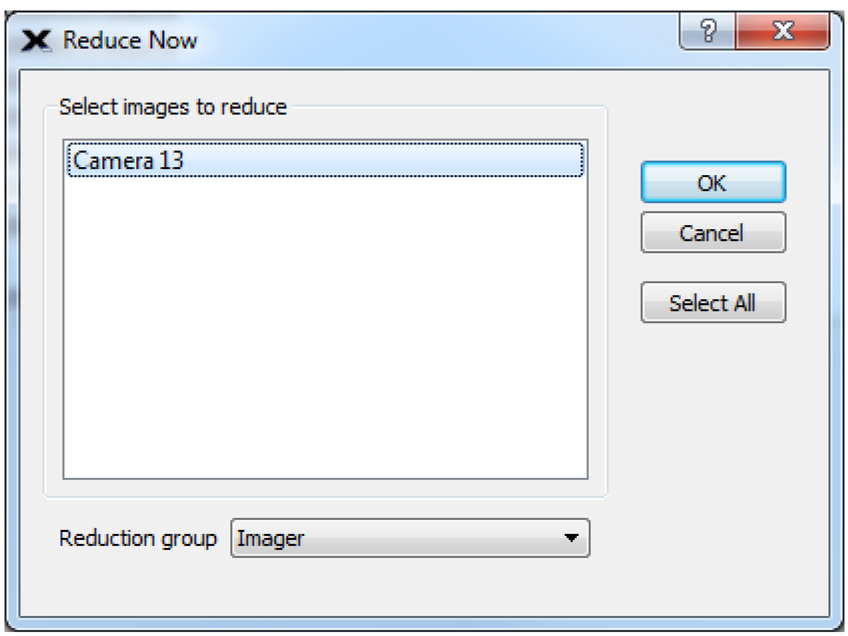


Figure 231: Reducing photos using the *Reduce Now* window.

As with a single flat field, you can evaluate the correction of an image reduction group by examining the background brightness values. Pass the mouse cursor over the image, and look for consistent brightness levels in the background. Gradients due to sky glow, moonlight, or light pollution make it harder to evaluate the quality of a reduction. Use an image that has a known flat background to evaluate the quality of your reduction, such as an image from a dark site taken near the zenith.

Reducing a Folder of Images

You can also use the Image Reduction window to reduce all of the images in a folder. This is convenient for many imaging situations – color images with many images taken at the same time and temperature, for example, or an evening's worth of images when hunting for supernovas, comets, or minor planets. Click ***Reduce Folder*** to open the dialog box shown in figure 30.

- Click on the top ***Choose Folder*** button to locate the folder with the images you want to reduce.
- Click on the lower ***Choose Folder*** button to locate the folder where the reduced images are to be saved.
- Choose the ***Reduction group*** from the drop-down list at the bottom of the dialog box.
- Click ***Reduce*** to start the reduction process.

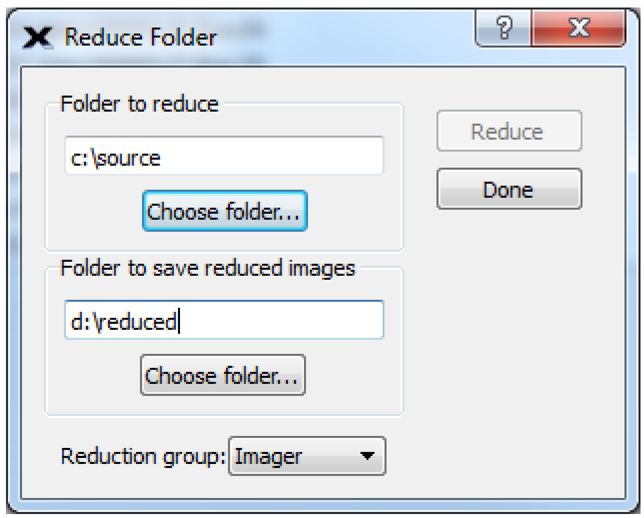


Figure 232: Reducing all of the images in a folder

Reduction Group Strategies

A reduction group is simply a collection of bias, dark, flat-field, and dark-for-flat-field frames. You can use dark frames taken at any exposure or temperature, so it is up to you to make sure that the right files go into each group you create. It is typical to create a number of groups for a given night's images, with each group being used for one or more of your light images.

For example, suppose you took the following images in one night:

- Ten one-minute images of M51.
- Ten two-minute images of the Owl Nebula.
- Four 10-minute images of M101.

You could create two or three reduction groups. If you created two groups, you would use 90-second darks in one group, and 10-minute darks in the second group. You could reduce both your M51 and Owl Nebula images with the first group, and your M101 images with the second group. The *Camera Add On* would scale the dark frames in the first group for the differences in exposure times. The 90-second exposure for dark frames is halfway between the exposure times of the M51 and Owl Nebula images.

Note: Bias frames are optional. However, if you scale dark frames, you should include bias frames in your reduction groups. The bias frames allow the *Camera Add On* to scale the dark frame more accurately.

Flat fields typically require exposures that are different from light frame exposures . As a result, you will often use a separate dark frame for your flat fields. There is a special heading in the Reduction window where you can add dark frames that are for flat fields only. If you do not add any dark frames for the flat-field frames, no dark is subtracted from the flat fields.

Color imaging often involves taking images that have different exposure times. You should normally use several reduction groups for a single set of color images. The ST-7E camera with a CFW-8 color filter wheel, for example, generally works best with exposures having a ratio of 1:1:1.6. If you intended to image the galaxy M101 in color, you might plan to take the following images:

- 5 luminance images with an exposure of 5 minutes each, binned 1x1.
- 3 red and 3 green images with exposures of 10 minutes each, binned 1x1.
- 3 blue images with exposures of 16 minutes each, also binned 1x1.
- 4 flat-field images at 40% of saturation, with exposures of 10 seconds each.

You could create one, two, or three reduction groups for these images. The difference between the groups would be the exposure time for the dark frames:

Method #1

Create one group, with an average dark frame exposure time suitable for all light images. Use dark frames with an exposure time between the shortest and longest exposures: 10 minutes, for example. Your darks would not perfectly match all of the light images, and there would be some additional noise in the final image as a result. A good reduction group using this approach could include:

- 3 dark frames at 10 minutes each.
- 3 bias frames.
- 3 dark frames at 10 seconds each for the flat-field frames.
- 4 flat-field frames at 10 seconds each.

Method #2

Create two groups, with each having an average dark frame exposure time suitable for some of the light images. Use darks of 5 minutes in one group (for the luminance images), and 13 minutes in a second group (for the red, green, and blue images). The two groups could look like this:

Group one:

- 3 dark frames at 5 minutes each.
- 3 bias frames.
- 3 dark frames at 10 seconds each for the flat-field frames.
- 4 flat-field frames at 10 seconds each.

Group two:

- 3 dark frames at 13 minutes each.
- 3 bias frames.
- 3 dark frames at 10 seconds each for the flat-field frames.
- 4 flat-field frames at 10 seconds each.

Method #3

Create three groups, with each having a dark frame exposure matched to specific light images.

Which method should you choose? It depends on your needs. If you want to get the greatest possible benefit from your dark frames, then use method #3 with three groups. If you are working at very cold temperatures (for example, -33ºC), you might feel that the noise levels are low enough to use Method #1 with a single group of darks. The *Camera Add On* scales the darks to match the actual exposures, but this scaling introduces some inaccuracies into the process. If you are imaging at a warmer temperature (for example, -22ºC), then you might choose Method #2.

Automatic Reduction

There is a third way to do image reduction: automatically when you acquire an image. The ***Take Photo*** tab in the ***Camera*** tab (see figure 31) provides a ***Reduction*** pop-up menu in the options for:

- No automatic reduction (choose ***None***).
- Take a single dark frame (choose ***AutoDark***) and apply it to each image.
- Apply a reduction group to images as they are downloaded (choose ***Bias, Dark, Flat***).

If you select ***Full Calibration***, the Group option appears. Pick a reduction group from the list of available groups.

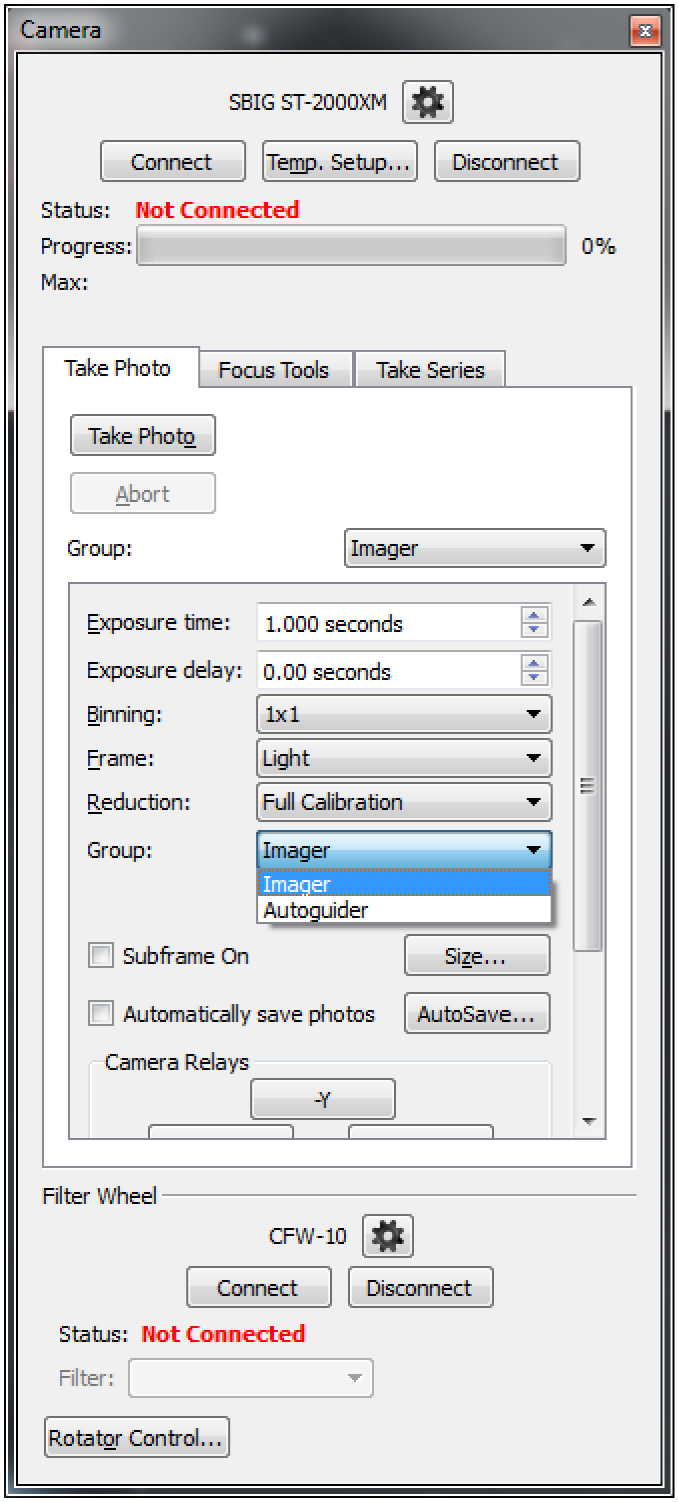


Figure 233: Setting up automatic image reduction.

We recommend turning the ***Automatically Save Photos*** checkbox on if you are automatically applying a reduction group to your images as they are downloaded. If ***Automatically Save Photos*** is turned on, two versions of the file are saved: the raw image, and the reduced image. If an error occurs during reduction, the raw data is still saved to disk.

For example, if you were imaging the Antennae galaxies, then the two filenames could be:

00000045.Antennae.FIT
00000045.Antennae.REDUCED.FIT

Focuser Control

PROFESSIONAL

TheSkyX can be used to adjust the camera's focus using pulse focusers and Optec motorized focusers.

The list of supported focusers includes:

- Astro-Physics built in focuser controller
- Gemini built in focuser controller
- Focuser simulator (from Software Bisque)
- Meade Autostar or LX200 built in focuser controller
- Optec TCF-S3 and TCF-S Temperature Compensated Focusers
- Paramount ME built in focuser controller
- Paramount MX built in focuser controller
- TeleAPI built in focuser

Serial port-based focusers, just like serial port-based telescopes, require a USB to serial adaptor to connect the focuser's serial port to the computer's USB port. See "USB to Serial Adaptors" on page 282 for details about this additional hardware device.

Focuser Setup

To configure *TheSkyX* to control a focuser:

1. Choose the ***Telescope Setup*** command from the ***Telescope*** window to display the ***Imaging System Setup*** window.
2. Highlight ***Focuser*** in the ***Hardware*** list.
3. From the ***Focuser Setup*** pop-up menu, select the ***Choose*** command.
4. Select the desired focuser from the ***Focuser*** list and click ***OK***.
5. For serial port-based focusers, choose the ***Settings*** command from the ***Focuser Setup*** pop-up menu to configure the focuser's settings.

Figure 234: The Focuser Settings window (Mac)

Figure 235: Focuser Settings window (Windows)

Serial Device/Serial Port

Select the serial device name (Mac) or COM port (Windows) for the focuser.

More Settings

Click the ***More Settings*** button for focusers that allow configuration of the focuser step size, backlash compensation and temperature compensation.

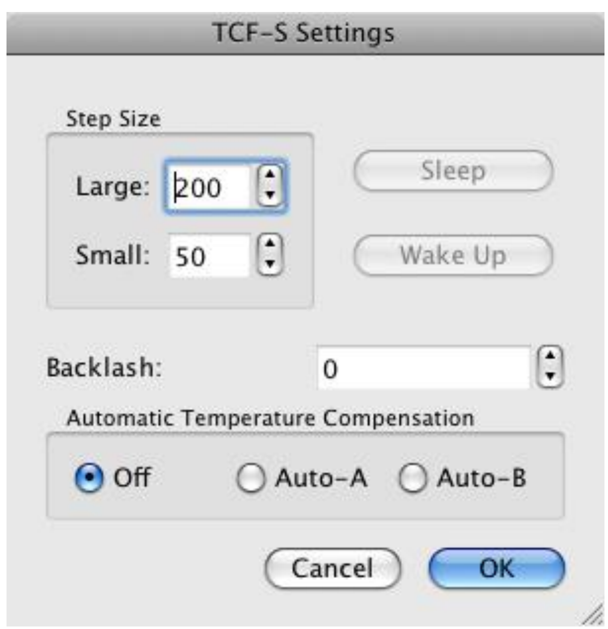


Figure 236: The Optec TCF-S Settings window.

Focuser Setup Pop-up Menu

The Focuser Setup pop-up menu has the following commands.

- **Choose –** Shows the Choose Focuser window to select the desired focuser.
- **Settings –** Displays a focuser-specific settings window for the selected focuser.
- **Connect –** Use this command to establish communications with, or connect to the selected. Make sure to configure the focuser port settings by choosing the Settings command first.
- **Disconnect –** Terminate communication between *TheSkyX* and the focuser.

Step Size (Large and Small)

The ***Large*** and ***Small*** focuser steps are applied when focusing a camera with CCDSoft's @Focus automated focusing algorithm. The step size number represents the relative motion of the focuser; the larger the number the more focuser motion. The large step is used to get close to focus, the small step size is used to get "optimal" focus.

Backlash

Enter a number for the relative amount of backlash compensation (gear slop) in the focuser. Consult the focuser hardware documentation for more information on this setting.

Automatic Temperature Compensation

Choose the Automatic Temperature Compensation setting for the Optec focuser. Consult the focuser hardware documentation for more information on this setting.

Controlling the Focuser

Figure 237 shows the ***Focuser*** controls on the ***Telescope*** window that can be used to adjust the focuser's position.

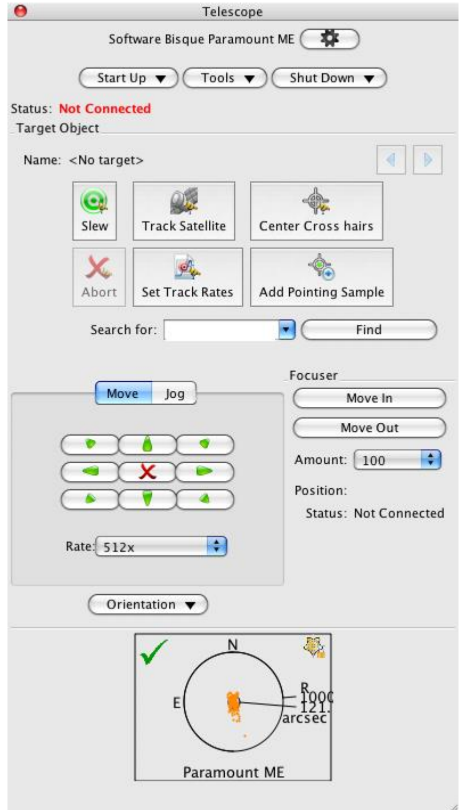


Figure 237: Focuser controls on the Telescope window.

Move In/Move Out Buttons

Click these buttons to adjust the position of the focuser.

Amount

Select the relative amount of focuser travel that will be applied to each ***Move In/Move Out*** button click.

Pulse Focuser Adjustments

- **Slow** – Adjusts the position of the focuser using a slow motor speed for adjusting final focus.
- **Fast** – Adjusts the position of the focuser using a fast motor speed for making large changes to focus.

Optec Focuser Adjustments

- **100** – Adjusts the position of the focuser using the ***Small*** step size (page 456).
- **1000** – Adjusts the position of the focuser using the ***Large*** step size (page 456).

Status

Shows the current status of the focuser connection.

- Not Connected – The focuser is currently not connected to *TheSkyX*.
- Connected – The focuser is connected to *TheSkyX*.

Focusing Principles

The human eye is a marvelous instrument. Not only can it follow rapidly moving objects, but it can also adjust focus in real time, compensating for minor focus drift or out of focus conditions. The eye is a very forgiving focuser, in other words.

The CCD camera, on the other hand, is a very unforgiving measurer of focus. Cameras require very precise focus to get sharp, detailed images. Precise focus is also important for research (astrometry and photometry).

The *Camera Add On* has features that will allow you to achieve the best possible focus. But there are also mechanical considerations about focus that play a role in how effectively you can achieve that "sweet spot" called *critical focus*.

"Critical focus" is a range of focal positions, not just a single point along the focuser's range of travel. Even at critical focus position, stars are not usually imaged as single points of light; atmospheric turbulence and other factors spread out the star's image on the CCD detector. Critical focus is the range of focus positions that provides the best possible focus and is dependent upon the focal ratio of your telescope.

The focal ratio alone determines the size of your critical focus zone. The zone of critical focus becomes shorter with lower, "faster" focal ratios. For the purposes of focusing, a fast focal ratio is f/6 or lower; a slow focal ratio is greater than f/6. The focal ratio is the ratio of the telescope focal length to the aperture. For example, a telescope with an aperture of 100mm and a focal length of 500mm has a focal ratio of f/5. Lower-numbered focal ratios are said to be "fast" because they require shorter exposure times.

Figure 239 shows light cones for fast (f/5) and slow (f/10) telescopes. The front of a hypothetical telescope is at left. Light enters from the left, and is brought to a focus where the converging lines cross.

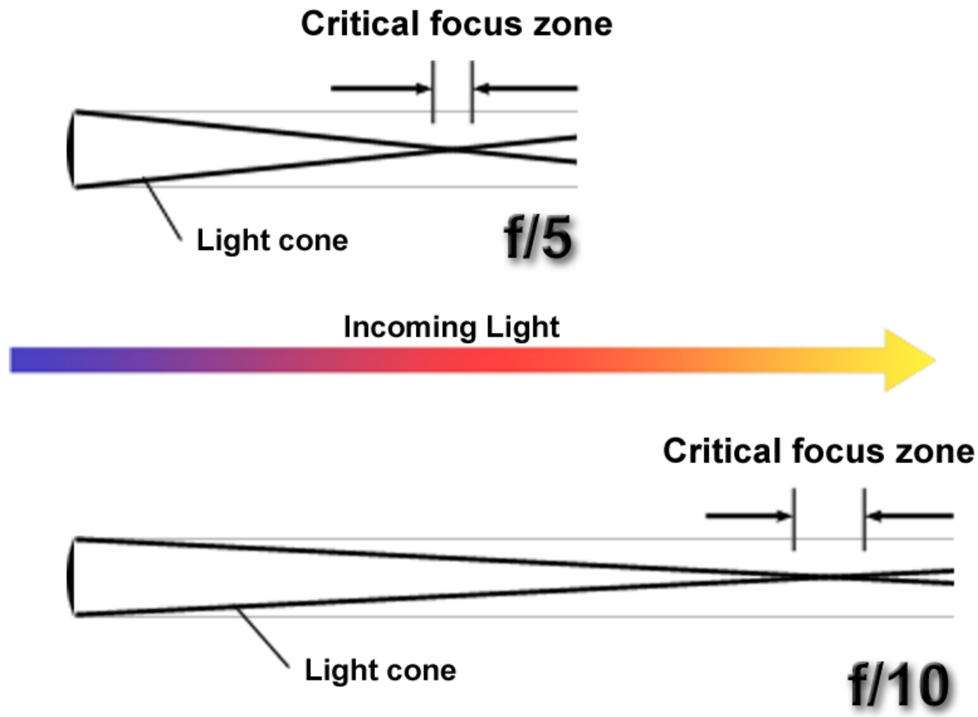


Figure 238: The focal ratio of your telescope determines the length of the critical focus zone.

The f/5 light cone is very steep; as you move away from the front of the telescope, the light converges to focus very quickly. The f/10 light cone is shallow, and does not converge as rapidly as you move away from the front of the telescope. For all telescopes, the light diverges again past the focal point. The telescope's focuser, manual or motorized, moves the CCD camera back and forth. The CCD detector inside the camera must sit within the critical focus zone to get a sharp image. To bring the CCD camera to focus, the focuser moves the camera so that the CCD detector is within the critical focus zone, as shown in Figure 239.

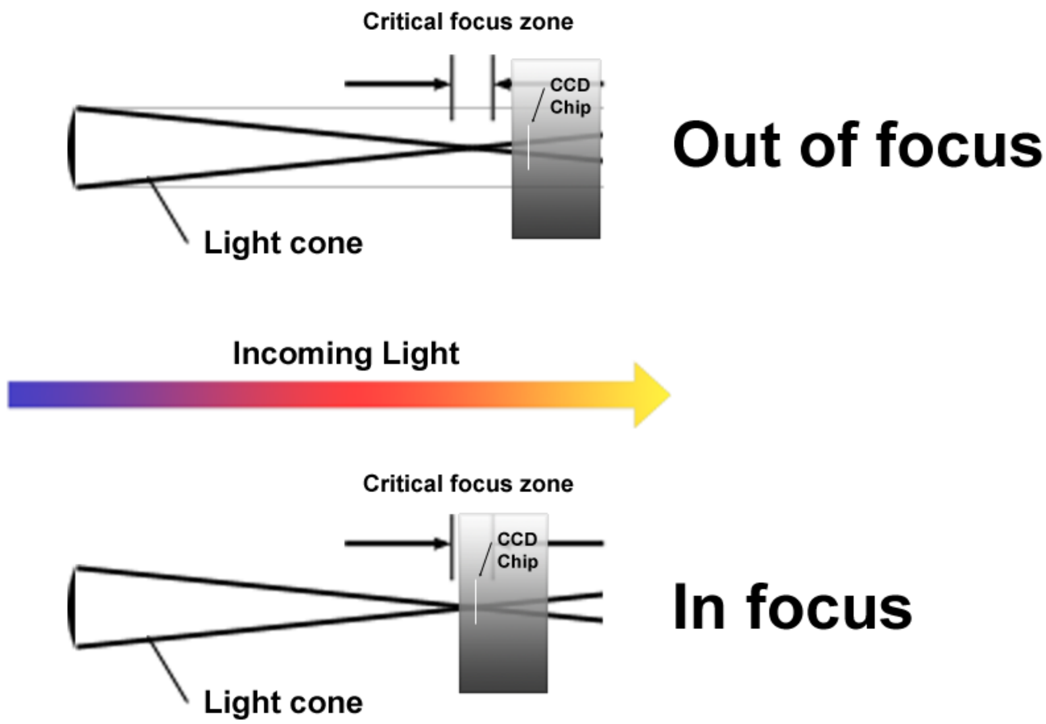


Figure 239: Moving the camera into the critical focus zone.

This means that telescopes with fast focal ratios have a shorter critical focus zone, and thus they are more challenging to focus manually. You can improve your ability to focus a fast telescope by adding a motorized focuser. The Camera Add On includes a focusing utility, *@Focus2* (pronounced "at focus two", which is capable of making extremely small focuser movements limited only by the minimum step size of a motorized focuser. Fast telescopes are also more susceptible to anything that will cause focus drift, such as falling or rising temperatures. A motorized focuser can also help you adjust focus throughout a long imaging session.

The slower your focal ratio, the longer the critical focus zone and the easier it will be to find focus.

When the seeing is very good (that is, the atmosphere is stable), star images hold steady and are very small and sharp. As the seeing deteriorates, star images begin to bloat and lose their hard edge. This makes measuring focus more difficult, and @Focus2, may not converge on the best focus position under poor seeing conditions. Manual focusing is also harder to achieve under poor seeing conditions (turbulent atmosphere).

If the zone of critical focus is very short, you may find it difficult to achieve critical focus reliably or easily using a manual focuser. You can purchase various types of motorized focusers that can help with this problem, including some that have digital readout of focus position.

A motorized focuser can provide smaller adjustments in many cases than you can do by hand, and is thus better at making the small adjustments that position the CCD detector inside the critical focus zone. To get useful results from a motorized focuser, it should enable you to make movements that are at least one-half the size of your zone of critical focus on nights of optimal seeing conditions. For optimal focusing, look for a focuser that will move in increments that are one-quarter or less the size of your critical focus zone.

The equation below computes the size of the critical focus zone (CFZ) in microns for a "perfect" optical system that is perfectly collimated:

$$CFZ = focal\_ratio^2 * 2.2$$

So for a C-14 that is f/11:

$$CFZ = 11^2 * 2.2 = 266$$

266 microns is 0.266 millimeters or 0.01 inches. Here's an example with an f/5 focal reducer on the C-14, making it effectively an f/5.5 system:

$$CFZ = 5.5^2 * 2.2 = 66.5$$

66.5 microns is 0.0665 millimeters or 0.0026 inches. Note that the critical focus zone is now one quarter that of the longer f-ratio system. This means that if you reduce the focal ratio by half, you reduce the close focus zone to one quarter. Note: real world values are approximately 10%-30% greater than the theoretical values above.

TheSkyX includes two methods of focusing: automatic using @Focus2, and manual focusing. To use @Focus2, you must have a computer-controlled focuser (for example, RoboFocus, Optec TCF-S, RCOS Focuser or JMI Smart Focus), or a motorized focuser controlled by your mount (for example, JMI NGF-S, Meade Zero Image Shift Focuser or MotoFocus connected to a Paramount, LX200, or Astro-Physics GTO, etc.).

To access @Focus2, click the ***Focus Tools*** tab on the *Camera* tab. Figure 240 shows the layout of the ***Focus Tools*** tab.

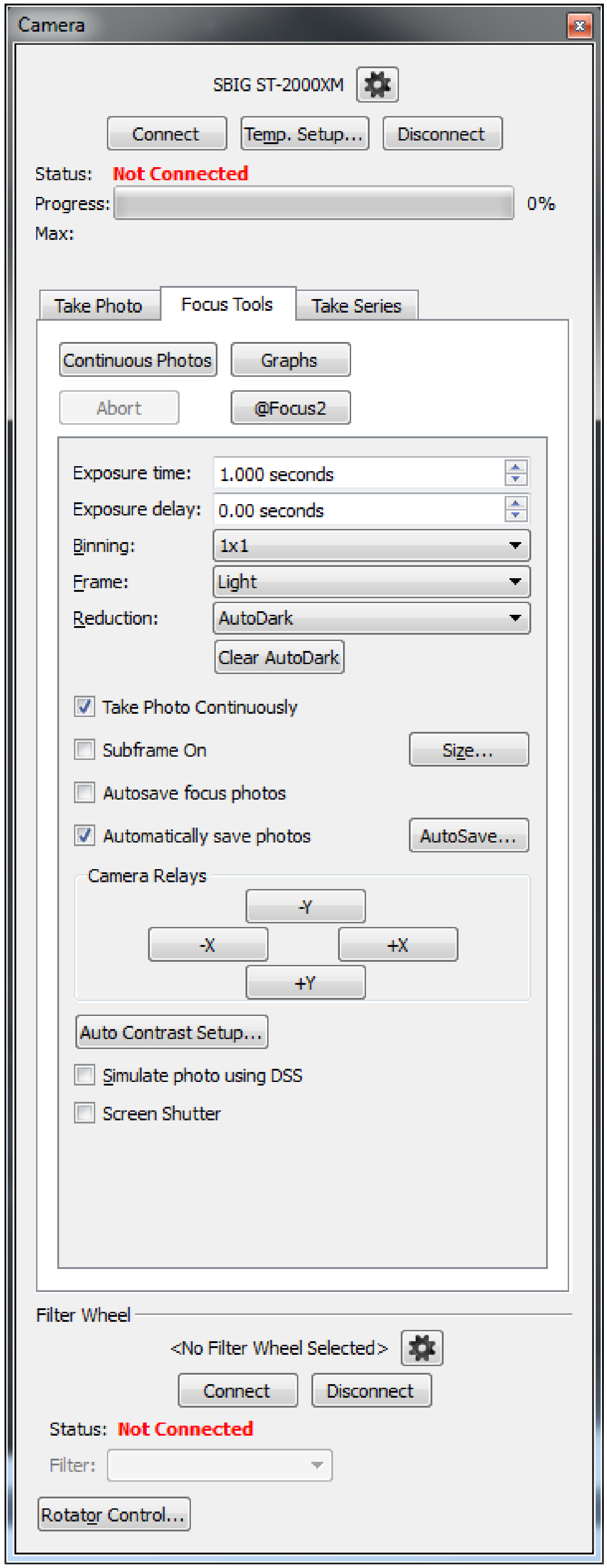


Figure 240: The Focus Tools tab of the Camera window.

Using @Focus2

@Focus2 is the second version of Software Bisque's automated focusing algorithm. You first use manual focusing methods to get close to focus and then @Focus2 does the hard part by optimizing the position of CCD detector in the critical focus zone. @Focus2 requires an automated focuser that can be controlled by the *Camera Add On*. The list of supported focusers is available by clicking ***Telescope*** > ***Telescope Setup***, highlight ***Focuser*** in the ***Hardware*** list, then click the ***Choose*** command from the ***Focuser Setup*** pop-up menu..

@Focus2 is designed to be an end-to-end, fully automatic focus routine. It will:

1. Slew to an appropriate focus star.
2. Automatically place a sub-frame around the focus star.
3. Compute an appropriate exposure time
4. Find critical focus.

@Focus2 is flexible enough to use even if you have manually sub-framed a candidate focus star, you can simply configure @focus to skip steps 1, 2, and 3 and "jump" to finding critical focus.

@Focus2 is a single star focus algorithm that requires focus data on either side of critical focus in order to work. It requires being "close to" focus initially. @Focus2 starts by moving the focuser in one half of the ***Focus Range*** setting and proceeds to move the focuser out by ***Focus Range***/(***Samples***-1) while measuring focus. Provided the ***Range*** is an appropriate value, @Focus2 will have crossed critical focus and will have the necessary data to compute and move to an accurate, critical focus.

The basic steps involved in using @Focus2 are:

Step 1: Manually get near focus.
Step 2: Click ***@Focus2*** on the ***Focus Tools*** tab of the ***Camera*** tab. Set the @Focus2 parameters to match your equipment's capabilities.
Step 3: Run @Focus2, and verify that it finds the best focus position.

@Focus2 automates the focusing process and needs an accurate focuser and appropriate settings to be successful. At a minimum it @Focus2 requires a starting point near focus and a ***Range*** value that is appropriate for your system.

Condition	Description
Mechanical quality of the focuser	**Best case:** The focuser should have virtually no backlash, and be able to be positioned with an accuracy of one half or less the size of the critical focus zone. (Backlash is free play in the focuser mechanism.) **Potential issues:** Poor mechanical quality in the focuser results in an inability to position the point of focus accurately. Typical mechanical quality issues include:

Condition	Description
	Backlash (looseness) in the focuser, which results in varying movement when reversing direction. Varying voltage levels in the mount or the focuser; this results in variable movement of the focuser. Non-orthogonality (focuser does not hold camera square to the optical path), which results in image distortions that make it harder to define the best focus position.
Position feedback from the focuser	**Best case:** If the focuser reports its actual physical position to TheSkyX, this allows TheSkyX to position the focuser with a very high degree of accuracy. The TCF-S focuser, for example, matches numeric values to specific focuser positions. Zero always means that the focuser is fully in; 3,500 is exactly halfway; and 7,000 always means the focuser is fully out. **Potential issues:** Focusers that do not report their position do not allow TheSkyX to reliably position the focuser. These include the NGF-S, RoboFocus, etc. Some focusers, such as the NGF-S with DRO and RoboFocus, report a number but the number does not necessarily correspond to a physical focus position. For example, if the focuser reaches its end of travel, and the motor continues to turn, the numbers continue to change but focus position does not. See the section on "Focuser Types" below for additional information. There can also be delays within the device that communicates with the focuser. Some mounts, such as the LX200, introduce variable delays while processing focus commands. Because the length of the delay cannot be predicted, the effects on @Focus2 are variable and do not allow @Focus2 to reliably position the focuser.
No movement in the optical system	**Best case:** Nothing in the telescope/camera system moves, other than the motorized focuser controlled by TheSkyX. **Potential issues:** If you have a moving primary mirror, a movement of the mirror (even a very small one) will not only change focus, but will change the field of view as well. A mount that tracks poorly, or that is not well aligned to the celestial pole, can also change the field of view. Both effects confound the data collected by @Focus2, and that may make it impossible for @Focus2 to get into the critical focus zone. Locking down the mirror in an SCT, and adding something like an NGF-S Crayford-style focuser, usually helps. Focusers that focus by moving the primary may or may not have sufficient accuracy to work well with @Focus2. If any part of the focuser has backlash, it becomes very difficult for @Focus2 to move the focuser reliably. Experiment with different backlash settings in the Setup dialog box for your focuser to see which works best.

Condition	Description
@Focus2 parameter settings	**Best case:** @Focus2 must be tuned to the focal length of your telescope, the focal ratio, the speed of your focuser, and other factors in order to perform effectively. These factors are described in detail in the section "Set @Focus2 Parameters" later in this chapter. **Potential issues:** If the Focus Range is too small, @Focus2 will not see much difference from one focus position to the next, and may not judge focus. If the Range is too large, @Focus2 may miss focus entirely by passing over it without generating enough data to know where best focus is. See the "Set @Focus2 Parameters" section for additional information.
Very good to excellent seeing	**Best case:** Steady seeing with minimal changes in apparent focus quality allows @Focus2 to converge upon focus quickly and easily. **Potential issues:** If the seeing is poor, the noise level in the focusing data makes it difficult to measure focus. A high noise level tends to make it more difficult for @Focus2 to determine focus. The averaging parameter allows @Focus2 to accommodate nights with poor seeing by averaging images and effectively averaging the noise. @Focus2 will take longer to find focus when averaging is high. @Focus2 will often work under surprisingly poor seeing, but we recommend that you monitor focus quality when the seeing is average or worse.
Dark skies	**Best case:** Dark skies without serious light pollution, moon glow, or sky glow. **Potential issues:** Any kind of sky illumination can decrease the signal to noise ratio in your images. The ultimate impact of a bright sky depends on whether you are using a light pollution filter, how bright the objects in the image are, and other factors. A bright sky by itself is usually not enough to confound focusing, but it can team up with other issues and make those problems harder to deal with.

Focuser Types

@Focus2 must be able to communicate with a motorized focuser. There are two types of motorized focusers available:

- Focusers that have positional feedback. The Optec TCF-S is an example of this type of focuser. These focusers can be positioned with repeatable accuracy. They are the best type of focuser for critical focusing because when @Focus2 says, "go to a specific position for best focus," the focuser goes to ***exactly*** that position.
- Focusers that do not have positional feedback. Typically, the focuser is pulsed for a brief period of time by the mount. These focusers can be positioned with variable success,

depending on how accurate the mount's pulse length is; how long it takes the mount to send the pulse (latency); how much backlash the focuser has, and other electrical and mechanical factors. When @Focus2 says, "go to a specific position for best focus," the focuser ***may or may not*** be able to go to that position.

@Focus2 is extremely reliable with focusers that provide positional feedback. Other types of focusers, and various combinations of focusers and mounts, provide varying degrees of success with @Focus2. The current list of compatible focusers, in roughly the order of quality of focus provided, includes (your results may vary):

- **Best:** Optec TCF-S model focusers that have a serial-port.
- **Very Good:** JMI SmartFocus, RCOS Focuser, or RoboFocus attached to a Paramount mount.
- **Good:** JMI NGF-S attached to an Astro-Physics GTO series mount. Small delays may occur in making position changes; verify quality of final focus.
- **Fair:** JMI NGF-S or Meade Zero Image Shift Focuser attached to a Meade LX200. Key problems include delays in carrying out focus position changes, and variable voltage applied to the focuser motor. Both problems result in random errors in positioning. You should use the methods described later in this chapter to evaluate the quality of focus before imaging. If you cannot achieve focus with a non-positional focuser, bypass the LX200 and use a focuser than can be controlled by your computer's serial port.
- **Variable:** RoboFocus attached to your computer's serial port. Since the RoboFocus controls the existing focuser on your telescope, the results you get with a RoboFocus depend heavily on the quality of your telescope's focuser.

In addition to those listed above, other focusers from third parties will become available over time. Software Bisque has a standardized, cross platform device driver architecture to allow the *Camera Add On* and *TheSkyX Professional Edition* to control most any focuser (www.bisque.com/x2).

Keys to @Focus2 Success

There are some things you can do to get the best possible results with @Focus2. Keep in mind that not all motorized focusers are accurate enough to work with @Focus2. @Focus2 may use extremely small movements to achieve critical focus, and not all focusers are capable of making such small adjustments accurately.

Here are some suggestions for getting the most out of @Focus2:

1. Use a focuser with an absolute minimum of backlash. The greater the backlash (free play or looseness), the less likely the focuser is to achieve accurate, repeatable focus. @Focus2 attempts to correct for backlash problems, but the less backlash, the better the results. If your focuser has too much backlash or other problems, @Focus2 should get you close, and you can manually refine focus following the @Focus2 run.
2. Use a focuser that provides accurate, absolute position feedback to @Focus2 (for example, Optec's TCF-S).

3. If your telescope uses a moving primary mirror for focus, lock down the primary mirror and use a motorized focuser such as the JMI NGF-S. Motorized focusers that move the primary mirror are among the least likely to be successful with @Focus2.
4. Make sure that focus can be reached within the travel of the motorized focuser controlled by @Focus2.
5. Set the correct Focus Range for focuser movement (see "Step 2: Set @Focus2 Parameters" for details on step sizes). The range must be large enough for @Focus2 is able to detect changes in focus, and yet small enough so that @Focus2 does not completely move through focus in less than the number of Samples. See the detailed information on Range in the section "Set @Focus2 Parameters" below.
6. Your mount must be well aligned to the celestial pole. Software Bisque's TPoint software, sold separately, can quantify polar alignment and is ideal for imaging. If objects drift in and out of the field of view during @Focus2ing, this will affects the measure of focus and could lead to spurious results.
7. There must be a single focus star in the photo. A single star usually leads to successful focus,

Step 1: Get Close to Focus

@Focus2 is designed to handle the hardest part of focusing: getting into the critical focus zone. Before you use @Focus2, you need to get the focus position close to the critical focus zone.

Here are some techniques you can use to get close:

- Move the focuser to a known good focus position. This technique works best with telescopes that allow you to physically see the position of the focuser tube, such as a refractor with rack and pinion focusing. Telescopes with internal focusers, such as many stock Schmidt-Cassegrains (SCTs), cannot use this method.
- Use an eyepiece that is parfocal with your CCD camera. (A parfocal eyepiece comes to focus at the same position as your CCD camera.)
- Manually adjust focus while using the Camera tab's **Focus Tools** tab in continuous mode and maximize peak value and or minimize HFD values.

How close should you be to perfect focus before running @Focus2? If the focus star looks like a large "doughnut" that may not be close enough.

Figure 241 shows an example of an OK starting point for an @Focus2 run. The medium-bright stars are clearly small doughnuts with central holes. Brighter stars often don't display doughnut holes because the default image histogram settings.

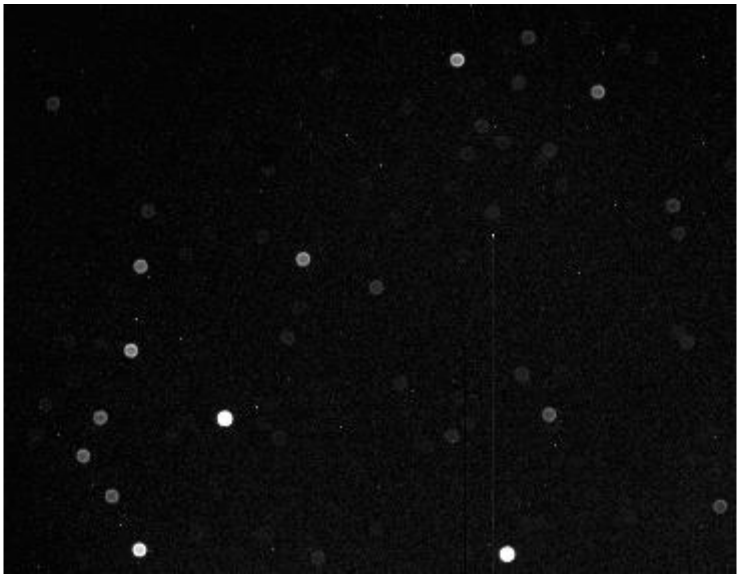


Figure 241: An example of an acceptable starting point for @Focus2.

Seeing conditions may have a significant impact on your ability to use faint stars for evaluating focus quality. This is especially true at longer focal lengths (greater than about 1500mm). The seeing may reach a point where fluctuations from turbulence scatter the light so much that it appears that you aren't at good focus. However, @Focus2 will still be able to find the best possible focus for the seeing conditions. Even on nights with very poor seeing there is a position of optimal focus. If the seeing is poor, and the best focus you can reach isn't good enough, switch to a shorter focal length if possible or image when the seeing is better.

Step 2: Set @Focus2 Parameters

If you have followed the guidelines in the "Keys to @Focus2 Success" section, you are ready to configure @Focus2 for optimal focusing with your system.

Parameter settings that change more frequently are included on the ***@Focus2 Automated Focus*** window, which opens each time you click on the **@Focus2** button on the ***Focus Tools*** tab of the ***Camera*** window (Figure 242). When you click **OK**, @Focus2 starts a focusing run. We suggest you review the detailed information about the various parameters below before you try your first focusing run, as you may need to adjust some of these parameters to suit your system.

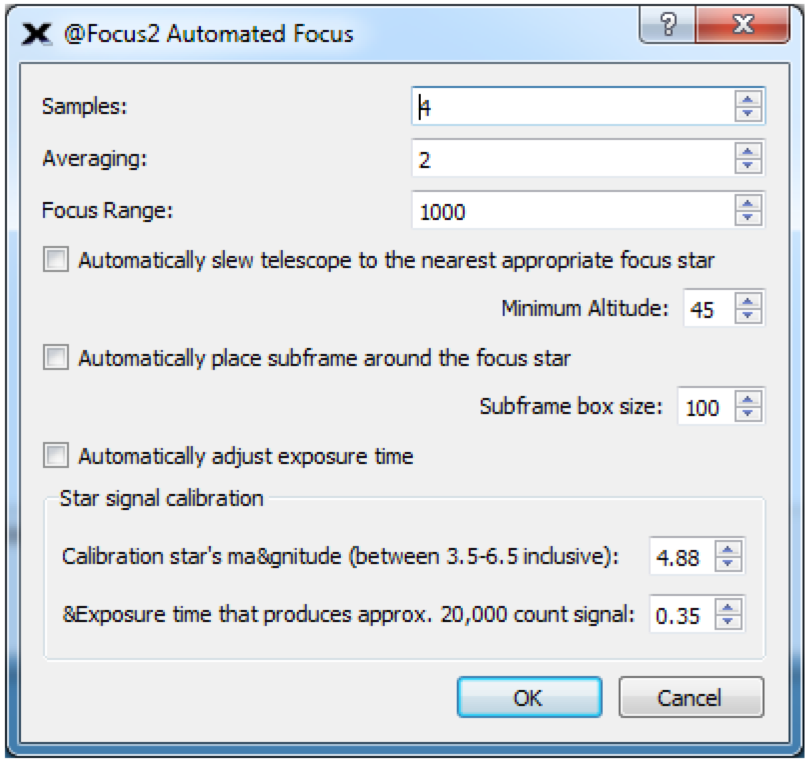


Figure 242: Setting @Focus2 parameters.

@Focus2 settings are described in this section. The following list includes the parameters you may encounter using @Focus2. Depending on the focuser you are controlling, however, some parameters may not be available.

Samples – This is the number of images @Focus2 will use to achieve best focus position. The available range is 4 to 50. For most applications, the default value of 4 will give you good results (two samples on each side of focus). @Focus2 requires at least 2 samples on each side of the critical focus zone. For critical applications, you can increase the Samples number.

Averaging – This is the number of images per sample. Averaging can help when seeing is poor. For good to excellent seeing conditions with a high-quality focuser, a value of 1 is usually satisfactory. For poor to average seeing, a value of 2 or 3 is a good compromise between speed and quality. When the seeing is creating serious problems, averaging 5 or higher will smooth out the focus curve significantly, although it will take longer for @Focus2 to converge upon focus. You can also use averaging when the seeing is good to reduce the overall noise level in the focusing data. Experiment to determine the optimal setting for your system. Generally, the smallest setting that regularly achieves excellent focus is the right value to use. We recommend starting with the default values, then change settings one at a time to see what affect that has on focus quality.

Focus Range – This is the focus range that will be sampled when performing a focusing run, half below and half above whatever focus position is at the start of the run. Setting the Range requires some analysis of the behavior of your telescope/mount/focuser system, and is covered in detail below.

The key parameter for success with @Focus2 is getting the Range value correct.

A rough starting point for your Range is approximately 40 times the size of your critical focus zone. For example, an initial Range for an f/5 scope with the TCF-S would be (40 * 55) = 2200 microns. At 2.18 microns per step, that would give an initial Range of about 1000.

Experience with your camera and using the Focus Graphs will also help you determine the Range. The Focus V-Curve graph should end up being a V shape where the vertex of the V points to the critical focus position.

Focuser Training

The Focuser window shows focuser status, with options for adjusting the focuser's position, and training the focuser offsets to apply for a given light filter when acquiring photos.

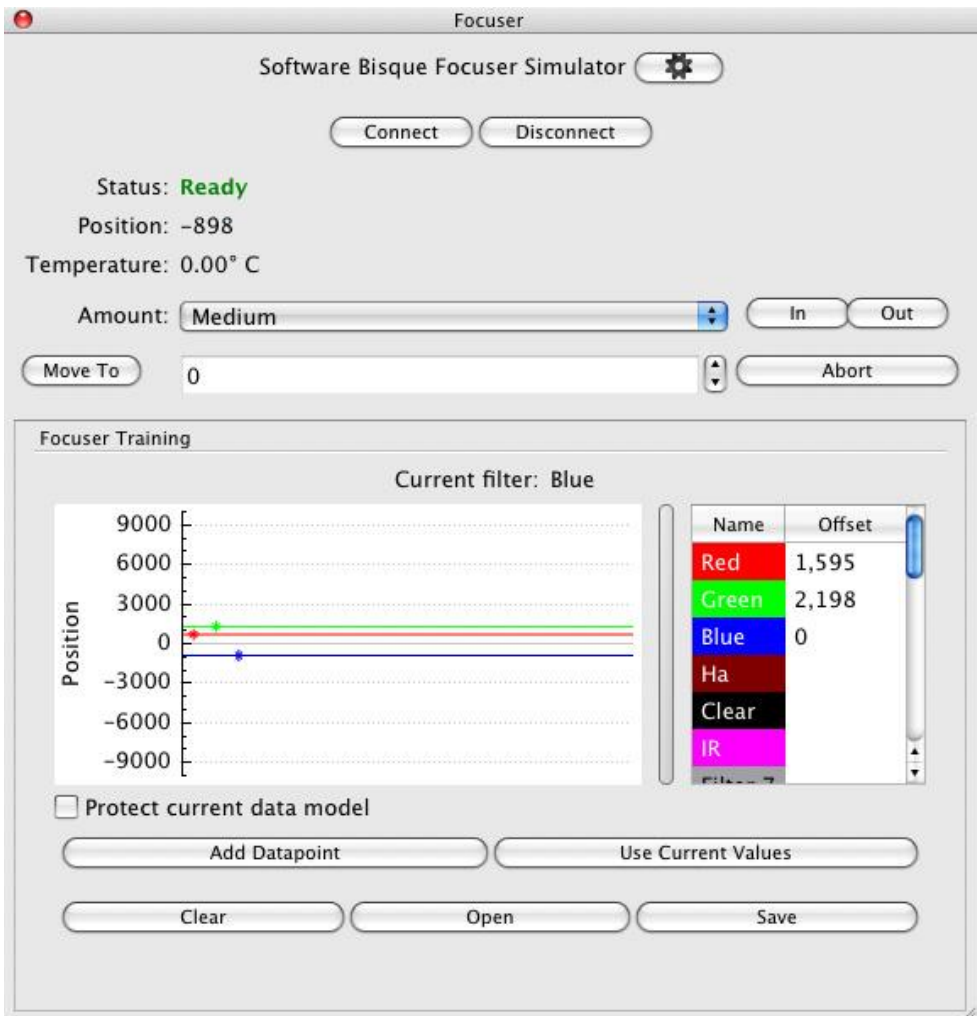


Figure 243: Focuser Training controls.

The currently selected focuser is displayed at the top of the ***Focuser*** window. Click the gear icon to display the ***Choose Focuser*** window and select your focuser, if necessary.

Connect

Click this button to establish connection to the selected focuser.

Disconnect

Click this button to terminate connection to the selected focuser.

Status

The connection status for the selected focuser is displayed next to the ***Status*** text.

Position

Shows the current position of the focuser. Depending on the model focuser, this value may be relative to an absolute focuser position, or relative to the starting focuser position.

Temperature

For focusers that report ambient temperature, the focuser's current temperature is displayed next to the ***Temperature*** text.

Amount

This pop-up menu can be used to select the relative amount of travel in the focuser's position when moving it in or out, ***Small***, ***Medium*** or ***Large***.

In/Out

Click these buttons to move the focuser in or out.

Move To

Click this button to move to the focuser position that is entered in the text box to the right of this control.

Abort

Click this button to stop an in progress focuser position adjustment.

Current Filter

The Focuser Training section of the Focuser window shows the currently selected filter wheel filter when one is present. If no filter is shown, click the ***Move Now*** button on the ***Camera*** or ***Video*** window to rotate the filter wheel to a known position.

Focuser Training Graph

Shows the data points that will be used to make adjustments to the position of the focuser for each filter.

Filter and Offsets Table

This table lists each filter wheel in the ***Name*** column, and the focuser offset in the ***Offset*** column. Double-click on each filter name to select the background color.

Protect Current Data Model

Turn this checkbox on to prevent changes to the filter offsets that are currently assigned to each filter.

Add Data Point

Click this button to add a focuser offset for the current filter.

Use Current Values

Click this button to use create a temperature compensation curve based on the current filter offset values.

Clear

Click this button to clear the data points from the existing model, and reset the graph.

Open

Click this button to open a Focuser Data file that contains

Focuser Training Details

Motorized focusers can be "trained" so that focus adjustments can be made while imaging. In the context of focuser training, there are two different types of focus:

- **Closed Loop Focus**: Focus is adjusted, and the results are verified (either automatically by software, or visually).
- **Open Loop Focus**: Focus is adjusted based on previously measured characteristics of the system.

In both cases, closed loop focus generally yields better results than open loop, but open loop can keep maintain critical focus for a good deal longer than would normally be possible.

@Focus2 provides automated closed loop focusing. The *Focuser Training Tool* attempts to characterize your system so that open loop focusing can be used effectively.

The *Camera Add On* attempts to compensate for two separate sources of defocus:

1. Defocus due to filters that are not, or are not *quite*, parfocal.
2. Defocus caused by temperature variations.

To successfully characterize the open loop movements that must be performed to compensate for these sources of focus "error", the *Camera Add On* must acquire a number of "known valid points" (KVPs). These data points record:

- Focuser position

- Current temperature
- Current filter

When a sufficient number of KVPs have been acquired, the *Camera Add On* is able to perform open loop focusing to compensate for different filters and varying temperatures.

There are two ways to acquire KVPs:

- **Automatically**: Successfully completing an @Focus2 run records a KVP (unless the ***Protect Current Data Model*** checkbox turned on in the training tool). An unsuccessful @Focus2 run will not record a KVP.
- **Manually**: Clicking the ***Add Data Point*** button in the training tool adds a KVP using the current system parameters.

The total number of KVPs needed to maintain focus is subjective. While more KVPs produce a more accurate model, in practice, a small number of KVPs for each filter will generate good results if the KVPs are collected over a wide temperature range.

Once a data model contains a good number of KVPs, click the ***Use Current Values*** button to make use of the collected data. If you have already characterized your system using another software package, you can also manually edit the focus compensation values.

The Filter and focus offsets may be entered in the ***Filter Names Setup*** window. The temperature compensation slope for your system may be entered in the ***Temp Compensation, Adjust C*** text box. These fields will automatically be filled out when you click the Use ***Current Values*** button on the focuser training tool.

Once these values have been filled out, they will remain in your imaging system profile. The focuser will automatically adjust itself each time a new filter is selected.

Turn on the ***Activate*** checkbox under ***Temp. Compensation*** to command the *Camera Add On* to automatically adjust the focuser's position as temperature changes. Note that at least one valid KVP must be recorded before temperature compensation can be performed.

The KVP data model can be refined over the course of several imaging sessions. Data models may be saved and loaded at any time, although their parameters will not become active until the ***Use Current Values*** button is clicked.

Some focusers do not return to the same physical position each time they are activated (examples would be a relative focuser that always comes up at position 0, or an inline focuser on the end of a drawtube). Special care must be taken when loading models generated by these sorts of focusers. Rather than simply loading a model generated by this sort of system, generate a new model with a few data points instead, then select ***Merge*** when loading the previously saved data set. This will ensure that the old data set makes use of the system's current focuser offsets.

Focusing Manually

The *Camera Add On* can assist you in achieving manual focus. You can get close to focus in several ways:

- If you found the correct focus position previously, mark the focuser position so you can move the focuser into position at the start of your imaging sessions. This will not work with scopes that have internal focusers, such as most Schmidt-Cassegrain telescopes.
- If you can get a very bright star in the field of view of the CCD camera, it will show a very large out of focus image of a star. The star should be magnitude 2 or brighter, or the out of focus image will be so dim that you might not recognize it. Center the star, and adjust focus until the star is close to focus.

Figure 244 shows four examples of images that are out of focus. Image A is just slightly out of focus. If you have a parfocal eyepiece or can position the focuser in the same place on subsequent nights, this is the type of focus quality you might see. Image B shows a star image very far out of focus, as it appears in a refractor. You can adjust focus to reduce the size of the star image, but you will likely have to make a large change in focus position to get close to focus. Image C shows a similar very far out of focus star image, but taken with an SCT. Note the shadow of the central obstruction. Image D shows an out of focus star image that is underexposed. The image is very grainy, and the default image settings had to be changed to show the star clearly.

The histogram or the background and range settings are used to make these changes. You will generally need longer exposures to show out of focus stars, even very bright ones. You can reduce exposure time during focusing as the star’s image becomes smaller and brighter. If you are sure you have a star in the field of view, but think it might be very far out of focus, try a much longer exposure to see if the star’s out of focus image comes into view.

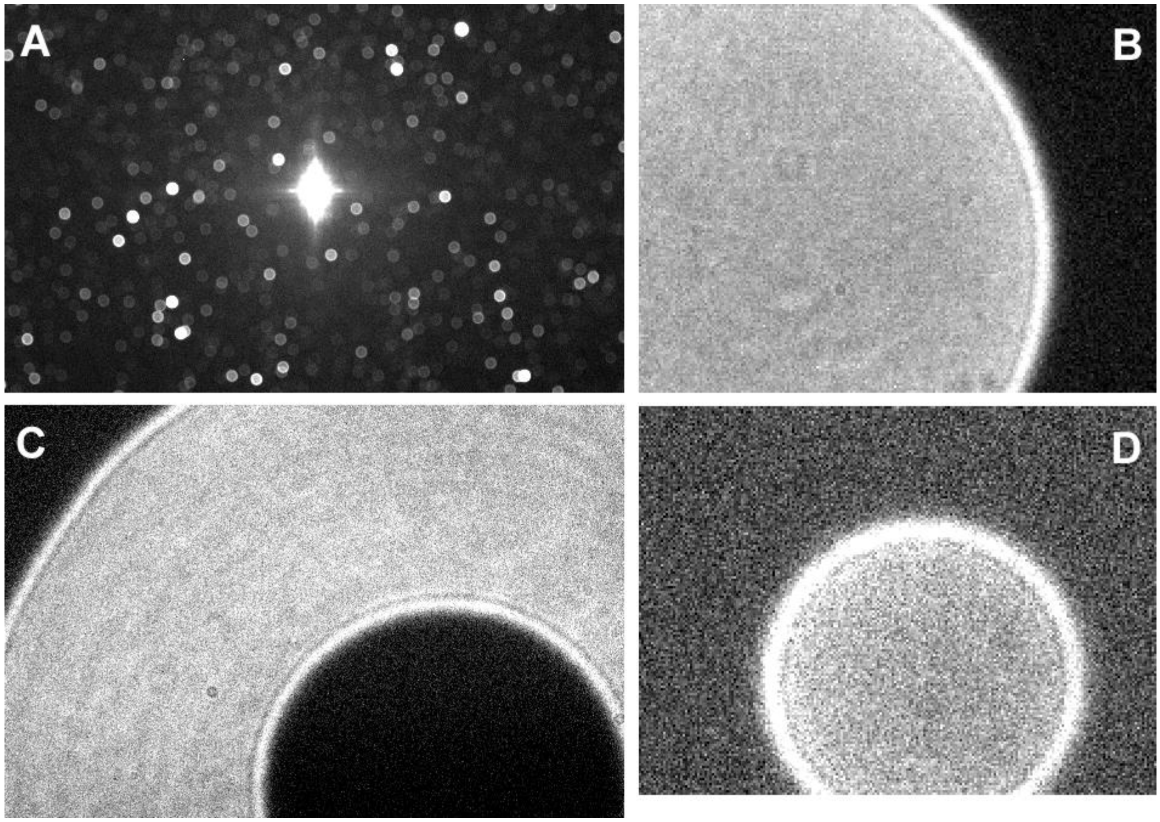


Figure 244: Various stages of focus. A: slightly out of focus with a wide-field refractor; B: far out of focus with a refractor; C: far out of focus with an SCT; D: moderately out of focus with a refractor and underexposed.

You may find it useful to center the out of focus star so that it will still be on the CCD detector when you get close to focus.

The idea behind manual focus is to take photos continuously while changing the focus position to maximize, maxim pixel value or minimize HFD.

Step 1: Get your focusing tools ready

You can use the ***Focus Tools*** tab to focus manually (Figure 245). To use the **Move Focus** buttons, you must have selected a focuser from Telescope, Setup. There are two types of focus adjustment outside of TheSkyX: manually changing the focus of your telescope, or controlling a motorized focuser with a hand paddle, such as a JMI MotoFocus.

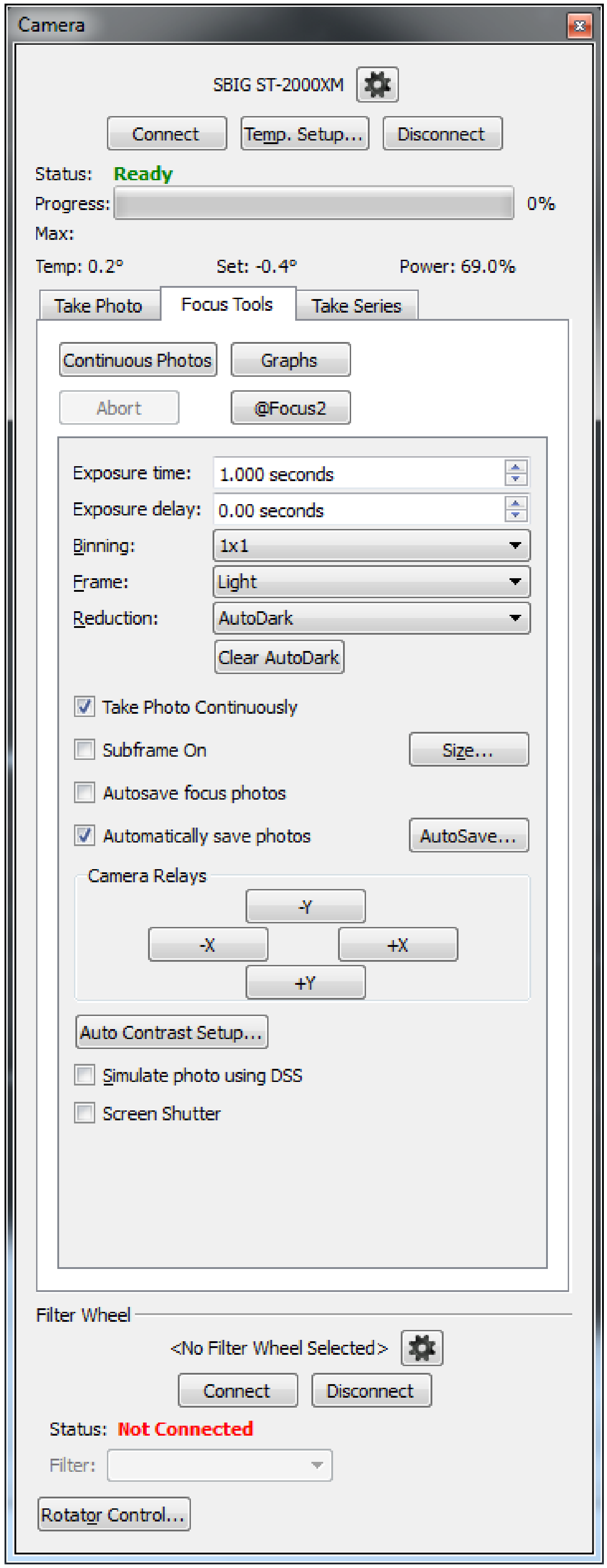


Figure 245: Most of the tools you'll need for focusing are found on the Focus Tools tab of the Camera tab.

ℹ	If the Camera tab isn't visible, click **Display | Camera** then click on the Camera tab to bring it forward.

Step 2: Verify Initial Settings

The initial focus exposure is often taken using the largest possible binning mode on your camera. Binning provides a faster download time, and lets you check your focus quality quickly. For example, with an ST-8E, the maximum binning is 3x3.

Typical initial settings should be: ***Image Frame*** set to ***Light***, and ***Image Reduction*** set to ***AutoDark***. The *Camera Add On* will automatically take dark frames with the same exposure length as the light frames. This removes hot pixels from the focus images, and makes it easier to tell when dim stars are properly focused. If you have a filter wheel installed, set it to the Clear filter for focusing.

Make sure ***Subframe On*** is not checked, and also make sure. For a quick test of your current focus position, start with a ***Bin*** setting of ***3x3***. Set the ***Delay*** to 0.00. Click **Graphs** to provide the most accurate assessment of focus quality.

Step 3: Enter an Exposure Time

Enter an exposure time in the **Exposure Seconds** box. This will typically be about 5 to 30 seconds, depending on how bright you expect the stars to be in your field of view, the aperture and focal ratio of your telescope, the quantum efficiency of your camera, the current state of focus, etc. Experience will show you what exposure lengths will work well for focusing with your setup. We suggest that you use 10 seconds as a starting point for your first attempt at focusing. You can increase or decrease this value based on the results you get from your system. If you have a non-antiblooming CCD detector, make sure your exposure is short enough that there are no blooming stars. Figure 244b shows an example of a blooming star. A bloom occurs when pixels have filled up with electrical charge and spill over (bloom) into their neighbors. Blooming only occurs in one axis, so a bloom is always a line extending from a star in two directions.

Figure 246: An example of a star that is bright enough to bloom.

Step 4: Take a Photo

Click **Take Photo**. You will see various messages in the Status area at the top of the Camera window:

- Selecting Filter (appears only if you have a color filter wheel).
- Exposing Light (appears during exposure, with a timer showing time remaining).
- Downloading Light (appears while the frame is being downloaded from the camera to your computer).
- Exposing AutoDark (appears during the dark frame exposure, taken with the shutter closed).
- Downloading AutoDark (appears while the dark frame is being downloaded from the camera to your computer.

The light frame will appear first. Do not be concerned if it has a large number of bright pixels; these will go away when the dark frame is downloaded and subtracted from the light frame.

The use of an AutoDark frame is optional for focusing. If you are using a very bright star for focusing, or if you are taking very long focus exposures, you can choose not to use AutoDarks. However, accurate focusing is critical to getting sharp images and useful photometry, and we recommend that you use AutoDark when focusing. A new AutoDark is taken only when the exposure length or image size changes, so you only have to wait for the first one.

If the stars are not small, round, and numerous in the image, adjust focus in until stars appear as small round dots. Aim for somewhere close to focus. Don't try to achieve optimal focus in 3x3-binned mode. You need to switch to 1x1 using sub-frames, covered below in step 5.

Make a mental note of the direction you are moving the focuser knob during step 4. Your goal is to approach focus from one side until it is optimum. In the next step, you'll be making very small changes, and it helps to know the direction you should be moving in to improve focus. Seeing conditions may interfere with clear evaluation of focus quality, and knowing the direction to move will help you keep track.

Step 5: Select a Star and Put It in a Sub-Frame

Another tool for speeding up your focusing is the sub-frame. This is a small portion of the image immediately around the star you will be using for focusing. To select a sub-frame, click and drag around a bright star in your 3x3 binned photos, as shown.

Which star should you select? The ideal star meets these criteria:

- It is one of the brighter stars in the frame, but it is not saturated. Move the cursor over the star and observe the brightness value in the status bar; make sure it's not saturated. That is, make sure it does not have a brightness level anywhere near the maximum value for your camera.
- There are other, dimmer stars close to the focus star. You can use these dim stars to assist you in accurately evaluating focus quality. When you are imaging in the Milky Way, this is easy to do. At other times, dim stars may not be available.

The better your polar alignment, the smaller your focusing sub-frame can be. With a good polar alignment, the stars will move very little between exposures, and you can use a small sub-frame without worrying about losing the star after a few exposures. The smaller your sub-frame, the faster it will download and the more efficiently you can focus. If the star gets close to the edge of the sub-frame, you can use the **N/S/W/E** buttons in the **Move telescope** section to make adjustments if you are have an autoguider connected to your telescope.

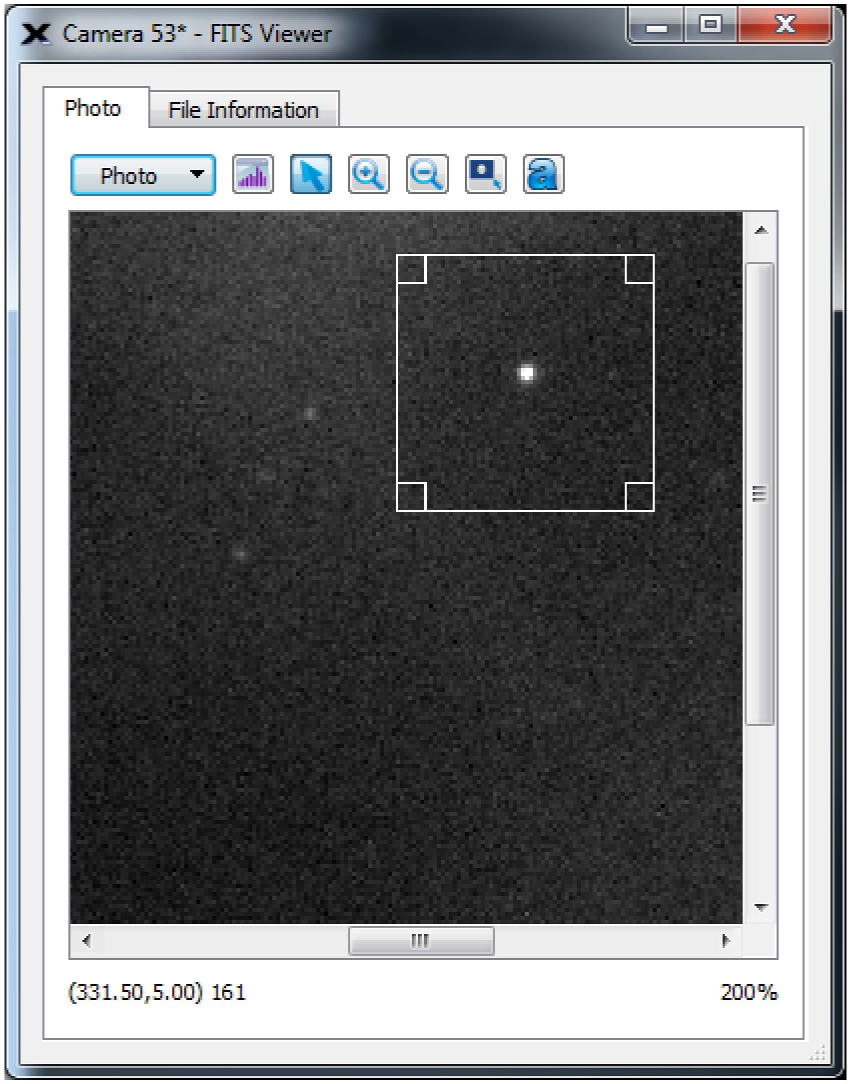


Figure 247: Select a focusing sub-frame by clicking the Sub-frame button and dragging a sub-frame in the FITS Viewer window.

Note that the Subframe checkbox in the Camera Control Panel gets checked automatically when you select a sub-frame using click and drag. You can also click **Size**, and enter the position and size of the subframe numerically, but for most focusing needs a click and drag will be your best bet. For best results, you want a small sub-frame so that you don't spend a lot of time waiting for focus images to download. Allow room around the star for any dim background stars to show up. These dim stars can be an effective asset when focusing.

Step 6: Adjust Focus Using Continuous Focus Mode

Click on the ***Take photos continuously*** checkbox on the ***Focus Tools*** tab. This activates continuous focus mode. The *Camera Add On* will take focus exposures one after another while you adjust focus. If the star you are using for focusing becomes too bright as you improve focus (that is, it becomes saturated and/or blooms), you can abort, adjust exposure time, ***Abort***, and resume in continuous focus mode.

Use the ***1x1*** (unbinned) bin mode to get best focus. Use the ***Bin*** pop-up menu at top center of the ***Focus Tools*** tab to select the **1x1** option.

If you need some time between exposures to make manual (or motorized) adjustments to focus position, enter an appropriate delay in the ***Delay*** box at upper left. We suggest 7-10 seconds when you are getting started. As you gain experience, you can use shorter delays to speed up your focusing process. No delays can work once you are familiar with the manual focus process.

If you have an electric focuser that is controllable from *TheSkyX Professional Edition* software, but not accurate enough to work with @Focus2, you can use the ***Move In*** and ***Move Out*** focuser control buttons on the ***Telescope*** window.

You can visually observe the sub-frame window to help you decide when you have reached optimal focus. The ***Focus Tools*** tab also provides several types of feedback that will help you identify when you are in the critical focus zone. These include a graph showing a history of HFD or brightest-pixel values, and a numeric readout below the graph. If TheSkyX is connected to a focuser the ***Focus Graphs*** will also display Focus V-Curve graph of HFD vs. Focus Position (the HFD is at a minimum when in focus).

If connected to a focuser that doesn't have digital readout, TheSkyX maps focuser ***Move In***, ***Move Out*** to relative numeric focus values so that the Focus V-Curve Graph may be valid provided the numeric focus values somewhat relate to reality and the focuser physically moves consistently.

To start fine focusing, continue focusing in the direction you established during your initial, very rough focusing procedure. The star image will get smaller, and the value of the brightest pixel in the image will increase.

The brightest pixel gets brighter because, as you get closer to optimal focus, you are concentrating more light energy from the star on the central pixels of the star image. This value rises steadily as you improve focus, but turbulence frequently causes it to become somewhat erratic as you get very close to focus.

The HFD value is a great tool for judging the quality of focus. HFD tracks the quality of focus more accurately than brightest-pixel values. You can always check the current brightest pixel value in the information lines at the top the Camera tab, under the heading Max.

The trick when focusing is to know what to expect at the point of best focus. The simplest way to find this out is to go past best focus and observe what happens with the appearance of the image and the Focus Graphs. As you move toward focus, the star's image gets smaller and brighter, and the HFD trends downward. Past best focus, the star image will begin to get fuzzy again, and the HFD will start to trend upward. Strong atmospheric turbulence makes the graph values especially erratic near optimal focus, but HFD is less susceptible to this compared to brightest pixel value.

Dim stars in your sub-frame are one of the best methods you can use to assist you in determining focus. The reason for this is simple: when you are out of focus, even by a little bit, dim stars will be invisible or extremely fuzzy. When you reach optimal focus, dim stars suddenly jump into view.

Several things indicate optimal focus. The minimum HFD and the brightest pixel value is now much higher than in the previous photos.

Some additional methods of focus include:

- Observing sharpness of diffraction spikes, such as from a Newtonian's spider or masking tape across the front of the telescope. These will appear double when you are out of focus, and will get closer together as you approach the critical focus zone. When they merge and become a single, bright diffraction spike, you know you are at the optimal focus position.
- Various kinds of masks, such as a Hartmann mask, can be used to assist in determining best focus. Such masks cover the aperture of your telescope, and have two or more holes cut in them. The holes cause multiple star images, which merge when you reach the critical focus zone.
- You can also create diffraction spikes using artificial spiders. For example, you can make a cross of wooden dowels to put across the front of your telescope, or you can make a cross of masking tape quickly and easily across the front of your scope.

Figure 248 shows two examples of spikes from a Newtonian spider: slightly out of focus on the left, and in focus on the right. Masking tape will produce the same kind of diffraction pattern. Note the two dim stars in both images, and how they also come into sharp focus at the same time as the diffraction spikes.

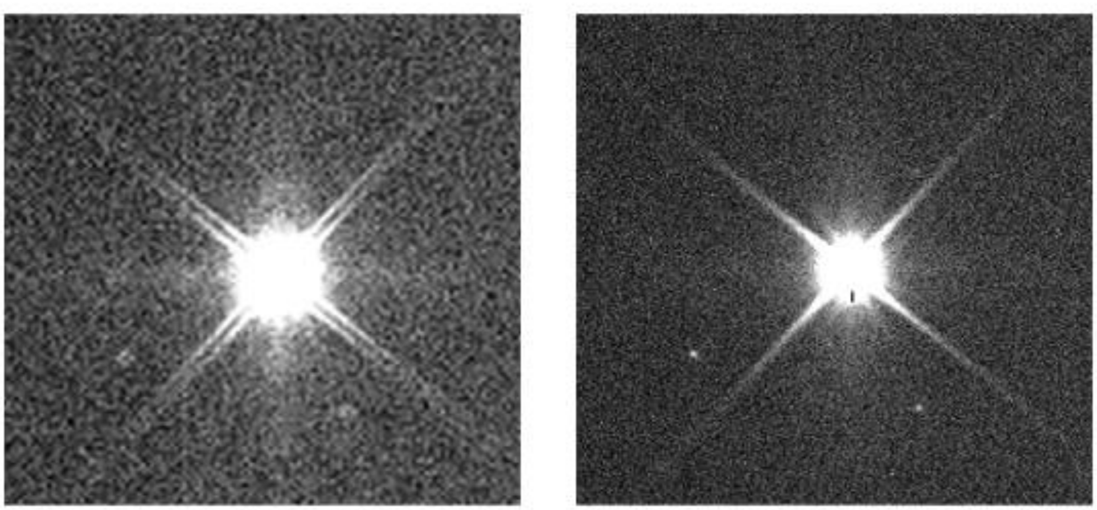


Figure 248: Diffraction spikes can be used to determine the point of best focus.

Figure 249 shows three examples of diffraction spikes created by three types of mask. From left to right, they are a three-hole mask, a two-hole mask, and a two-triangular hole mask. The advantage of the triangular-hole mask is that each triangle throws off diffraction spikes. When all the spikes have a common center, you are focused.

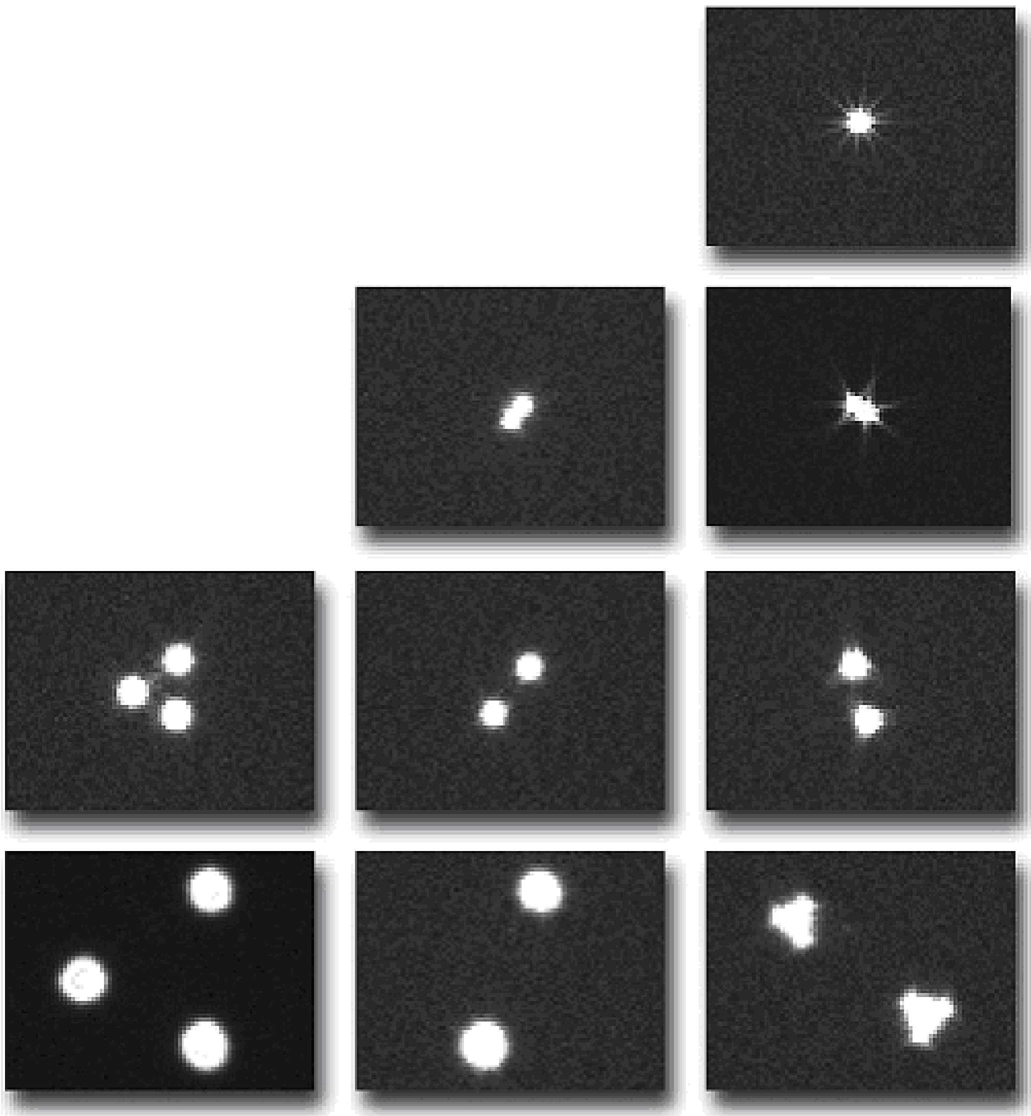


Figure 249: Focusing masks show bright spots with the same shapes as the holes in the mask. The holes converge as focus improves. The two-triangle mask (right) is easy to use because it has diffraction spikes; round holes do not have diffraction spikes.

When you have reached focus, you can proceed to capture images. The *Camera Add On* offers several opportunities for productive imaging and guiding using the ***Camera*** tab and ***Autoguider*** tab.

Filter Wheel Control

PROFESSIONAL

The *Camera Add On* can natively control SBIG camera filter wheels or any ASCOM-compatible filter wheel under Windows.

Filter Wheel Setup

Choose the ***Telescope Setup*** command from the ***Telescope*** menu to display the ***Imaging System Setup*** window. On the ***Imaging System Setup*** window, highlight ***Filter Wheel*** in the ***Hardware*** list to display filter wheel specific options.

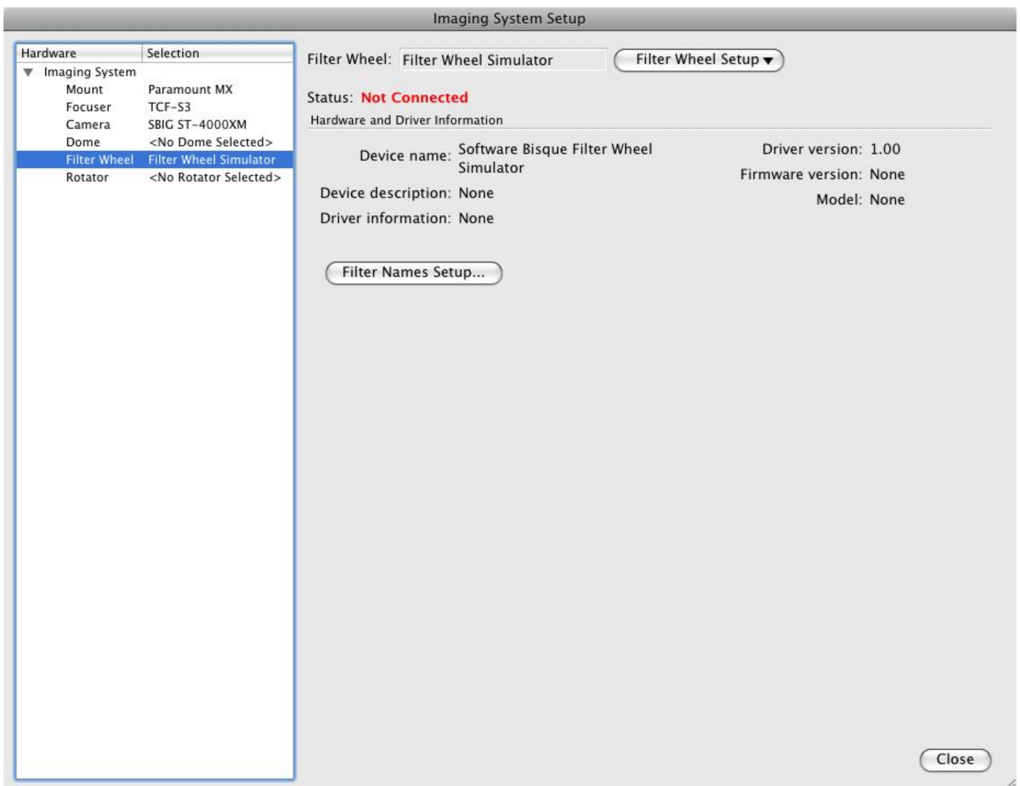


Figure 250: The Filter Wheel options on the Imaging System Setup window.

Currently Selected Camera (Camera text)

The ***Filter Wheel*** text at the top of the ***Imaging System Setup*** window shows the manufacturer and model of the currently selected filter wheel.

Filter Wheel Setup Pop-Up Menu

The ***Filter Wheel Setup*** pop-up menu provides commands for choosing, setting up, connecting to and disconnecting from a filter wheel.

Choose

Click this command to display the ***Choose Filter Wheel*** window. The ***Filter Wheel*** list shows all supported models.

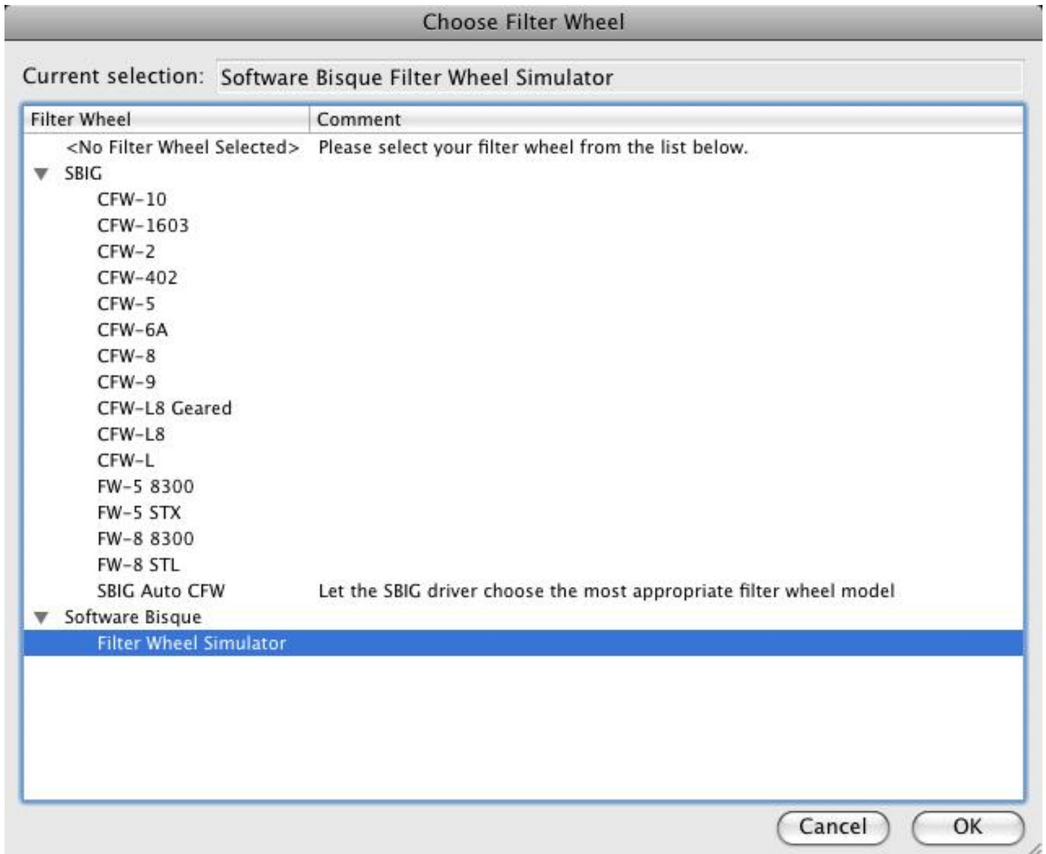


Figure 251: The Choose Filter Wheel window.

Settings

Click this command to display filter wheel-specific port setup and driver options, when available.

Figure 252: The Filter Wheel Settings window.

Connect

Choose this command to establish a connection to the filter wheel.

Disconnect

Choose this command to stop communicating with the filter wheel.

Filter Wheel Status (Status text)

This text box displays the filter wheel status.

Hardware and Driver Information

When ***Filter Wheel*** is highlighted in the ***Hardware*** list on the ***Imaging System Setup*** window, the following hardware and driver-specific information is displayed.

Device Name

Shows the name of the selected device.

Device Description

Shows a short driver-specific description of the device.

Driver Information

Shows additional information about the driver for this device.

Driver Version

Shows the version of the software driver used to control this device.

Firmware Version

Lists the version of the device's firmware, when available.

Defining Filter Names (Filter Names Setup Button)

Click the ***Filter Names Setup*** button to show the ***Filter Names Setup*** window so that each filter can be assigned a custom name.

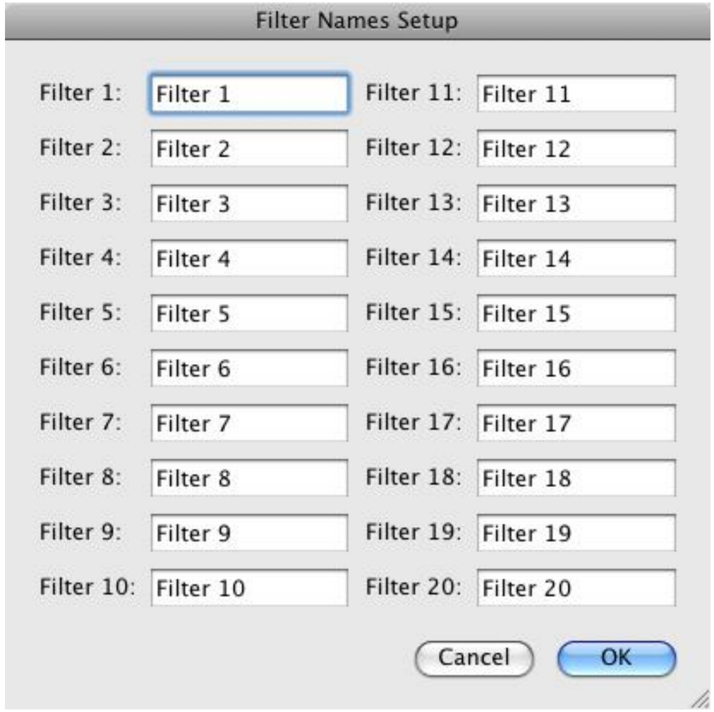


Figure 253: The Filter Names Setup window.

Filter 1-20

Enter the name of the filter in each filter position.

Note that the number of filter wheel positions that appear on Filter Names Setup window will change based on the number of filter wheel positions that are reported by the camera driver. The Filter Wheel Simulator shown in Figure 253 has a simulated “20-position filter wheel.”

Changing Filters

To change the current filter, choose the desired filter name from the ***Filter*** pop-up on the ***Camera Setup*** window.

Figure 254: Change the position of the filter wheel on the Camera window.

Rotator Control

PROFESSIONAL

The *Camera Add On* can natively control Pyxis rotators or any ASCOM-compatible rotator under Windows.

Rotator Setup

Choose the ***Telescope Setup*** command from the ***Telescope*** menu to display the ***Imaging System Setup*** window. On the ***Imaging System Setup*** window, highlight ***Filter Wheel*** in the ***Hardware*** list to display rotator-specific options.

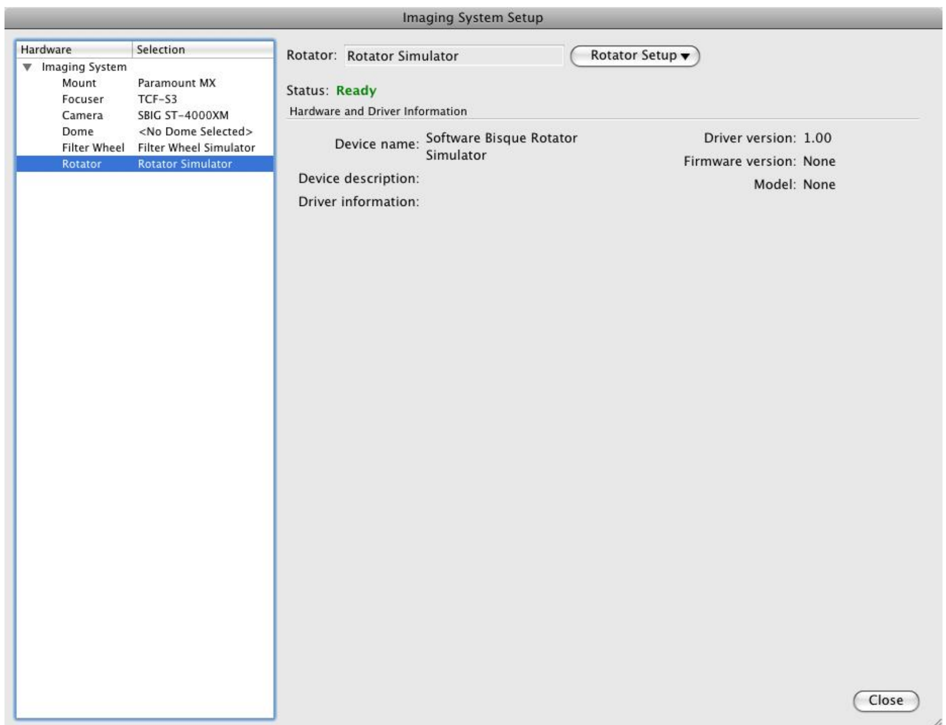


Figure 255: The Rotator options on the Imaging System Setup window.

Currently Selected Rotator (Rotator text)

The ***Rotator*** text at the top of the ***Imaging System Setup*** window shows the manufacturer and model of the currently selected rotator.

Rotator Setup Pop-Up Menu

The ***Rotator Setup*** pop-up menu provides commands for choosing, setting up, connecting to and disconnecting from a rotator.

Choose

Click this command to display the ***Choose Rotator*** window. The ***Rotator*** list shows all supported models.

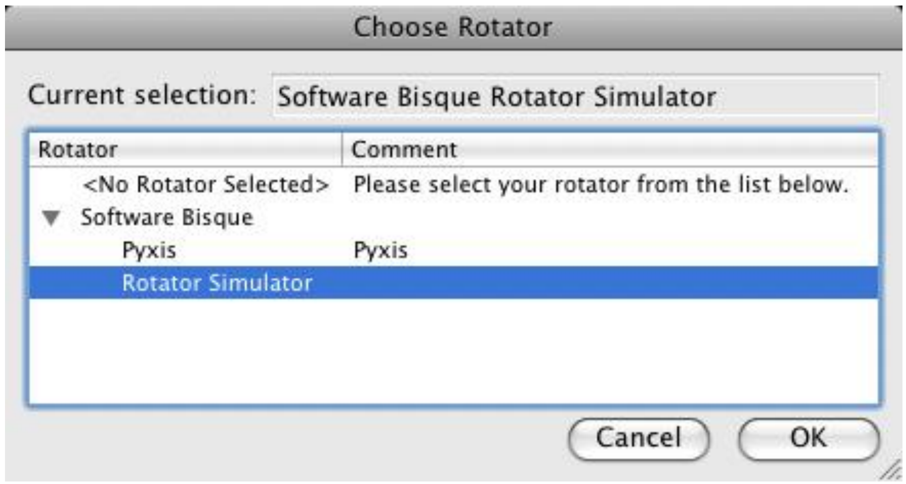


Figure 256: The Choose Rotator window.

Settings

Click this command to display rotator-specific port setup and driver options, when available.

Figure 257: The Rotator Settings window.

Connect

Choose this command to establish a connection to the rotator.

Disconnect

Choose this command to stop communicating with the rotator.

Rotator Status (Status text)

This text box displays the rotator status.

Hardware and Driver Information

When ***Rotator*** is highlighted in the ***Hardware*** list on the ***Imaging System Setup*** window, the following hardware and driver-specific information is displayed.

Device Name

Shows the name of the selected device.

Device Description

Shows a short driver-specific description of the device.

Driver Information

Shows additional information about the driver for this device.

Driver Version

Shows the version of the software driver used to control this device.

Firmware Version

Lists the version of the device's firmware, when available.

Controlling the Rotator

To change the position of the rotator, click the ***Rotator Control*** button on the bottom of the ***Camera Setup*** window.

Figure 258: The Rotator Control button on the Camera window.

This displays the ***Rotator Control*** window.

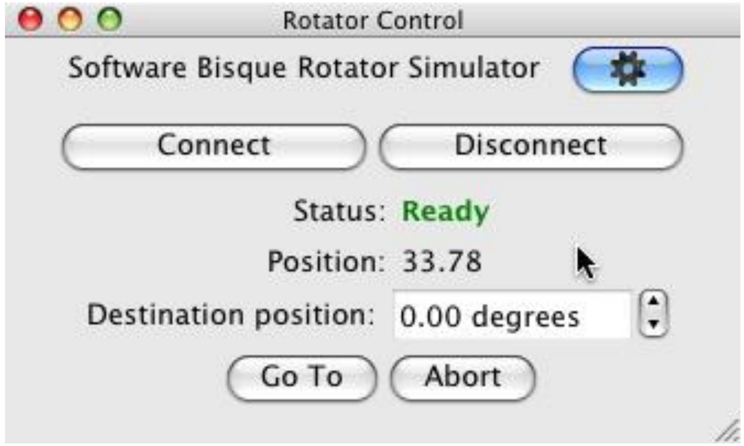


Figure 259: The Rotator Control window.

The name of the rotator is displayed at the top of the Rotator Control window. Click the button with the gear icon to select a different model or to configure the rotator hardware.

Connect

Click this button to establish communication with the rotator hardware. Make sure to choose the correct serial or other interface port for your rotator hardware and that the hardware is plugged in turned on and connected to the computer before proceeding.

Disconnect

Click this button to terminate communication with the rotator hardware.

Status

Shows the current status of the rotator.

Status Text	Description
Not Connected	The red text indicates there is no connection between *TheSkyX* and the rotator. To connect to the rotator: Choose your rotators from ***Rotator List*** window on the ***Rotator Setup*** pop-up menu from the ***Telescope Setup*** window. Choose the communication port by clicking the ***Settings*** command on the ***Rotator Setup*** pop-up menu. Click the ***Connect*** command from the ***Rotator Control*** window to connect to the rotator.
Connecting	This message is displayed while *TheSkyX* attempts to establish communication with the rotator. If connection fails, double check:

Status Text	Description
	• The rotator is powered on. • The communication cable is plugged into the correct port on the rotator and computer. • When using the device's RS232 communications port (serial port), make sure the USB to Serial Adaptor driver for your operating system are installed. Under Windows, check the Device Manager to ensure the driver is recognized and functioning properly. • Click the ***Settings*** button on the ***Telescope Setup*** window to make sure *TheSkyX Professional Edition's* ***Rotator*** settings are correct. • Make sure the cable (RS232 or USB cable) is not frayed, damaged or otherwise compromised.
Ready	This message appears after *TheSkyX* has successfully established communication with the rotator and the device is ready to use.
Rotating	This message is displayed while the rotator is changing position.
Disconnecting	This message appears while *TheSkyX* terminates communication with the rotator.

Position

The current position of the rotator, in degrees.

Destination Position

Enter the destination position for the rotator, in degrees.

Go To

Click this button to rotate the rotator to the destination position.

Abort

Click this button to stop rotation.

Linking Rotator to Field of View Indicator

The position of the rotator can be tied or "linked to" the position angle a field of view indicator. See Link to Rotator on page 96 for details how to perform this step.

When a field of view indicator is linked to the rotator and the field of view indicator is rotated, the following window appears.

Figure 260: Rotating hardware based of FOIV.

Click the ***Send Command To Rotator*** button to change the position of the actual rotator to match the FOVI position angle. Click the ***Adjust FOVI Position Angle*** button to change the FOVI only.

Dome Control

PROFESSIONAL

TheSkyX can control astronomical domes that support the Astronomy Command Language (ACL) and any dome that can be controlled by *AutomaDome for Windows*.

As you slew the telescope using *TheSkyX*, the *Dome Add On* algorithms automatically rotate the dome's aperture to the correct azimuth taking into account the telescope-dome geometry.

The position of the dome's opening is displayed on the Sky Chart for reference.

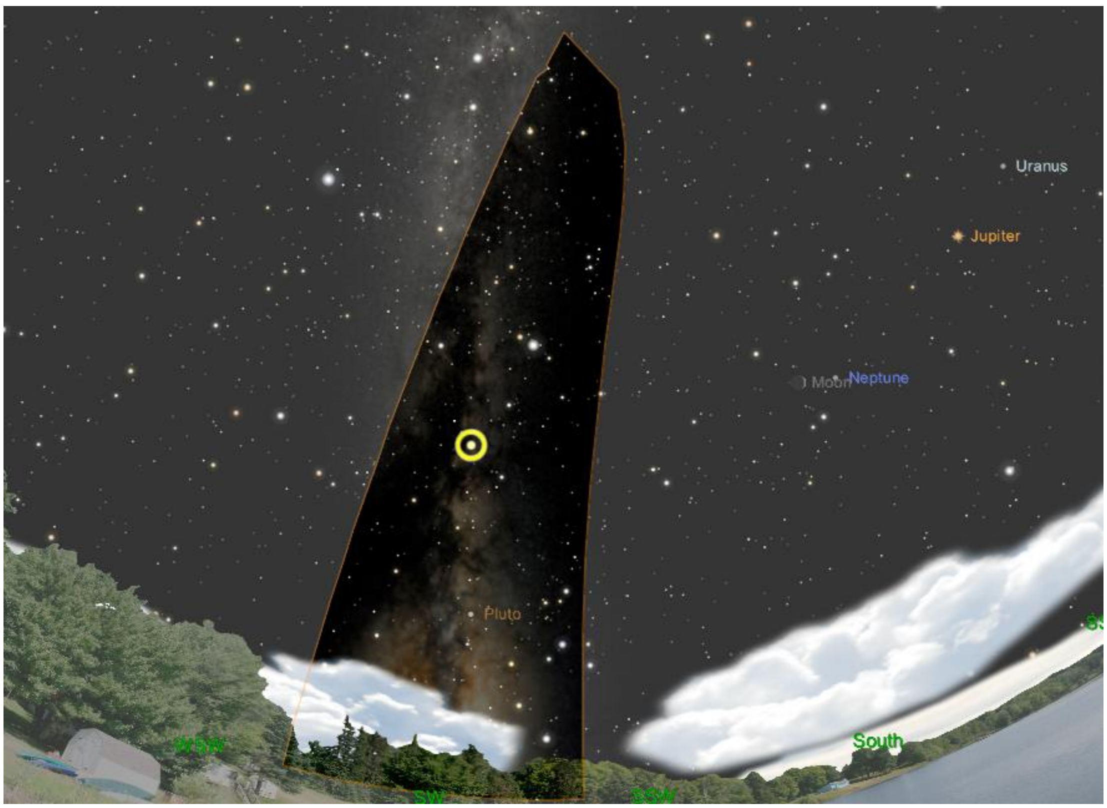


Figure 261: Sky Chart showing dome slit and telescope cross hair.

Minimum Requirements

- Any ACL-compatible dome hardware.
- Any dome controller supported by *AutomaDome for Windows* version 1.00.012 or later.

TheSkyX Professional Edition for Mac and Windows, stand alone, can control astronomical domes with the *Dome Control Add On*. (Software Bisque plans to add and expand support for additional domes controllers in future updates.)

Additionally, *TheSkyX Professional Edition* for Windows can control domes supported by AutomaDome for Windows version 1.00.012 or later.

Activating the Dome Add On

When you purchase *Dome Add On to TheSkyX Professional Edition* from the Software Bisque Store, your *Dome Add On* serial number is automatically registered and can be viewed by visiting your Software Bisque account's Subscriptions page.

The Dome Add On serial number is used to activate the dome software directly from TheSkyX Pro. **No additional installers, software or software downloads are required.**

To access your serial number and activate the *Dome Add On*,

1. Sign in to the Software Bisque web site by clicking the ***Sign In*** link in the upper right corner of the site. After you are signed in, your *Sign In Name* appears in the upper right corner of the site.
2. Navigate to your subscriptions page by clicking your ***Sign In Name***, then click the Subscriptions link.
3. From *TheSkyX Pro*, click the ***Telescope Setup*** command on the ***Telescope*** menu.
4. Highlight ***Dome*** on the ***Imaging System*** list.
5. Click the ***Enter Serial Number*** command on the ***Dome Setup*** pop-up menu.
6. Enter your ***Name*** and ***Serial Number***.
7. Click ***OK***.

The *Dome Add On* is now activated and ready to use. You'll need to repeat the above procedure on each computer that is running a licensed copy of *TheSkyX Professional Edition*.

Configuring the Dome Control Add On

Follow the steps below to configure *TheSkyX Professional Edition* to directly control a dome.

1. Make sure your dome controller is ready.
2. From *TheSkyX*, select the ***Telescope Setup*** command from the ***Telescope*** menu.
3. Select ***Dome*** from the ***Imaging System*** list.
4. Click the ***Choose*** command on the ***Dome Setup*** pop-up menu. If you have not purchased the *Dome Control Add On*, you can click the ***Run Trial*** button to use begin the 90 day trial period.
5. Select your dome controller and click ***OK***.
6. Select the ***Connect*** command from the ***Dome Setup*** pop-up menu. If the dome drivers are installed properly, after about 15 seconds, the green Connected status text appears on the ***Imaging System Setup*** window and on the ***Dome*** window.

Using AutomaDome for Windows

TheSkyX Professional Edition's Dome Add On supercedes *AutomaDome for Windows*. The section immediately below remains for legacy reference only.

In addition to the *TheSkyX's* standalone support for domes, any dome that can be controlled by *AutomaDome for Windows* can also be used. Please double-check that you have installed the latest release of AutomaDome for Windows before continuing.

Configuring TheSkyX to Use AutomaDome

- Make sure *AutomaDome*, standalone, can connect to control the dome. If *AutomaDome* does not work to control the dome, *TheSkyX* can't use it to control the dome either.
- From *TheSkyX*, select the ***Telescope Setup*** command from the ***Telescope*** menu.
- Select ***Dome*** from the ***Imaging System*** list.
- Click the ***Choose*** command on the ***Dome Setup*** pop-up menu. If you have not purchased the *Dome Control Add On*, click the ***Run Trial*** button to use begin the 90 day trial period.
- Expand ***Software Bisque***, then select ***AutomaDome Dome*** and click ***OK***.
- Select the ***Connect*** command from the ***Dome Setup*** pop-up menu. The green Connected status text appears on the ***Imaging System Setup*** window and on the ***Dome*** window.

Dome Preferences

Dome preferences are configured on the ***Imaging System Setup*** window. Click the ***Telescope Setup*** command from the ***Telescope*** menu to show this window. Next, highlight ***Dome*** in the Imaging System list on the left side of the window to reveal the dome-specific settings.

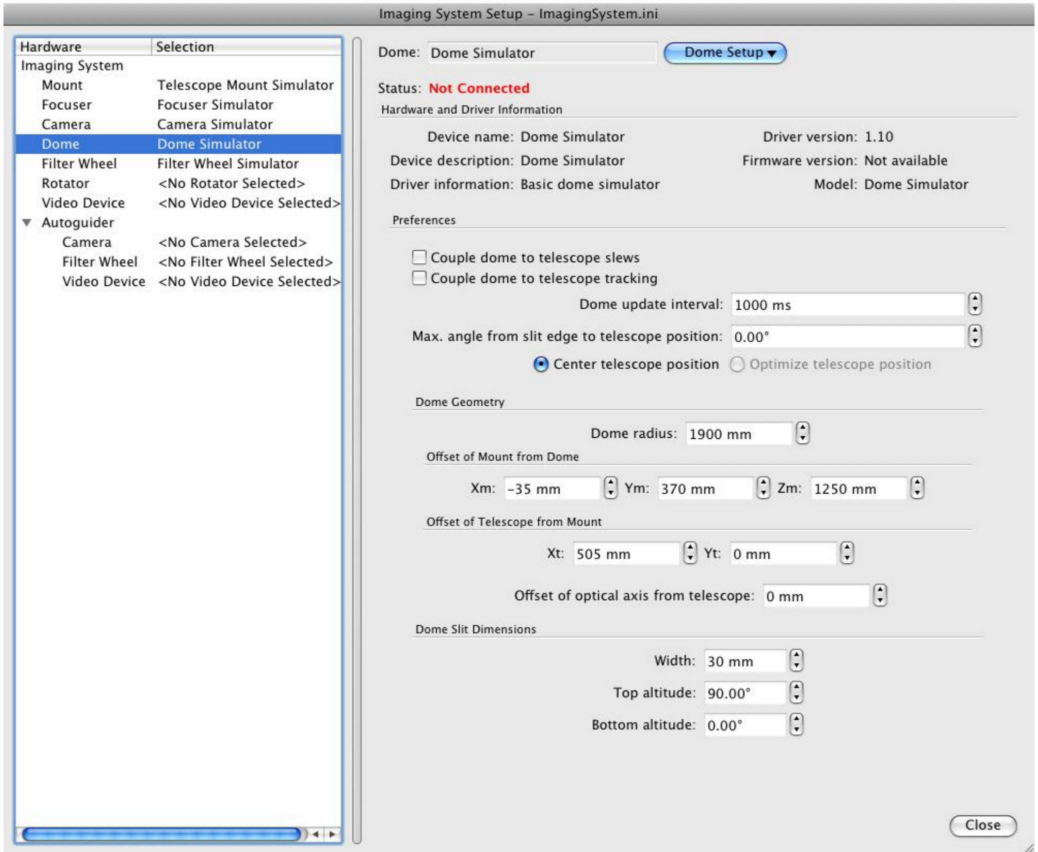


Figure 262: The dome preferences on the Imaging System Setup window.

Dome

Shows the name of the selected dome hardware driver. Choose the ***Setup*** command from the ***Dome Setup*** pop-up menu to change the current selection.

Dome Setup Pop-up Menu

Click this pop-up menu to access dome-specific commands.

Choose

Click this command to show the ***Choose Dome*** window and select the dome driver for your dome controller.

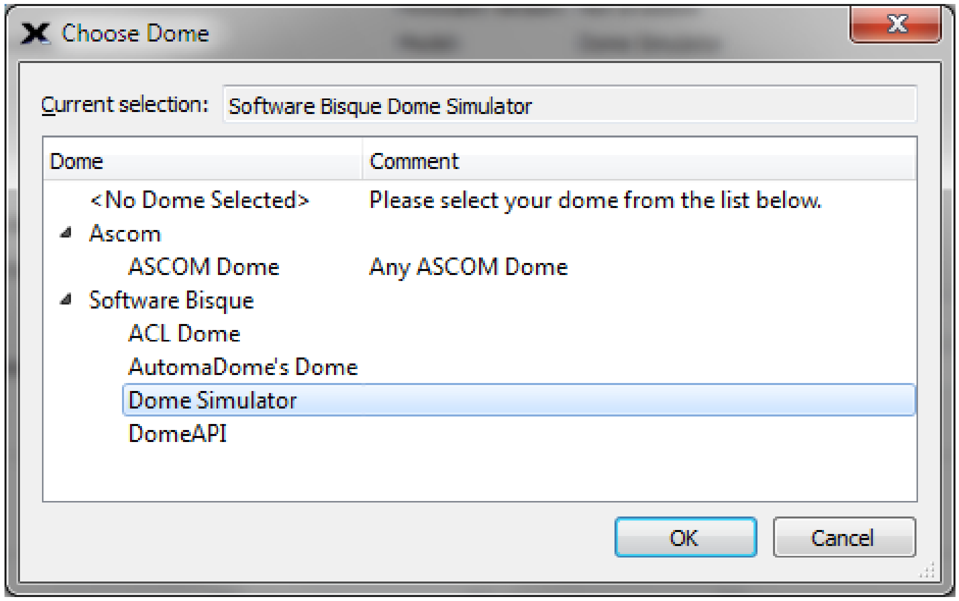


Figure 263: The Windows Choose Dome window.

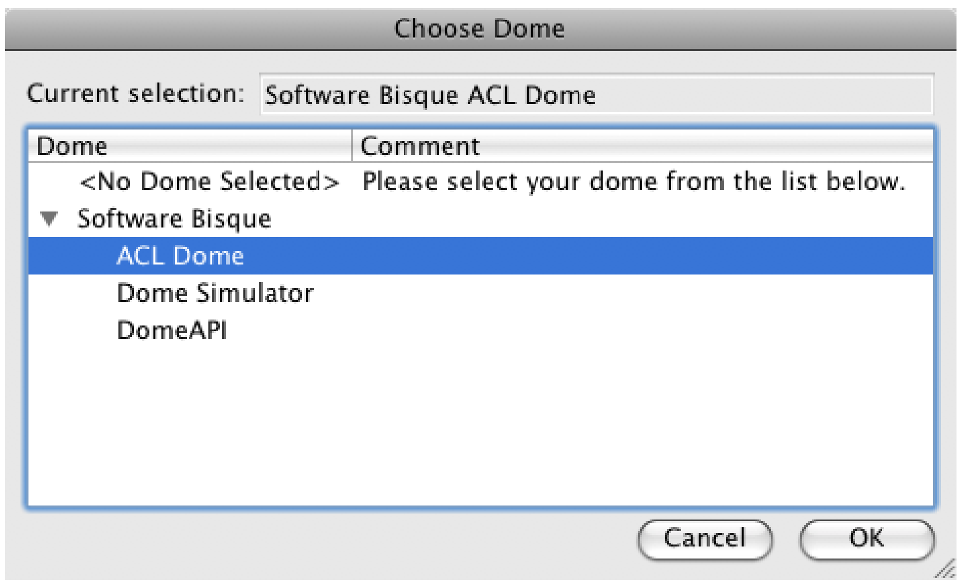


Figure 264: The Mac Choose Dome window.

Dome Hardware		
ASCOM-compatible Dome	—	✓
ACL Dome	✓	✓
DomeAPI	—	✓
Dome Simulator	✓	✓

ASCOM Dome

On Windows, choose ***ASCOM Dome*** under ***Ascom*** in the ***Dome*** list if to use an ASCOM driver to control your dome hardware. You must install the ASCOM platform and the ASCOM-specific dome driver first. See the ASCOM site for details about how. Next, click the ***Settings*** command from the ***Dome Setup*** pop-up menu to display the ***ASCOM Chooser*** window. If you have installed the ASCOM platform and the ASCOM-compatible dome driver for your dome hardware, the driver name will appear in the list of supported domes. Choose it, then click the ***Properties*** button to configure the ASCOM dome settings. TheSkyX Professional Edition should now be able to connect to and control the dome.

ACL Dome

Choose ACL Dome if your dome hardware is compatible with the Astronomy Command Language (ACL).

DomeAPI

If your dome hardware has a custom-written dome driver based on Software Bisque's legacy *DomeAPI* framework. Dome driver developers are strongly encouraged to update these drivers to conform to the X2 Standard (page 541) instead.

Dome Simulator

The Dome Simulator lets you setup, connect to, and use the dome without actually connecting to any dome hardware. This can be useful to get familiar with how *TheSkyX Professional Edition* and the telescope interact with a dome.

Dome Information

The Dome Information controls let you configure dome-specific options.

Couple Dome to Telescope Slews

When this checkbox is on, and slew commands are issued from a telescope that is controlled by *TheSkyX Professional Edition*, the dome will be rotated to keep the two aligned. Note that the geometry of where the telescope is mounted inside the dome must be configured using the dome geometry controls below.

Couple Dome to Telescope Tracking

When this checkbox is on, as the telescope tracks, the dome will be rotated to keep the two aligned. Note that the geometry of where the telescope is mounted inside the dome must be configured using the dome geometry controls below.

Dome Update Interval

Enter the number of milliseconds that must elapse before the dome's position is updated.

Maximum Angle from Slit Edge to Telescope Position

Enter the maximum number of degrees that the edge of the dome slit can be separated from the telescope before the dome's position is updated.

Center Telescope Position

Turn this option on so that the telescope will be kept near the center of the dome slit.

Dome Geometry

The next step is to define the dome geometry so that the dome opening can be coupled to, and follow the telescope.

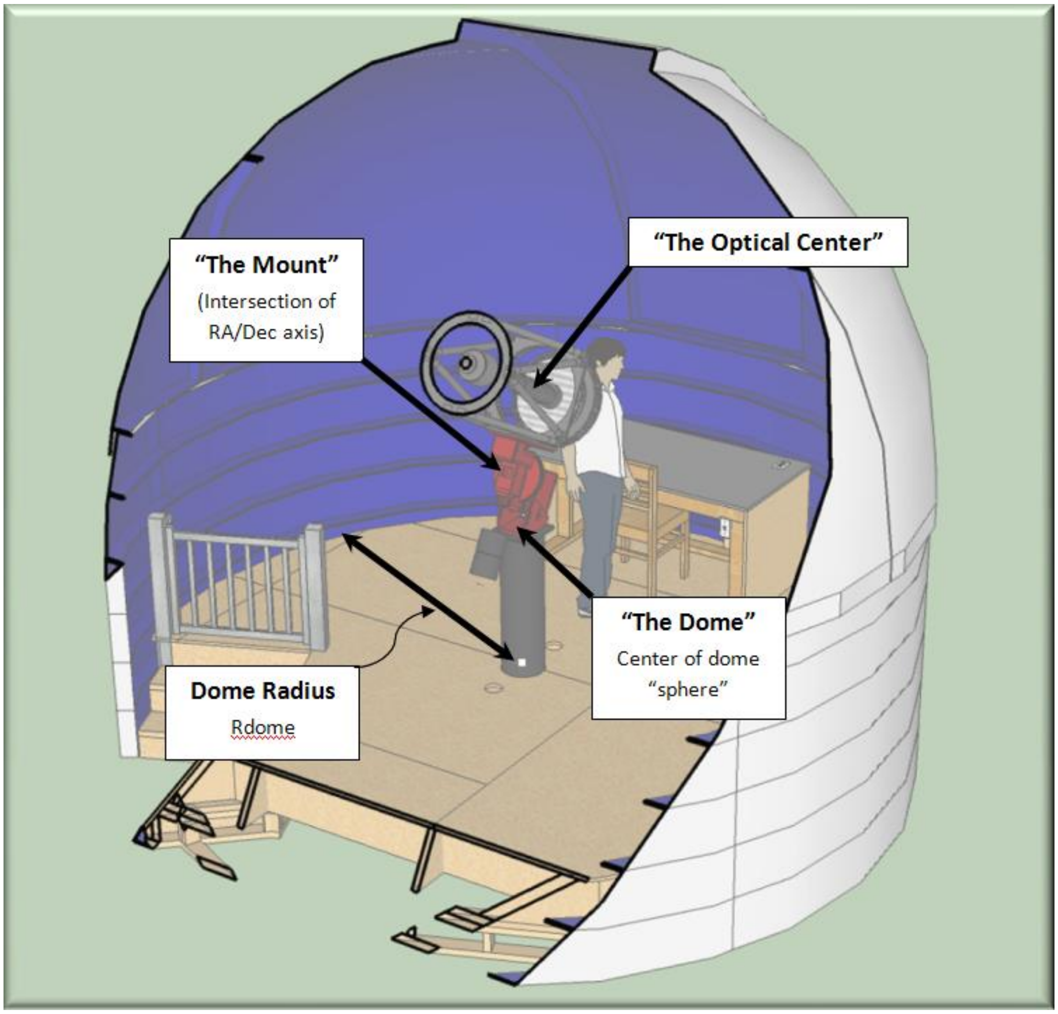


Figure 265: The positions of the dome geometry parameters in an actual dome. Three-dimensional dome drawing courtesy Gene Kochanowsky.

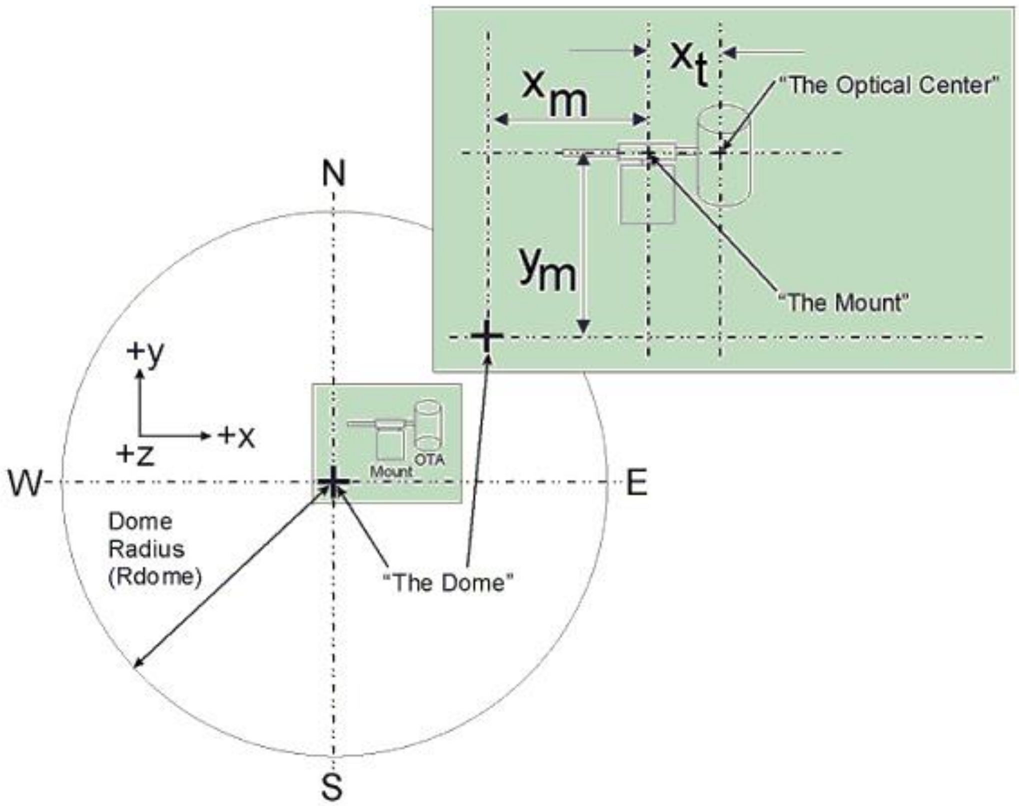


Figure 266: An overhead view of the dome.

Figure 262 shows the Dome settings that are used to define the geometry between the dome, telescope, and optical system. Refer to Figure 265, Figure 266, and the dome geometry definitions below for an explanation of these parameters.

Dome Radius

Enter the radius of the dome. All measurements should be the same units. See above diagram for details. See the section "Technical Description of Required Parameters" on page 503 for more information.

Offset of Mount from Dome

The arguments xm, ym, zm specify the offset of "the mount" from "the dome." See the section "Technical Description of Required Parameters" on page 503 for more information.

Xm

Enter the distance from the N-S centerline of "the dome" to "the mount." See above diagram for details. See the section "Technical Description of Required Parameters" on page 503 for more information.

Ym

Enter the distance from the E-W centerline of "the dome" to "the mount". See above diagram for details. See the section "Technical Description of Required Parameters" on page 503 for more information.

Zm

Enter the distance from “the dome” to “the mount”. This parameter is not defined in the above diagram. See the section “Technical Description of Required Parameters” on page 503 for more information.

Offset of Telescope from Mount

The arguments xt, yt specify the offset of the telescope from the mount. See the section “Technical Description of Required Parameters” on page 503 for more information.

Xt

Enter the distance from the N-S centerline of “the mount” to the “optical center”. See the section “Technical Description of Required Parameters” on page 503 for more information.

Yt

Enter the distance from the E-W centerline of “the mount” to the “optical center”. This parameter is not defined in the above diagram, and is normally zero. See the section “Technical Description of Required Parameters” on page 503 for more information.

Offset of Optical Axis from Telescope (yo)

Enter the offset of the optical axis within the telescope. This value is typically zero for most amateur telescopes.

Use these dome and telescope mount geometry options to define the position of your telescope mount with respect to the center of the dome. These parameters are required to predict the azimuth and elevation of the dome aperture for any asymmetrically mounted telescope. See the section “Technical Description of Required Parameters” on page 503 for more information.

Technical Description of Required Parameters

Parameter	**Description** (See notes below)
Rdome	Radius of dome
xm, ym, zm	Offset of mount
xt, yt	Offset of telescope
Yo	Offset of optical center
ta, tb	Telescope roll/pitch, in radians.

Notes:

- The dome is presumed to be hemispherical (or some other portion of a sphere). The radius of the sphere is specified through the Rdome argument. Any desired units can be used as long as the other “length” arguments are in the same units.
- The arguments **xm**, **ym**, **zm** specify the offset of the mount from the dome. "The dome" is the center of the sphere. "The mount" is that point along the roll axis (and hence fixed in

space) that lies nearest to the telescope (Note 5). The x, y, z coordinate system is oriented east, north, up.

- The arguments xt, yt specify the offset of the telescope from the mount. “The mount” is the fixed point defined in Note 4. “The telescope” is that point along the pitch axis (and hence fixed within the moving part of the mount) that lies nearest to the optical axis (Note 6).
- The argument yo specifies the offset of the optical axis within the telescope. "The telescope" is the point defined in Note 5. “The optical center” is the point along the optical axis that lies nearest to the pitch axis. It is the intersection of the optical axis with the dome that defines the point the azimuth and elevation of which are to be calculated.
- The telescope roll/pitch coordinate system matches hour angle and declination in the equatorial case. This means that it is left-handed, longitude increasing clockwise as seen from the positive pole. It means also that zero roll occurs when a northern-hemisphere telescope is pointing south. Thus the telescope roll/pitch system matches azimuth/elevation in handedness but there is an azimuth zero-point offset of 180 degrees. Note that the roll/pitch are mechanical rather than celestial, so that above/below pole and east/west of the pier cases are distinguished.
- The coordinate systems for the offsets are as follows.
    - ✓ They are all right-handed.
    - ✓ The **xm**, **ym**, **zm** axes point east, north, up.
    - ✓ The orientation of the **xt**, **yt** axes is such that they coincide with xm, ym for the case of an alt-azimuth mount pointing south. Other types of mounting follow suit. For an equatorial mount in the Northern Hemisphere, when the telescope is pointing at the meridian north of the zenith, xt points east (i.e. aligned with **xm**), and the horizontal component of **yt** points north (i.e. aligned with **ym**).
    - ✓ The **yo** axis is coincident with **yt** when the telescope is pointing at the positive pole.
    - ✓ The units of **rdome**, **xm**, **ym**, **zm**, **xt**, **yt**, **xo** and **yo** must all be the same.
    - ✓ The dome azimuth/elevation coordinate system follows the normal convention. Azimuth increases clockwise from zero in the north, through 90 degrees (pi/2 radians) in the east. The value returned is in the range zero to 2π. At the zenith, zero is returned.
    - ✓ Small "pointing corrections", minor non-perpendicularities and misalignments, are ignored.

Dome Commands

Select the ***Dome*** command from the ***Display*** menu to show the Dome window. This window is normally “docked” to the left side of the Sky Chart, but can be positioned elsewhere by dragging the caption.

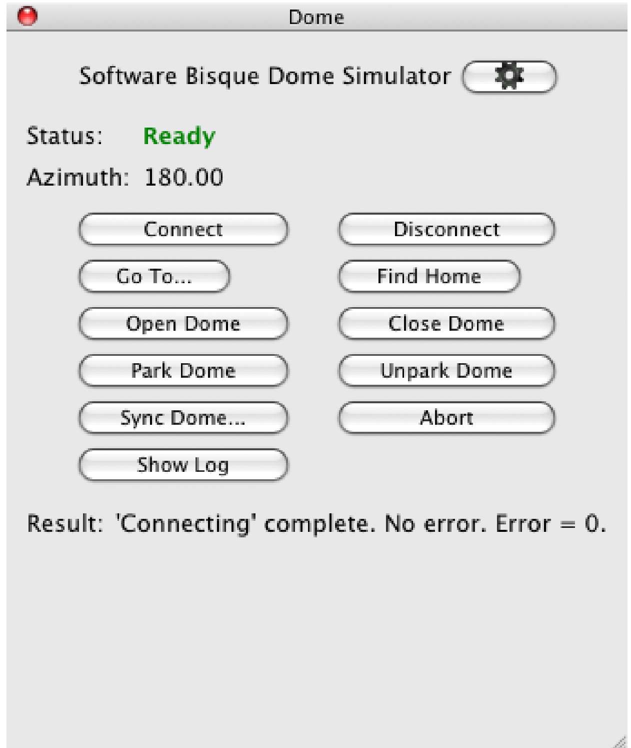


Figure 267: The Dome commands window (Dome window, Display menu).

Dome Driver Name

The name of the currently selected dome driver is listed at the top of the ***Dome*** window.

Dome Commands Pop-up Menu

Click this button to display the Dome-specific settings on the Imaging System Setup window.

Status

Shows the current status of the dome connection.

Azimuth

Shows the current azimuth of the dome opening.

Connect

Click this button to establish communication with the dome controller.

Disconnect

Click this button to terminate communication with the dome controller.

Go To

Click this button to enter the azimuth to position the dome opening.

Find Home

Click this button to locate the dome's home position.

Open Dome

Click this button to open the dome shutter.

Close Dome

Click this button to close the dome shutter.

Park Dome

Click this button to send the dome to its park position.

Unpark Dome

Click this button to perform any necessary initialization when starting up the dome for the night.

Sync Dome

Click this button to synchronize the dome opening to a specific azimuth.

Abort

Click this button to terminate in any dome command that is currently in progress.

Result

Shows the result of the dome command that is reported by the dome controller hardware.

Appendix A: Databases and Cross References

TheSkyX Professional Edition and *Serious Astronomer Edition* include databases of celestial objects from the standard astronomical catalogs listed in the tables below.

If you want to use a specific set of databases, select the ***Database Manager*** command from the ***Input*** menu to turn any catalog on or off.

Star Catalogs

The Hipparcos-Tycho Catalogs are the primary stellar databases used to display information by *TheSkyX* for stars to about 12th magnitude and brighter.

TheSkyX also cross-references stars from the following catalogs.

- Bayer/Flamsteed Designations
- Smithsonian Astrophysical Observatory Catalog (SAO)
- Positions and Proper Motion Catalog (PPM)
- Henry Draper Catalog (HD)

Star Catalog Name	Details/Object Count
Hipparcos/Tycho Stellar Catalog	1.2 million stars, complete to 12th magnitude
Hubble Guide Star Catalog (GSC) Version 1.2	19 million stars, complete to about 14th magnitude
General Catalog of Variable Stars (GCVS)	40,214 variable stars
New Suspected Variable Star Catalog (NSV)	13,490 suspected variable stars
Struve Double Star Catalog	4,307 double stars
Washington Catalog of Double Stars (WDS)	102,139 double stars

Non-Stellar Catalogs

Non-stellar Catalog Name	Details/Object Count
Historically Corrected New General Catalogue (HCNGC) from the NGC/IC Project*	7,840 non-stellar objects
Index Catalog (IC) from the NGC/IC Project*	5,382 non-stellar objects
Catalog of Principal Galaxies (PGC 2003)	900,000 galaxies
Catalog of Principal Galaxies (PGC 2011)	1,670,818 galaxies
PK Planetary Nebula Catalog (PLN)	1,455 planetary nebulae
Tomm Lorenzin 2000+ Catalog	2,088 non-stellar objects

Non-stellar Catalog Name	Details/Object Count
Herschel Catalog	400
Caldwell Catalog	109
Messier Catalog (M)	110
Saguaro Astronomy Club (SAC) Database	10,580

*The HCNGC and IC catalog is used with permission of The NGC/IC Project LLC - http://www.ngcic.org – please contact Bob Erdmann at *hcngc at ngcic dot org* for questions or clarifications regarding this astronomical catalog.

Additional Sky Databases (SDBs)

TheSkyX includes the following additional astronomical catalogs that can be displayed on the Sky Chart. From the ***Input > Database Manager*** window, navigate to the ***Sky Databases (SDBs) > Optional Databases*** node in the ***Databases*** list to turn them on or off.

Catalog Name	Search Prefix	Object Count	Object Type
1.4 GHz Northern Sky	1-4ghz	31524	Reference Point
6C Survey of Radio Sources	6CSRSI	1761	Radio Source
6C Survey of Radio Sources II	6CSRSII	8278	Radio Source
6C Survey of Radio Sources III	6CSRSIII	8749	Radio Source
6C Survey of Radio Sources IV	6CSRS-IV	5421	Radio Source
6C Survey of Radio Sources V – A	6CSRS-VA	2229	Radio Source
6C Survey of Radio Sources V – B	6CSRS-VB	1229	Radio Source
6C Survey of Radio Sources VI	6CSRS-VI	6752	Radio Source
Abell–Zwicky Clusters of Galaxies	AGC	2712	Cluster of Galaxies
Abell Planetary Nebulae	APN	86	Nebula
Ackerman Red Stars	ARS	267	Reference Point
APM Bright Galaxy Catalogue	APM	14681	Galaxy
Arp Globular Clusters	Arp-GC	43	Globular Cluster

Catalog Name	Search Prefix	Object Count	Object Type
Arp Peculiar Galaxies	ARP-PG	38	Galaxy
Barnard's Dark Nebulae	Barnard	349	Dark Nebula
Bright Nebulae Drawings (TMB)**	TMB-BN	25743	Bright Nebula
Catalog of Bright Galaxies	CBG	4364	Galaxy
Celestron NexStar Doubles	CND	55	Double Star
Cepheids in the Large Magellanic Cloud	LMC-CV	97	Variable Star
Cluster System of the Large Magellanic Cloud	LMC-CL	1762	Mixed Deep Sky
Cool Galactic Carbon Stars	CCS	5987	Reference Point
Cousins Photometric Standards	CPS	670	Reference Point
Culled Henden CI Labels	HC-L	0	Reference Point
Dark Nebulae Isophotes TMB**	DND	650	Dark Nebula
Declination Zero		51	Reference Line
Declination Zero Label		13	Reference Point
DeepMap 600		470	Reference Point
Don Macholtz Messier Marathon	Macholtz	110	Target Object
Double Stars with common names		169	Double Star
Einstein Observatory Ex M-S Survey	EMSS	835	X-Ray Source
Feitzinger Dark Nebula	FZ-DN	489	Dark Nebula
Feitzinger Globules	FG	331	Reference Point
Florsch - Small Magellanic Cloud Stars	SMC-Florsch	584	Reference Point
G2 V Stars from SIMBAD Query	G2V	688	Reference Point
Galactic Globular Clusters – Monella	GC-Monella	160	Globular Cluster
Galactiglob Galaxies	TJ-GG	2495	Galaxy
Galaxy Isophote M51 Example	BSR-GI	902	Galaxy
Hickson Compact Groups of	Hickson	463	Galaxy

Catalog Name	Search Prefix	Object Count	Object Type
Galaxies			
Hickson Compact Groups of Galaxies – Group Identifier	HGG	100	Cluster of Galaxies
Hickson Compact Groups of Galaxies – Labels	<none>	463	Galaxy type
Heinz Nebula Small Magellanic Cloud	HN	117	Nebula
Henden 3C	H3C	504	Reference Point
Herbig-Haro Objects	HH	454	Reference Point
HW Clusters Large Magellanic Cloud	HW-SMC	87	Globular Cluster
IRAS 1.2 Jy Redshift	IRAS-1.2	9899	Galaxy
IRAS Small Scale Structure	IRASS	16740	Reference Point
Kron Clusters Small Magellanic Cloud	SMC-KRON	69	Globular Cluster
Landolt Faint Photometric Standards	LFPS	526	Reference Point
Landolt Photometric Standards	LPS	1154	Reference Point
Landolt Photometric Standards South	LPS-S	109	Reference Point
Lindsay Clusters Small Magellanic Cloud	SMC-L	118	Globular Cluster
Lynds' Bright Nebulae	LBN	1053	Bright Nebula
Lynds' Dark Nebulae	LDN	1791	Dark Nebula
Meade Alignment Star Labels	MAS	78	Reference Point
Michael Covington Deep Sky Objects	COV	200	Mixed Deep Sky
Milky Way Globular Clusters	MW-GC	150	Globular Cluster
Molonglo Reference - Radio Sources	Molongo Radio	12141	Radio Source
Navigational Stars	NavStar	58	Reference Point

Catalog Name	Search Prefix	Object Count	Object Type
NB Carbon Stars – Skiff	NBC	211	Reference Point
Nebulae in the Magellanic Clouds – HII	LMC-HII	358	Nebula
NGC and IC objects UNKNOWN magnitudes		982	Mixed Deep Sky
NGC Max Alignment Stars – JMI	JMI	30	Star
Objects in the Direction of the SMC	SMC-B	965	Reference Point
Open Cluster Data Fifth Edition (Lynga 1987)	OC-L	1151	Open Cluster
Palomar Globular Clusters	PAL	15	Globular Cluster
Palomar Sky Survey - 102 CD labels	DSS-102	0	Reference Point
Palomar Sky Survey Plates Additional Data	POSS	1037	Reference Point
Parkes Radio Sources	PKS90	8264	Radio Source
Planetary Nebulae in LMC	LMC-PLN	169	Planetary Nebula
Pulsars (Taylor+ 1993)	PULSARS	558	Radio Source
Query Common Non-Stellar		329	Mixed Deep Sky
RealSky CD's North Labels	RealSky-N	765	Reference Point
RealSky CD's South Labels	RealSky-S	800	Reference Point
RealSky North & South Labels	RealSky-NS	658	Reference Point
Redshift Galaxies	RG	12844	Galaxy
Rich Clusters of Galaxies (North)	RC-GN	2712	Cluster of Galaxies
Rich Clusters of Galaxies (South)	RC-GS	1364	Cluster of Galaxies
Roslund Red Stars in Scorpious	RR	69	Reference Point
Seyfert Galaxies	Seyfert	121	Galaxy
Shapley-Ames Bright Galaxies	SA-BG	1246	Galaxy
Sharpless H II Regions	SH2-	313	Nebula
Skiff North Bright Standards	BK-NBS	119	Reference Point
Southern hemisphere H-alpha	RCW	14	Nebula

Catalog Name	Search Prefix	Object Count	Object Type
emission regions (Rogers+ 1960)			
Southern hemisphere H-alpha emission regions (Rogers+ 1960) Labels	<none>	14	Label
Star Clusters and Associations	SCA	1039	Open Cluster
Stars in the Double-Double	DDS	2	Star
Supernova Remnants – Green	SNR-G	231	Supernova
Terzan Globular Clusters	Ter	11	Globular Cluster
Third Catalogue of Nearby Stars	CNS3	3802	Reference Point
Trapezium Circumstellar disks	TCD	149	Reference Point
Trapezium ROSAT PSPC	Trap-XRay	171	X-Ray Source
Trapezium Stars – TMB**		14	Star
Trapezium Stars VizieR	Trap-Vzr	292	Reference Point
Trumpler Clusters	Tr	34	Open Cluster
Trumpler Stars	Tr-S	39	Reference Point
UV-Excess Galaxies	UVG	8162	Galaxy
Van Den Berg Reflection Nebulae	Vdb	158	Nebula
Video Calibration Stars	VCS	958	Target Object
W-G Clusters Small Magellanic Cloud	WG	18	Globular Cluster
X-ray source	1RXSJ	108	Galaxy
Yale Bright Star Catalog First Half	YBSC-1	4991	Star
Yale Bright Star Catalog Second half	YBSC-2	4105	Star

*TMB indicates this optional SDB was created or compiled by Thomas M. Bisque.

Solar System Objects

Group	Objects in Group	Number of Objects
Sun, Planets, Moons	Sun Mercury Venus Earth Earth's Moon Mars Jupiter Io Ganymede Europa Callisto Saturn Enceladus Mimas Tethys Dione Rhea Titan Hyperion Iapetus Uranus Neptune	22
Small Solar System Bodies	Pluto	1
	Comets	Up to 1000 at once.
	Asteroids (Minor Planets)	Every known asteroid (Orbital elements are updated from the web.)
Artificial Satellites	Updated from the web via the *Input > Satellites* command.	Up to 10,000 two-line elements (TLEs) can be imported and updated from the web when *TheSkyX* is launched.

Photographs

Photos Database	Details
Anglo-Australian Observatory Photos	172 color photos from the David Malin collection of AAO images.
Deep-sky Overlays	127 photos that appear on the Sky Chart.
Hubble Photos	314 color photographs from the Hubble Space Telescope.
Messier Overlays	104 color photographs.
Non-stellar objects	53 color photographs of non-stellar objects.
Solar System Photos	255 color photographs of the solar system objects.

Digitized Sky Survey thumbnails	100,000 grayscale photos from the Digitized Sky Survey.

Catalog Cross References

TheSkyX includes cross references the following catalogs. Use the ***Find*** command on the ***Edit*** menu to locate any object in these catalogs.

Cross-Referenced Catalogs	Prefix	Object Count
2MASS Galaxies	2MASXJ	–
2MFGC Catalog	2MFGC	–
6dFJ	6dFJ	–
Abell	ABELL	–
Abell 1644	ABELL_1644	145
AGC	AGC	–
AM	AM	–
Antila Group	Antila Group	–
Arakelian Catalog of Galaxies	ARK	591
Arp	ARP	–
Bayer/Flamsteed Designations	n/a	–
Bonner Durchmusterung Number	B+nn nnnnn	–
BTS	BTS	–
Caldwell Catalog	Caldwell + Cn	109
Cape Durchmusterung Number	P-nn nnnn	–
Catalog of Galaxies and Clusters of Galaxies	CGCG	29,809
Catalog of Galaxy Groups	KDG	253
Catalog of Isolated Pairs of Galaxies	KCPG	–

Cross-Referenced Catalogs	Prefix	Object Count
CGMW	CGMW	–
Common Non-Stellar Object Names	name of object	–
Common Star Names	name of object	–
Compact Groups of Galaxies	2DFGRSN	–
Constellations	name of constellation	88
Cordoba Durchmusterung	C-nn nnnnn	–
David Dunlap Observatory Catalog of Galaxies	DDO	242
DDO	DDO	–
Dorado Group	DORADO_GROUP	–
DRCG	DRCG	–
DUKST	DUKST	–
EDCC	EDCC	–
European Southern Observatory (Southern objects)	ESO	16,239
Fairall Catalog of Galaxies	FAIR	1,185
FCC	FCC	–
FCCB	FCCB	–
FGC	FGC	–
FGCE	FGCE	–
FM	FM	–
Galaxy Identification Number	GIN	795
GIN	GIN	–

Cross-Referenced Catalogs	Prefix	Object Count
GMP	GMP	–
Groups of Galaxies	2DFGRSS	–
HCG	HCG	–
Henry Draper Number	HD	359,083
Hickson Compact Galaxy Groups	HCG	450
HIPASSJ	HIPASSJ	–
HRG	HRG	–
HSTGC	HSTGC	–
IC (PGC 2011 Cross Reference)	IC	–
IISZ	IISZ	–
Infrared Astronomical Survey	IRAS	9,347
ISZ	ISZ	–
Karachentseva Catalog of Galaxies	KARA	183
Kazaryan UV Galaxies	KAZ	581
KDG	KDG	–
KIG	KIG	–
Kiso UV Galaxies	KUG	5,455
KKH	KKH	–
KPG	KPG	–
KUG	KUG	–
LCRSB	LCRSB	–
Leo Group	LEO_GROUP	–

Cross-Referenced Catalogs	Prefix	Object Count
LGG	LGG	–
MCG	MCG	–
Messier Catalog	M	110
MRK	MRK	–
NFPJ	NFPJ	–
NGC (PGC 2011 Cross Reference)	NGC	–
NPM	NPM	–
NRGb	NRGb	–
NRGs	NRGs	–
PDFJ	PDFJ	–
PGC (PGC 2011 Cross Reference)	PGC	–
PKS	PKS	–
Positions and Proper Motions Number	PPM	-
POX	POX	–
RKK	RKK	–
SBS	SBS	–
SDSSJ	SDSSJ	–
Second Byurakay Survey	SBS	259
Smithsonian Astrophysical Observatory Catalog (SAO)	SAO	258,997
SRGb	SRGb	–
SS	SS	–
Struve Catalog	STRUVE	3,100

Cross-Referenced Catalogs	Prefix	Object Count
Tololo Galaxies	TOL	111
UCG	UCG	–
UCGA	UCGA	–
University of Michigan Catalog of Galaxies	UM	652
LGS	LGS	5
Uppsala General Catalog of Galaxies	UGC	13,073
VCC	VCC	–
Virgo Cluster Catalog of Galaxies	VCC	2097
VV	VV	–
Weinberger Catalog of Galaxies	WEIN	207
WINGSJ	WINGSJ	–
WKK	WKK	–
WMMA	WMMA	–
ZOAG	ZOAG	–
Zwicky1	1ZW	238
Zwicky2	2ZW	199
Zwicky3	3ZW	159
Zwicky4	4ZW	203
Zwicky5	5ZW	531
Zwicky6	6ZW	238
Zwicky7	7ZW	1,145
Zwicky8	8ZW	645

Cross-Referenced Catalogs	Prefix	Object Count

Ephemeral Data

TheSkyX can display the positions of comets and minor planets and man-made satellites. The orbital element data required to *accurately* display these objects changes frequently and can be updated from *TheSkyX* using different sources on the worldwide web.

The table below lists the sites the *TheSkyX* uses to update this information.

Object Type	**Object Count**	**Web Site Address to Obtain Updated Orbital Element Data**
Comets	Up to 1000	http://www.minorplanetcenter.net/iau/MPEph/MPEph.html
Satellites	Up to 10,000	http://celestrak.com
Asteroids (Large Database)	All known asteroids	http://asteroid.lowell.edu

TheSkyX Professional Edition-Specific Databases

PROFESSIONAL

In addition to the databases listed above, *TheSkyX Professional Edition* includes optimized versions of the UCAC3 and UCAC4 star catalogs with approximately 30 million stars each.

TheSkyX Professional Edition Database Add On

Software Bisque sells an optional set of astronomical catalogs for TheSkyX Professional Edition in a product name *TheSkyX Professional Edition Database Add On*. Distributed on a hard drive, it contains 200 GB of native star catalogs, the Software Bisque-optimized UCAC star catalog and the complete Palomar Digitized Sky Survey at your disposal.

Catalog Name	Number of Stars	Approximate Size (GB)
Native NOMAD Catalog and related files.	1.1 billion	100
Software Bisque NOMAD plot files.	800 million	40
Native UCAC3 Catalog and related files.	100,766,420	8
Small TheSkyX Pro-specific UCAC3 plot file.	30 million	0.8
Large TheSkyX Pro-specific UCAC3 plot file.	100 million	2
Native UCAC4 Catalog and related files and folders.	113 million	8
Small TheSkyX Pro-specific UCAC4 plot file.	30 million	0.85
Large TheSkyX Pro-specific UCAC4 plot file.	113 million	2.7
Digitized Sky Survey (10x compression).	Photographic data for the entire celestial sphere	60
Total		222

These databases can be accessed from TheSkyX Professional Edition for Mac or TheSkyX Professional Edition for Windows.

Packing List

TheSkyX Professional Edition Database Add On includes the following items:

Quantity	Description
1	250 GB USB 2.0 hard drive
1	Mini-USB cable
1	Carrying case

Figure 268: TheSkyX Database Add On Contents

The USB drive and cable are shipped inside the carrying case.

Getting Started

After unpacking the drive and cable from the shipping box, the next step is to plug the USB drive into your computer. The following procedure applies to Mac or Windows.

1. Plug the mini USB end of the supplied USB cable into *TheSkyX Professional Edition Database Add On* mini USB port.

Figure 269: Plug the Mini USB end of the cable into the mini-USB port.

2. The mini USB cable has a *primary* USB connector and a *secondary* USB connector (to apply additional power to the hard drive if necessary). See Figure 270. Plug the ***primary*** USB connector on the USB cable into a free USB port on your computer.

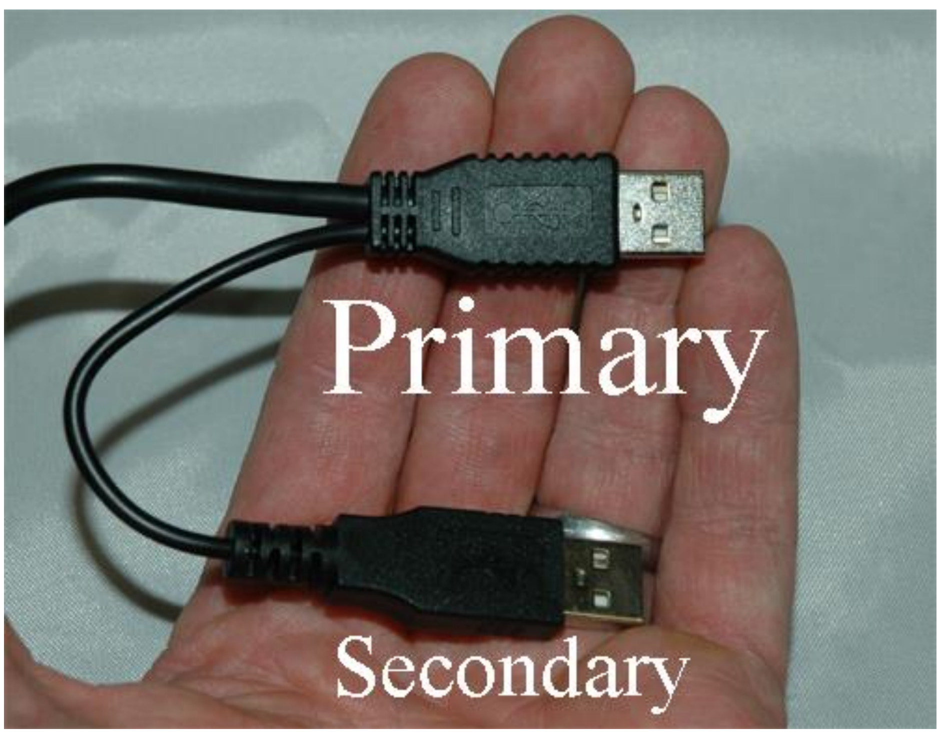


Figure 270: Plug the *primary* USB connector into the computer's USB port.

Troubleshooting

If you encounter any difficulties accessing the contents of the drive, please read the following section before contacting Software Bisque technical support.

We make every effort to ensure that your USB drive is ready to go out of the box by replicating and testing every drive at our facilities before boxing them for shipment.

TheSkyX Pro Database Add On hard drive can normally be powered using the primary USB connector only, so the secondary USB connector, or an external power supply, is not needed.

If the drive light does not illuminate when you plug in the primary USB connector, or the drive is not recognized by your operating system:

- Double check that you have plugged in the *primary USB connector*, not the secondary USB connector. See Figure 270.
- Make sure the computer is plugged in to an electrical outlet. Battery powered laptop and Netbook computers normally do not supply power to USB ports when the computer is powered using only the battery.
- If the drive light still does not turn on, or your OS does not recognize the volume (Mac) list the drive in Explorer (Windows) after 30 seconds or so, try plugging the secondary connector into a free USB port to supply additional power to the drive.

If, after carefully following the above recommendations, the drive light still does not illuminate, then the internal *hard drive unit* may have become unseated from the *hard drive controller* during shipment (or if the drive was jarred or dropped). Reseating the drive into the drive controller is a straightforward procedure.

To reseat the hard drive to the hard drive controller:

1. With the mini USB connector side of the drive case pointed away from you, turn the drive over, remove the back cover and place the case on a flat surface.
2. Push the hard drive toward the mini USB connector. The best way to accomplish this is to place both thumbs on the end of the drive near the foam spacer, and both middle fingers on the outside of the case, then squeeze both hands using equal pressure. (See Figure 271.)
3. Replace the back cover.

Figure 271: Finger placement to properly reseat the hard drive in the hard drive controller. (Photographer's right hand is holding the camera.)

The drive should now operate normally.

Windows AutoPlay

If your computer is configured to run AutoPlay when a USB drive is plugged in, the following AutoPlay window appears:

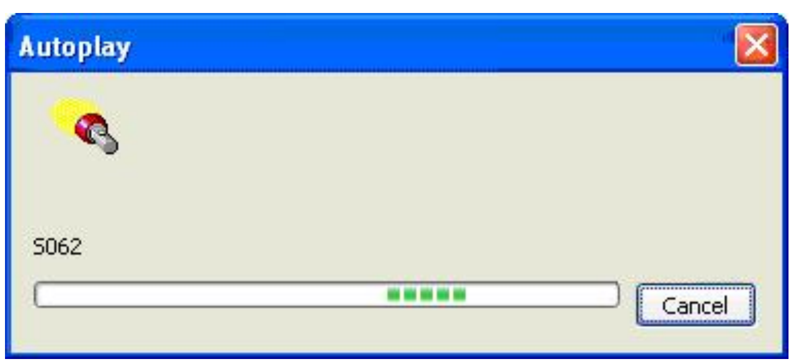


Figure 272: The Windows XP AutoPlay window.

Click ***Cancel*** to prevent Windows from scanning the 1.2 million files on the drive.

Accessing TheSkyX Pro Database Add On Catalogs

Configuring *TheSkyX Professional Edition* to use the *Database Add On* star catalogs and photos from Digitized Sky Survey is simple.

1. Launch TheSkyX Professional Edition.
2. From *TheSkyX Pro*, select the **Database Manager** command from the **Input** menu.
3. In the list of databases, expand the **Database Add On** node, then highlight the **Database Add On Root**.
4. Click the **Choose Folder** button.
5. Select the volume name (Mac) or drive letter (Windows) for the drive and click the **Choose** button. The **Property** table should now show the location of the files on the Database Add On hard drive.
6. Click **Close**.

The Sky Chart can now show all the stars from the UCAC3, UCAC4 and NOMAD star catalogs at small fields of view.
When the ***Disc Or Other Drive*** option is turned on from the ***Create Photo*** tab on the ***Digitized Sky Survey*** dialog (***Tools*** menu), photos from the Digitized Sky Survey will be retrieved from the hard drive when the ***Show Digitized Sky Survey Photo*** command is selected from the ***Tools*** menu.

Copying Database Add On to another Drive

The files and folders on *TheSkyX Professional Edition Database Add On* hard drive are not copy protected, and can by moved to, or copied to a different hard drive (subject to the Copyright Notices below).
If you want to copy the databases to a different drive, make sure to copy the entire contents of *TheSkyX Professional Edition Database Add On* drive to the second drive, then configure *TheSkyX Pro* accordingly (see “Accessing TheSkyX ” on page 525).

Copyright Notices

TheSkyX Professional Edition Database Add On is a compilation of copyrighted astronomical catalogs from various sources. Please carefully read the copyright information below.

TheSkyX Professional Edition Optimized UCAC and NOMAD Catalogs

The large and small *TheSkyX Professional Edition-specific plot files* included on *TheSkyX Pro Database Add On* hard drive are copyright Software Bisque. They are licensed to you for private, non-commercial use with TheSkyX Professional Edition and cannot be redistributed.

Palomar Sky Survey

The data supplied in the Palomar folder is licensed under agreements between the Association of Universities for research in Astronomy, Inc (AURA), the UK Astronomy Technology Centre, ROE and Software Bisque, Inc.

This dataset is distributed for scientific and educational use, primarily to amateur astronomers and educational institutions. ***Redistribution of this dataset is prohibited without explicit permission from STScI and ROE.***

UCAC and NOMAD Catalogs

This catalog contains data from a diverse collection of photographs, reductions, and catalogs. A large number of different organizations claim copyright and/or intellectual property rights on the various components. Although the details differ, all permissions for usage of data are contingent on unrestricted access. Distribution and/or other direct costs can be recovered, but re-packaging, re-formatting, or similar activities, especially for commercial purposes, are not permitted except as authorized by the U. S. Naval Observatory in consultation with the other institutions listed below and as appropriate.

1. Palomar Observatory, National Geographic Society, and California Institute of Technology own Palomar Observatory Sky Surveys I and II.
2. European Southern Observatory.
3. The UK Particle Physics and Astronomy Research Council (formerly Science and Engineering Research Council and before that Science Research Council).
4. The Anglo-Australian Telescope Board.
5. The Hipparcos and Tycho Teams on behalf of the European Space Agency.
6. Space Telescope Science Institute on behalf of AURA, Inc. and NASA.
7. U.S. Naval Observatory on behalf of the U. S. Government. USNO claims domestic and international copyright protection for the digitized images, the data reduction, catalog compilation, and all other aspects of the derived products.

When using data from this catalog, please acknowledge the source of the data, and if appropriate, please include a specific citation.

Database Add On Hard Drive Warranty Information

Software Bisque warrantees all product media for 30 days from the date of purchase and will replace it free of charge (please return defective media to Software Bisque). Proof of purchase is required for warranty replacements.

Backing Up the Databases

As with all removable media, Software Bisque *strongly recommends* that you make a backup copy of the contents of the Database Add On hard drive.

Appendix B: Migrating from TheSky6 to TheSkyX

If you are familiar with *TheSky6*, please review the table of changes below to ease the transition to *TheSkyX*.

Terminology Changes

This phrase or command in TheSky6…	**Is now this in TheSkyX…**
Chart Mode	Map Like option, Display menu, page 202.
Comets/Minor Planets/Extended Minor Planets	Small Solar System Bodies command, page 198.
Data Menu	Input Menu.
Data Wizard	Advanced Query, page 231.
Data Wizard Results	Observing List, page 230.
Daytime Sky Mode	Show Daylight, page 46.
Display Explorer	Chart Elements, page 192.
Display Properties	Chart Attributes, page 192.
Eclipse Finder	Solar & Lunar Eclipse Viewer, page 150.
Extended Labels	Detailed Labels, page 64.
Extended Minor Planets	Asteroids (Large Database), page 199.
Image Groups	Place Photos, page 77.
Image Link and Sync	Synchronize on an Image Link photo, page 297
Image Manager (Data Menu)	Place Photo, page 77.
Images	Photos, page 74.
Import command	Create Sky Database command, page 220.

This phrase or command in TheSky6…	Is now this in TheSkyX…
Mapping/Map Points	Pointing Calibration/Pointing Samples. See the TPoint Add On User Guide for details about pointing calibration.
Minor Planets	Asteroids, page 199.
Mirror Image	Show Mirror Image, page 40.
Moon Phase Calendar	Calendar, page 107.
Moon Viewer	Moon Photo Viewer, page 137.
N/E Indicator	Celestial North Arrow (Chart Elements window, page 192).
Night Vision Mode	Show Night Vision Mode.
Options command	Preferences (Tools Menu, Windows) page 163.
Pole Up	Celestial Sphere, Orientation menu, page 38.
Print Preview	Export Chart, page 132.
Real Mode Options	Horizon & Atmosphere Options, page 208, and Milky Way Options, page 214.
Sky Database Manager	Database Manager, page 216.
Sky Display	Sky Chart, page 30.
Sky Document	Sky Chart Settings, page 46.
Sky View Preferences	Chart Element Attributes, page 192.
Stellar & Solar System Update Frequency	Target Frame Rate, page 185 . Solar system object updates now occur *30 times per second* by default, rather than *once every 5 minutes* as did TheSky6.
Sun & Moon Report	Reports, page 117.
Sync command	Startup pop-up menu on the Telescope window (Display menu), page 295.

This phrase or command in TheSky6…	Is now this in TheSkyX…
Use Computer's Clock	Computer Clock, page 183.
User-Defined Data	My Chart Elements, page 227.
User-Defined Object Types	My Object Types, page 40.
View Menu	Display Menu.
Virtual Sky Mode	Photo Like, page 202.
Zenith Up	Terrestrial Sphere Orientation, page 119.

TheSky6 Feature	Equivalent TheSkyX Feature
Changing Font Colors	Edit the Attributes of Chart Elements (page 192).
Defining Telescope Limit Lines	Click the ***Telescope Limits*** command from the ***Telescope*** menu.
Edit or Draw the Local Horizon	Click the ***Horizon & Atmosphere*** command on the ***Display*** menu. Click the ***Horizon*** tab. Select the ***Custom Drawn*** option in the ***Horizon Type*** list.
Object Tips (Tool Tips)	Click the ***Preferences*** command from the ***Tools*** menu (Windows) or ***TheSkyX*** menu (Mac). Click the ***Report Setup*** icon. Select ***Tool Tips*** from the ***Report*** list. Turn on the desired ***Object Properties*** to appear in the tool tip.
Right-click to drag the screen	*Left-click* the mouse to drag the Sky Chart.
Setting the Upper and Lower Magnitude Limits	Setting the magnitude limit, page 126.
Showing Labels (common labels and extended labels) on Sky Chart	Labels (for *common names* and *detailed labels*) are located on the Labels window. Click ***Labels*** command on the ***Display*** menu to show this window.
Showing Reference Lines and Reference Photos, including: Constellation Figures	Reference lines can be turned on or off from the ***Chart Elements*** window (page 205).

TheSky6 Feature	**Equivalent TheSkyX Feature**
Constellation Drawings Constellation Boundaries Galactic Equator Milky Way Equatorial lines (equatorial grid and North/East Indicator) Horizon Ecliptic Telescope Limit Lines Horizon-based lines, including the local horizon, refracted horizon, meridian and horizon grid Local Horizon Fill Color	
Zoom Box	Press and hold the SHIFT key while dragging the mouse on the Sky Chart to create a zoom box.

TheSky6 and TPoint for Windows Settings

TheSky6 can open and save a variety file formats. The follow section describes each format and how to transition your existing data to *TheSkyX*.

Sky Documents

- By default, *TheSkyX* uses your computer's IP address to determine your location. *TheSkyX* also has a ***To Google Map*** option that can be used verify and refine your location. If you have the GPS coordinates of your observing site, then you can enter them manually, as well as your time zone, from the ***Input > Location > Custom*** tab (page 33).
- *TheSkyX* uses the computer's local time by default. See "Entering the Date and Time (Date & Time Control)" on page 111 for details how to set a specific date and time.

Field of View Indicators

- TheSky6 stores your custom field of view indicators in a text file named Field of View Indicators.txt in the folder named <My Documents>\Software Bisque\TheSky6\Field of View Indicators.

TheSkyX also stores FOVIs in a text file of the same name, but in the folder named *<My Documents>\Software Bisque\TheSkyX Professional Edition\Field of View Indicators*. The format of TheSky6's *Field of View Indicators.txt* text file the same as *TheSkyX*. So, you can copy TheSky6's *Field of View Indicators.txt* to *TheSkyX's* folder to preserve your FOVIs.

Telescope Configuration

- Telescope-configuration is a manual process. You'll need to manually set the telescope and the telescope settings (telescope type, COM port, limit settings, etc.) from *TheSkyX*.
- Use TheSky6 to park the telescope. Then connect to the telescope from *TheSkyX* and, without slewing the telescope, on the Telescope window, from the Shut Down pop-up menu, configure *TheSkyX's* park position by clicking the ***Set Park Position*** command (page 294).

TPoint for Windows Settings and Models

Important Note: TPoint for Windows is not compatible with TheSkyX Professional Edition. TheSkyX Professional Edition instead now offers the integrated TPoint Add On.

- In *TheSky6*, the *TPoint for Windows* model is saved as part of the Sky Document (.SKY) document. *TPoint for Windows* is a separate application. In *TheSkyX*, the can be purchased as an "Add On" but is an integrated component and is accessed by clicking the Telescope > TPoint Add On command at any time (there's a 90 day free trial period to use the TPoint Add On).

To transfer an existing TPoint for Windows model to TheSkyX Pro and the TPoint Add On

1. From *TheSky6*, open the TPoint document by right-clicking on the TPoint icon, and then click *Open*. This launches *TPoint for Windows* and opens the .TPT document with the model.
2. From *TPoint for Windows*, click the ***Export*** command from the ***File*** menu, then enter a name for the text file that will hold your exported mapping data. This "pointing data" can be imported into the *TPoint Add On*.
3. From *TheSkyX*, click the *TPoint Add On* command from the ***Telescope*** menu.
4. From the *TPoint Add On* ***Setup*** tab, select the ***Import*** command from the ***TPoint Add On Settings*** pop-up menu.
5. Select the text file name that holds the TPoint for Windows pointing data and then click ***Open***.

The *TPoint Add On* now has your pointing data, and you can turn on the desired terms for your model. A *recalibration* will be required to restore the CH, IH and ID terms (the telescope's "synchronization" information). See the TPoint Add On User Guide for more information about recalibration

Comets/Asteroids/Satellites

- The latest orbital elements and two-line elements TLEs for these objects will need to be downloaded from *TheSkyX*. See page 149 for details.

Sky Databases

A folder of *TheSky6* SDBs can be converted to *TheSkyX*-compatible Sky Database format (.SDBX) from the ***Advanced*** tab of *TheSkyX*'s ***Database Manager*** (page 218).

Importing Photographic Horizons

If you have created a photographic horizon for TheSky6 for Windows and want to show it in TheSkyX do the following:

1. Open the tagged image format (.tif) photograph from *TheSky6 for Windows* in your favorite image processing software.
2. Save the photo as a PNG (see "Tips for Creating Panorama Photos" on page 211).
3. Copy the PNG photo to the appropriate folder and select it as the current panoramic horizon (see "Selecting the Panorama Photo" on page 211).

In TheSky6, the orientation of the photographic horizon relative to the local horizon is stored in a file with the extension <Horizon Name>.horizon. If you wish to maintain this position for the same photograph in TheSkyX, do the following:

1. Manually copy *TheSky6's* <Horizon Name>.horizon file for the particular photo into the *Horizons* folder (see "Selecting the Panorama Photo" on page 211).

When the panoramic horizon is selected in *TheSkyX*, the appropriate horizon photo options are set based on the contents of the <Horizon Name>.horizon file, so that the photo is oriented correctly.

Importing Custom Drawn Horizons

TheSkyX can display custom-drawn horizons that were created in TheSky6. TheSky6's custom drawn horizon data must be saved in a TheSkyX-compatible format first.

Here's how:

1. Launch TheSky6.
2. Choose the ***Reference Lines*** command from the ***View*** menu.
3. Click the ***Edit Local Horizon*** button to show the ***Horizon Editor*** window.
4. On the ***Horizon Editor*** window, click the ***Copy*** button to copy the horizon's azimuth and altitude positions to the Clipboard.
5. Launch Windows Notepad.
6. From Notepad, type the number 360 and press the Enter key.
7. From Notepad, choose the ***Paste*** command from the ***Edit*** menu.
8. From Notepad, choose the ***Save As*** command from the ***File*** menu.
9. On the ***Save As*** window, navigate to *TheSkyX's* Application Support Files Folder (see page 25).
10. In the ***File Name*** text box of the ***Save As*** window, type the name `custom horizon.hrz` and click the ***Save*** button.

When TheSkyX is launched, and ***Custom Horizon*** is selected in the ***Horizon Type*** pop-up menu on the ***Horizon*** tab of the ***Horizon and Atmosphere Options*** window (Display menu), this custom horizon exported from TheSky6 will appear.

Appendix C: Daylight Saving Time

The following table lists the international Daylight Saving Time (DST) starting and ending dates that *TheSkyX* uses to determine when DST begins and ends.

The Time Zone options are found in the Daylight Saving Option (DSO) pop-up.

Time Zone	DST Starts	DST Ends	Adopting Countries
Australia-NSW	Last Sunday of October	Last Sunday of March	Australia (Australian Capital Territory, Lord Howe Island, New South Wales)
Australia-South	Last Sunday of October	Last Sunday of March	Australia (Broken Hill NSW, South Australia, Victoria)
Brazil	Third Sunday of October	Third Sunday of February	Brazil
Chile	Second Sunday of October	Second Sunday of March	Chile
China	Third Sunday of April	Second Sunday of September	China
Cuba	First Sunday of April	Second Sunday of October	Cuba
Egypt	First Day of May	First Day of October	Egypt
Europe	Last Sunday of March	Last Sunday of October	Albania, Andorra, Austria, Belarus, Belgium, Bosnia Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Faroe Islands, Finland, France, Georgia, Germany, Gibraltar, Greece, Greenland (Scoresbysund), Hungary, Italy, Kazakhstan, Latvia, Lebanon, Lithuania, Luxembourg, Macedonia, Malta, Monaco, Mongolia (Ulan Bator),

Time Zone	DST Starts	DST Ends	Adopting Countries
			Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, San Marino, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, Yugoslavia
Falkland Islands	Second Sunday of September	Third Sunday of April	Falkland Islands
Greenland	Last Sunday of March	Fourth Sunday of September	Greenland (except Scoresbysund and Thule)
Iran	21st Day of March	21st Day September	Iran
Israel	Last Friday of March	Last Sunday of August	Israel
Jordan	First Friday of April	Third Friday of September	Jordan
Kyrgyzstan	Second Sunday of April	Last Sunday of September	Kyrgyzstan
Moldova	First Sunday of March	Last Sunday of September	Moldova
Namibia	First Sunday of September	First Sunday of April	Namibia
New Zealand	First Sunday of October	Third Sunday of March	New Zealand
U.S. and Canada	Second Sunday of March	First Sunday of November	Begins March 2007 Bahamas, Bermuda, Canada, Greenland (Thule), Mexico, St. Pierre and Miquelon, Turks and Caicos Islands, United States of America
Paraguay	First Sunday of October	Last Sunday of February	Paraguay
Syrian	First Day of April	First Day of October	Iraq, Syria

Time Zone	DST Starts	DST Ends	Adopting Countries
Tasmania	First Sunday of October	Last Sunday of March	Tasmania
United Kingdom	Last Sunday of March	Last Sunday of October	England, Ireland, Isle of Man, Scotland, Wales
Mexico	First Sunday of April	Last Sunday of October	Mexico

Appendix D: Macro Commands

The table below lists the macro commands that can run at waypoints in tours.

Command Name	Number of Arguments	Argument 1	Argument 2	Argument 3	Argument 4	Argument 5
SetVisible	2	Object type	Visible			
SetMagFaintest	2	Object type	Magnitude			
SetMagBrightest	2	Object type	Magnitude			
SetSizeMin	2	Object type	Size (arcmins)			
SetSizeMax	2	Object type	Size (arcmins)			
SetPenStyleWidth	3	Object type	Pen style (0=none)	Pen width		
SetPenColor	5	Object type	Red	Green	Blue	Alpha
SetFillRgb	5	Object type	Red	Green	Blue	Alpha
SetFontRgb	5	Object type	Red	Green	Blue	Alpha
SetFontFamilySize	3	Object type	Family name	Point size		
SetSymbolSVG	3	Object type	SVG filename	Size(mm)		
ToggleVisible	1	Object type				
SetExtendLabel	4	Dataset/Type	Database	Field	Value	
AddObject	4	RA	Dec	Type	Magnitude	
AddLabel	3	RA	Dec	Label		
AddArrow	4	RA	Dec	Width	Height	
AddAreaOfInterest	3	RA	Dec	Size		
AddChartScale	2	RA	Dec			
AddTelrad	2	RA	Dec			
AddMoveTo	2	RA	Dec			
AddLineTo	2	RA	Dec			
AddPolyPoint	2	RA	Dec			
AddEllipse	5	RA	Dec	Major axis	Minor axis	Position Angle
AddSVG	4	RA	Dec	File name	Size	
ClearUserData	0					
SetRefFrame	1	Frame				
SetDefaultType	1	Object type				
SetConstlLine	2	Constellation	On/Off			
SetConstlBoundary	2	Constellation	On/Off			
SetConstlDrawing	2	Constellation	On/Off			
SetConstlLabel	2	Constellation	On/Off			

Command Name	Number of Arguments	Argument 1	Argument 2	Argument 3	Argument 4	Argument 5
ConstlLinesUpdate	0					
LaserPointer	3	RA	Dec	Duration		
Fade	1	Seconds				
Zoom	1	Degrees				
Center	1	Object name				
Frame	1	Object name				
TourIncrement	1	Days				
TourText	3	Text	Height	Position		

Appendix E: Constellation Abbreviations

(And) Andromeda	(Cru) Crux Australis	(Ori) Orion
(Ant) Antlia	(Cyg) Cygnus	(Pav) Pavo
(Aps) Apus	(Del) Delphinus	(Peg) Pegasus
(Aqr) Aquarius	(Dor) Dorado	(Per) Perseus
(Aql)Aquila	(Dra) Draco	(Phe) Phoenix
(Ara) Ara	(Equ) Equuleus	(Pic) Pictor
(Ari) Aries	(Eri) Eridanus	(Psc) Pisces
(Aur) Auriga	(For) Fornax	(PsA) Pisces Australis
(Boo) Bootes	(Gem) Gemini	(Pup) Puppis
(Cae) Caelum	(Gru) Grus	(Pyx) Pyxis
(Cam) Camelopardus	(Her) Hercules	(Ret) Reticulum
(Cnc) Cancer	(Hor) Horologium	(Sge) Sagitta
(CVn) Canes Venatici	(Hya) Hydra	(Sgr) Sagittarius
(CMa) Canis Major	(Hyi) Hydrus	(Sco) Scorpius
(CMi) Canis Minor	(Ind) Indus	(Scl) Sculptor
(Cap) Capricornus	(Lac) Lacerta	(Sct) Scutum
(Car) Carina	(Leo) Leo	(Ser) Serpens
(Cas) Cassiopeia	(LMi) Leo Minor	(Sex) Sextans
(Cen) Centaurus	(Lep) Lepus	(Tau) Taurus
(Cep) Cepheus	(Lib) Libra	(Tel) Telescopium
(Cet) Cetus	(Lup) Lupus	(Tri) Triangulum
(Cha) Chamaeleon	(Lyn) Lynx	(TrA) Triangulum Australis
(Cir) Circinus	(Lyr) Lyra	(Tuc) Tucana
(Col) Columba	(Men) Mensa Berenices	(UMa) Major Ursa
(Com) Coma Berenices	(Mic) Microscopium	(UMi) Ursa Minor
(CrA) Corona Australis	(Mon)	(Vel) Vela
(CrB) Corona Borealis	(Mus) Musca	(Vir) Virgo
(Crv) Corvus	(Nor) Norma	(Vol) Volans
(Crt) Crater	(Oct) Octans	(Vul) Vulpecula
	(Oph) Ophiuchus	

Appendix F: TheSkyX Pro Automation Model

PROFESSIONAL

TheSkyX Professional Edition can be scripted using *TheSkyX Scriptable Objects*. Documentation is available on the web at http://www.bisque.com/scripttheskyx.

For third-party developers using TheSky6's object model, note that *TheSkyX Professional Edition's* automation model interface, for the most part, mirrors *TheSky6 Professional Edition*. Click on the Modules tab on the above web page for details about *TheSkyX* objects and *TheSky6 Classic Objects*. See *ScriptTheSkyX Documentation and Source Code Examples* at ScriptTheSkyX Documentation and Source Code Examples on the Software Bisque Downloads page for scripting documentation and source code examples. The URL to this page is: http://www.bisque.com/sc/media/p/44090.aspx.

TheSkyX Pro can replace or be exchanged for *TheSky6 Pro* as far as automation is concerned, the only caveat is that controlling programs (clients) need to use *TheSkyX Pro's* program identifiers (or program ids) in place of *TheSky6 Pro's* program identifiers.

For example, if your existing script or application source code references *TheSky6 Pro's* ***StarChart*** object:

TheSky6.StarChart

In order to use *TheSkyX Pro*'s StarChart object, replace the above syntax with:

TheSkyXAdaptor.StarChart

Your application will now use *TheSkyX Professional Edition's* StarChart object instead of *TheSky6 Pro's* StarChart object.

The table below includes a complete list of *TheSky6 Pro* and *TheSkyX Pro* program ids.

***TheSky6 Pro* Program ID**	**Equivalent *TheSkyX Pro* Program ID**
TheSky6.DataWizard	TheSkyXAdaptor.DataWizard
TheSky6.MyFOVs	TheSkyXAdaptor.MyFOVs
TheSky6.ObjectInformation	TheSkyXAdaptor.ObjectInformation
TheSky6.RASCOMTele	TheSkyXAdaptor.RASCOMTele
TheSky6.RASCOMTheSky	TheSkyXAdaptor.RASCOMTheSky
TheSky6.RASServerApp	TheSkyXAdaptor.RASServerApp
TheSky6.Raven	TheSkyXAdaptor.Raven
TheSky6.StarChart	TheSkyXAdaptor.StarChart

***TheSky6 Pro* Program ID**	**Equivalent *TheSkyX Pro* Program ID**
TheSky6.Utils	TheSkyXAdaptor.Utils

The Windows-specific Visual Basic (VB) code below shows an example how to use the ***StarChart*** object in either *TheSky6 Pro* or *TheSkyX Pro*. Note that both applications can be installed and run on the same computer, and both object models can be accessed on a single computer, without issue.

```
Dim StarChart
'Remove the tic mark below to use TheSky6
'Set StarChart = CreateObject("TheSky6.StarChart")

'The following line will use TheSkyX Pro's StarChart object
Set StarChart = CreateObject("TheSkyXAdaptor.StarChart")
```

Automation and User Account Control

In an effort to minimize the spread of malware, Windows Vista and later operating systems employ User Account Control (UAC) which attempts to prevent unwanted or unauthorized changes to the operating system.

UAC, unfortunately, may also prevent wanted or *necessary* changes to your computer. For example, when *TheSkyX Professional Edition* is launched, it attempts to "register" COM automation interfaces in the Window Registry.

By default, UAC blocks the registration, so that attempts to access *TheSkyX Professional Edition's* automation interfaces in an external script (or by a third-party observatory automation application) are not possible.

The workaround is to run *TheSkyX Professional Edition* as an Administrator to elevate the account's privileges and allow changes to the Windows Registry.

To run *TheSkyX Professional Edition* as an Administrator:

1. Right-click on ***TheSkyX Professional Edition*** icon.
2. Click the ***Run As Administrator*** command.

Appendix G: TheSkyX Pro Device Driver Architecture

PROFESSIONAL

TheSkyX Professional Edition’s *X2 Standard* provides a cross platform, plug in device driver architecture that allows third party software developers and hardware manufacturers to develop and distribute *TheSkyX Professional Edition*-compatible software drivers for astronomical devices (mounts, cameras, rotators, focusers, domes).

Documentation and source code examples are available at:

http://www.bisque.com/x2.

Appendix H: TheSkyX Change Log

Changes and improvements to *TheSkyX Professional Edition* and *TheSkyX Serious Astronomer Edition* since the initial release are listed below.

Version 10.2.0 May, 2013

New Features, Improvements and Enhancements

- ✓ Added support for Orion StarShoot autoguider (SSAG).
- ✓ The TPoint polar alignment report now shows adjustment information for the Paramount currently in use, only.
- ✓ Improved autoguiding when using large diameter guide stars.
- ✓ Paramount sidereal tracking is turned off when a software limit is encountered.
- ✓ Rotators now have a tabbed dialog in the same style as the other major hardware devices.
- ✓ MoveTo now implemented for focusers (just like CCDSoft).
- ✓ Improved histogram performance.
- ✓ Image link window now has min/max buttons (because the window is rather large on small screen, and it is nice to be able to minimize/restore).
- ✓ Added a "Set Chart Time To Photo Time" menu command to the FITSViewer's right-click pop-up menu. This sets TheSkyX's time to the time at which the FITS image was taken.
- ✓ The FITS viewer now supports a CCDSoft-style crosshair reticule.
- ✓ Camera Add On supports autoguiding.
- ✓ Added UCAC4 support.
- ✓ FOVIs are now integrated with the hardware rotator.
- ✓ Camera Add On Support for the following cameras:
    - SBIG STT
    - SBIG FW7-STX
    - SBIG FW8-STT
- ✓ TheSkyX can control most serial devices (mounts, domes, focusers, etc.) over Wi-Fi. Click here for more information.
- ✓ TheSkyX can route native RS-232 serial data streams over TCP/IP instead of a serial port (instead of choosing "COM", choose "TCP/IP"). Can eliminate the need for operating system level, virtual serial ports when using TheSkyX to control serial devices over third party, TCP/IP to serial or Wi-Fi to serial adaptors.
- ✓ Added support for rotators.
- ✓ New FITS display engine – new toolbar, zoom in, zoom out, drag.
- ✓ Integrated ASCOM-compatible plug ins for cameras, focusers, filter wheels, domes and rotators.
- ✓ Improved Image Link success on images covering three degrees and more.
- ✓ Camera Add On supports Canon camera drivers. Canon DSLR driver for Mac included with Mac Daily Build installer (OS X 10.6 or later and Intel Mac required). See *TheSkyX Pro and SAE User Guide* Revision 1.4.3 or later for details about using this driver.

- ✓ Tweaked Polar Alignment report to make it more understandable.
- ✓ Camera Autosave by default now creates a date-based sub-folder (can be shutoff).
- ✓ Errors reported by standard FITS library are displayed as textual strings.
- ✓ Tools > Open Fits automatically zooms out on large images.
- ✓ Added a manufacturer/model label to the top of the Rotator window.
- ✓ Rotator hardware may now be commanded to any position angle by simply dragging a FOVI that is linked to the rotator.
- ✓ Camera Add On now displays camera temperature, setpoint and TE cooler power.
- ✓ ACL dome supports LoggerInterface.
- ✓ Update Rotator window. It now includes the usual connect/disconnect/configure buttons common to the other devices, implements an implicit connect, and ties into the starchart FOV.
- ✓ AutoZoom applied camera acquired images.
- ✓ Added phase angle to asteroids.
- ✓ Added SBIG ST-400 and ST-401 cameras to Detector Geometry list.
- ✓ SDB searches now include angular size (like ARP).
- ✓ Added Zoom Tool command to Tools menu.
- ✓ ProTrack takes slew errors including aborted slews in stride.
- ✓ When connected to a Paramount going to File, Open or TPoint, File, Open (or any operating system dialog to view the file system) would take a long time for the system dialog to display the file system.
- ✓ UI is more responsive when ProTrack is engaged.
- ✓ Photos and constellation drawings slowly fade to black as the field of view decreases.
- ✓ TheSkyX can be exited and restarted while doing a TPoint full calibration or re-calibration and continue the calibration.
- ✓ A single button click downloads the latest FOVI equipment databases from Software Bisque web page.
- ✓ Temma driver now allows sidereal tracking to be turned on via Orchestrate and external script for Temama 2 and later mounts.
- ✓ Based on updated tracking rate documentation, AP mounts can now track satellites using TheSkyX's Track Satellite command.
- ✓ Added an option to the Astro-Physics window that allows the mount's tracking rate to be configured when TheSkyX disconnects (When tracking satellites, TheSkyX sets the AP mount's tracking rates in both ra and dec. These rates can cause the mount to quickly track into unwanted orientations.)
- ✓ Added SBIG STF-8300 support for Camera Add On customers.
- ✓ Allowed setting the interface for SBIG ST-5C/PixCel255, ST-237/PixCel237.
- ✓ Added Auto Contrast Setup for camera add on acquired images.
- ✓ Added ‘Allow dragging flip hour angle’ option under Telescope setup.
- ✓ Enhanced movie creation.
- ✓ Finding Super Model is faster.
- ✓ DSS images now use a better DSS specific autocontrast algorithm (was SBIG).
- ✓ Added exposure delay to camera add on.
- ✓ On the Bisque TCS window, the joystick graphic is enable/disabled appropriately based on firmware version (introduced in prior daily build).

Changes and Bug Fixes

- ✓ Mirror image now shows an icon in upper left corner of the star chart.
- ✓ Clients no longer receive the error "Error in loading DLL" when attempting scripting operations (on 32 bit operating systems only).
- ✓ Constellation lines were "automatically" turned on when certain SDBs where present and turned on.
- ✓ @Focus2 would not restore telescope cross hair option if error happened early when running @Focus2.dbq (i.e. the daylight option makes AtFocus2.dbq result in no object found).
- ✓ Getting the longitude from an LX200 compatible mount no longer results in a command failed error message.
- ✓ Fixed a bug where the magnitude for asteroids was wrong.
- ✓ TPoint calibration runs have the "Telescope name" default to the name of the currently selected mount (use to be the short name from the mount driver).
- ✓ On the Enter Coordinates tab of the Navigation window, the “Center Chart on RA/Dec” button didn't take into account nutation (error of a few arcseconds).
- ✓ Fixed case sensitive URL to Celestron downloads site.
- ✓ A bug that only affected custom mounts, using Bisque TCS, configured as a fork, where slews missed with a fixed offset on one side of the meridian. (The bug does not apply to Paramount mounts.)
- ✓ Fixed a bug where selecting “SBIG FW-8 STL” wouldn't move the filter.
- ✓ Distribute filterwheel.txt.
- ✓ Distribute AtFocus2.DBQ fix to "File not found" error running @Focus2 with AutoSlew/AutoExposure turned on.
- ✓ Fixed a regression bug slewing NexStar mounts to negative declinations did not work.
- ✓ @Focus2 incorrectly logged subframe option twice.
- ✓ ImageLink now saves WCS when operating on multiple files.
- ✓ Fixed a bug where aborting UCAC compilation put TheSkyX in sleep mode.
- ✓ Autoguiding clarification - show the units on the Calibrate Autoguider window for Relays vs. DirectGuide.
- ✓ The “AutoSave focus images” checkbox works as expected.
- ✓ Running @focus2 no longer incorrectly changes the “Crosshair Option” to “No”.
- ✓ ASCOM Focuser changes:
    - Fixed a display error for the current position of relative focusers.
    - Implicit connections (i.e., move without first connecting) no longer causes strange focuser movement
    - Commands to move a focuser by 0 steps no longer fail (but do nothing)
    - Fixed move command for focuser drivers that block on MoveTo rather than returning immediately (RoboFocus should work now)

- ✓ The autoguiding/focus 3D star plot is no longer black on non OpenGL 2+ videos (it use to crash).
- ✓ Exercise Mount works under all circumstances.
- ✓ Sidereal tracking stays turned off.
- ✓ Dome Add On: the dome aligns to telescope even when OTA lower then counterweights.
- ✓ Attempting to autoguide with SBIG remote guide head would always, incorrectly result in the error 565 "Autoguider calibration is required…" even after a successful calibration.
- ✓ @Focus2 now converges consistently.
- ✓ Photos with low signal should be displayed correctly (appeared inverted).
- ✓ Description of the angular size of Mars is now correct (4-15 arcseconds, not arcminutes) in the Angular Size of Mars Tour.
- ✓ Minor pictures window changes.
- ✓ "Take Photo" and "Abort Camera" available as custom toolbar commands.
- ✓ Asteroid orbits can be displayed on the Solar System window.
- ✓ Dark limb of Exaggerated moon is now opaque (was transparent).
- ✓ Added a tooltip for each Graph on the TPoint window.
- ✓ The moon's size is no longer exaggerated at fields of view of less than 90 degrees.
- ✓ Added the ability to draw the lower telescope limit line with a "Follow telescope" option.
- ✓ Filter wheel con/disconnect buttons plus device name and setup button appear at the top of the filter wheel control.
- ✓ All Target based sky commands (center, frame, slew to, etc.) are disabled if there is no current target for the rare case of having just started *TheSkyX* and no object has yet been found or clicked on. The old behavior was confusing, go to Find, type "Venus" and click Center\Frame\Slew - no object found error resulted.
- ✓ It is okay now to home the Paramount from the joystick while TheSkyX is connected. Prior to this build, pointing errors may have resulted if the Paramount was homed from the joystick while TheSkyX was connected.
- ✓ On the Bisque TCS window,
    - the "hours beyond meridian" now has a correct maximum value of 2.5 (for MX's).
    - the "hours beyond meridian" displays the correct value when the "OTA on the west side of pier" radio button is clicked (it use to incorrectly display the east value, although the "Set To This Value" was/is correct).
    - the slew log is updated only when necessary, not constantly.
- ✓ Fixed default min/max slew limit values for the Paramount MX which were broken in a prior daily build.
- ✓ Edited the descriptions for several optional SDBs.
- ✓ The About window shows the version and build for *the* executable being run, not a hardcoded to the executable "TheSkyX.exe" which presented confusion when running renamed TheSkyX.exe.
- ✓ Fixed a bug with Paramounts where turning off sideral tracking wouldn't stick.
- ✓ Orion Star Shoot x2 camera driver is now distributed.
- ✓ Improved accuracy of NEO's.
- ✓ Modulate the transparency of bright, color images at wide fields.

- ✓ TPoint Add On automatically disables tracking adjustments on the ProTrack tab when starting a new model.
- ✓ Rotators may now synchronize their mechanical angle to their actual position angle. This may be done manually in the Rotator dialog, or automatically using a new button under the "FOV Options" tab of Image Link (after successfully linking an image). Please note that if this is attempted without the rotator linked, a rotator position of 0 will be assumed.
- ✓ The rotator dialog display may be toggled between showing mechanical angles or position angles.
- ✓ Rotators now display their current angle (or position angle) to two digits of decimal precision.
- ✓ Version 2.2 of the Pyxis rotator plugin. The plugin will now automatically detect what type of Pyxis it is talking to, so the option to toggle between 2" and 3" modes has been removed from the configuration GUI. More importantly, the plugin now implements high-precision rotation mode for rotators whose firmware supports it (2" rotators at 2.03 or greater, and 3" rotators at 3.4 or greater). Pyxis rotators may now also abort a rotation in progress. However, this should be done in emergency situations only, as the Pyxis must be homed following an aborted rotation.
- ✓ Automated pointing calibration run displays "Retry X of Y" when appropriate.
- ✓ Fixed the Windows keyboard accelerators on several windows.
- ✓ Fixed a bug that prevented some customers from being able to "Exercise" their Paramount.
- ✓ Fixed a bug that prevented setting Paramount soft limits in the southern hemisphere. Also fixed a bug when setting soft limits with "Set to current" when the OTA was on the west.
- ✓ Pyxis rotator plugin now allows the user to select the rotator model and home-on-connect behavior via a configuration window.
- ✓ Automated pointing runs, with camera AutoSave on, have images saved underneath "date-based subfolder" if this option is turned on.
- ✓ Stars will not drift off screen in Terrestrial Sphere mode when zoomed in less than 3 degrees.
- ✓ Ignore errors on TCFS with no temperature probe connected.
- ✓ Separated Pyxis rotator entries for the 2" and 3" models and moved both to the "Optec" manufacturer. This update will continue to work with the 2.00 and earlier firmware versions, but will allow 2.01 (and on) to use the correct step-size for the two models.
- ✓ Fixed typo in FITS header.
- ✓ Added a wait cursor when connecting camera.
- ✓ Fix for isolated case when unable to save PEC to a Paramount with error 21002 followed by 213.
- ✓ TCFS driver fix - poor com would incorrectly cause "Not linked" error.
- ✓ The Paramount's dynamic flip hour angle now accommodates TPoint modeling. Clears up unintuitive behavior for slews very close to the flip hour angle.
- ✓ Updated locations database (McDonald Obs.)
- ✓ TPoint polar alignment report now shows sigma to one decimal place.
- ✓ Non-stellar object fill type is now updated and saved correctly.
- ✓ Fixed missing period in polar align report.
- ✓ Fixed a bug using the Camera Add On connected to "CCDSoft's Camera" with AutoDark on and AutoSave on. Photo's would save with "NoAutoDark" included in the file name but they were indeed light frames.

- ✓ Fixed a bug where selecting a new focuser would incorrectly display an error message "No device selected".
- ✓ Fixed a bug where attempting to move a TCF-S3 beyond 7000 would incorrectly give "Limit Exceeded" error.
- ✓ Fixed a bug where TCFS only gave the option to move 100 or 1000 steps.
- ✓ Fixed three bugs when using advanced autosave filenames:
- ✓ Exposure time in the file name wasn't correct when doing automated pointing runs (resultant FITS file was correct).
- ✓ Temperature in the file name was zero if temperature control was off.
- ✓ Filter Name in the file name was always blank.
- ✓ Turning PEC on/off from TheSkyX does not alter Gemini PEC data.
- ✓ Fixed a bug that caused Automated Pointing Runs to behave incorrectly (introduced in build 5837).
- ✓ Date-based subfolder is now noon based as tool tip documented (was mid-night based).
- ✓ Fixed a bug introduced in a prior daily build where controls in the Auto Contrast setup window didn't disable correctly.
- ✓ Fixed a bug where the ImageLink image display didn't show Light Sources even when checked until after a forced redraw (i.e. resize).
- ✓ Fixed a bug introduced in daily build 5837 that caused Automated Pointing Runs to fail.
- ✓ Fixed a bug when TheSkyX Camera Add On used CCDSoft's Camera the temperature setpoint was incorrectly displayed as -100.
- ✓ Fixed a bug introduced in the prior daily build where Take Photo would occasionally report “command in progress”.
- ✓ Fixed two possible crashes associated with FOVI manipulation related to the new rotator link options.
- ✓ Fixed a bug that with the "ACL Dome" driver that prevented TheSkyX from connecting.
- ✓ Prevent a crash from occurring if a user toggles one of the new checkboxes after changing FOV display modes.
- ✓ Fixed a bug introduced in an earily daily build where Image Link would incorrectly fail if FITS key XPIXSIZE was not present (XPIXSIZE is not required for Image Link).
- ✓ Connection to Meade Autostar III telescopes should work now (regression serial port flag change).
- ✓ Fixed a bug where disconnecting then reconnected to a Paramount MX would cause the MX to slew at half speed (rebooting the MX would return full speed slews).
- ✓ ProTrack no longer makes tracking worse when a TPoint model has more than 30 terms (which is not very common).
- ✓ Temma synchronization for some negative declinations no longer fail.
- ✓ Text error correction (inactive camera coolers were showing Off).
- ✓ On Windows, the default horizon is now selected the first time the Horizon & Atmosphere window is opened (which avoids potentially confusing behavior when no horizon is selected).
- ✓ No longer disable TPoint's Super Model button when Super Model is not possible; instead allow the button to be pressed and give descriptive information why Super Model is not possible.
- ✓ Fix possible bug using configuring proxy server.

- ✓ Image link gets center RA/Dec of DSS photos when OBJCTRA, OBJCTDEC keywords are not in the FITS header (fixes ImageLinks not working on DSS images).
- ✓ Attempting to connect to hardware that relies on Miscrosoft COM at the driver level would no longer causes the message “You are about to start a second instance of TheSkyX” when the COM driver was not installed.
- ✓ Fixed a bug where the Canon driver didn't show under Windows.
- ✓ Declination telescope limits now work for southern hemisphere.
- ✓ Calibrate button text changed to Calibrate Joystick on Bisque TCS window.
- ✓ Greek smooth moving labels work on Windows.
- ✓ If camera autosave is on during an automated pointing run, the images are saved under a folder Automated Pointing Run in the camera autosave folder.
- ✓ Fixed a bug introduced in the prior daily build where saving a FITS photo would result in the error “Unable to complete operation because one or more files are read only.”
- ✓ Fixed a bug where the wrong sample was ignored when clicking on a TPoint orthographic plot.
- ✓ TPoint orthographic plots support graphics input.
- ✓ Fixed a bug where the wrong sample was ignored when clicking on a TPoint orthographic plot.
- ✓ Fixed a bug on some TPoint graphs that the sign of what is plotted flips beyond the pole, which it should not.
- ✓ PDS update.
- ✓ Fixed a bug introduced in a prior daily build that caused the second AutoDark to be all black.
- ✓ Allow handbox control checkbox on the Meade window states Autostar III only now.
- ✓ Corrected spelling of anomaly in object information.
- ✓ On the Manage Observing List window, changed text of Column Setup button to Report Setup.
- ✓ Telescope cross hair is not plotted at 0,0 when off screen.
- ✓ ProTrack is now strictly correct for MX (was using ME values that were very slightly wrong).
- ✓ ProTrack applies without ever having to display the TPoint Add On window. Prior to this build, the TPoint Add On window had to be displayed at least once per TheSkyX session. This is no longer necessary. For example, start TheSkyX, connect to a Paramount, Open TPoint Addd On Window, enable ProTrack, close TPoint Add on Window. Exit TheSkyX, restart, Connect, slew to an object and ProTrack is “doing its thing” without TPoint Add On window having ever been displayed.
- ✓ No longer necessary to slew twice on arcsecond slews with ProTrack is on.
- ✓ ProTrack maintains telescope cross on target even with extensive Super Models active.
- ✓ Chart status displays corrected telescope coordinates.
- ✓ If a dome is parked but coupled to the mount, the dome respects the park state and not attempt to slew to follow the scope.
- ✓ Use a photo for the stick pin on Earth map.
- ✓ Include elevation when double-clicking location on Earth map.
- ✓ Updated Mt. Evans Obs. latitude, longitude.
- ✓ Corrected PICTYPE comment in FITS header.
- ✓ Scripting ImageLink::execute() command works on the Mac.
- ✓ When a dome had poor communication, invoking any command would incorrectly give “Command in progress.”

- ✓ Fixed a bug where the fits INSTUME keyword was blank when acquired using third party, X2 camera drivers.
- ✓ Fixed a bug where the fits MOUNT keyword was blank when using third party, X2 mounts drivers.
- ✓ PDS TLE fix.
- ✓ Regression bug fix: TCP/IP is displayed in the telescope port list.
- ✓ Windows Daily Build installer is a single executable that does not need to be run as an Administrator.
- ✓ Mac Daily Build installer uses PackageMaker.
- ✓ Flush serial port for Sky Commander, SGT, Gemini and Celestron mounts (Wi-Fi)
- ✓ Autosave path is now created with mkpath rather than mkdir, allowing target directories that would require the creation of parent directories first.
- ✓ TheSkyX defaults to AutoSave/imager, and currently that fails on fresh installs unless the user manually create the “AutoSave” folder.
- ✓ Fixed Mac-specific scripting bug (ImageLink.scale type definition wrong).
- ✓ Revised ImageLink.js to use ImageLinkResults.imageScale.C
- ✓ Corrected a bug that caused autosaves of images to fail (without informing the user) when the target name contains a ‘:’ character (i.e., any GSC or UCAC catalog object, and probably others).
- ✓ For asteroids w/o H and G magnitude parameters, default the magnitude to 30.
- ✓ Camera Add On, Aperture and aperture area were reversed in FITS header.
- ✓ Save Gemini HC mode.
- ✓ Temma turn on tracking from script.
- ✓ Gemini window now displays and maintains the correct Hand Paddle Mode.
- ✓ The current tab on the Gemini window is now preserved.
- ✓ Gemini driver now prompts to home the mount upon connection with the telescope.
- ✓ Dome slit only renders in stereographic projection. Attempted fix of non-functioning dome slit on some graphics card.
- ✓ Import sky6 files maintains rotation angle when appropriate.
- ✓ Allow CCDSoft to see TheSkyX targets using PushTo mounts.
- ✓ Undo ReCal is now enabled after finishing recalibration.
- ✓ Supermodel button is disabled for recal model.
- ✓ For the auto-import of TheSky6 files introduced in the prior daily build, the File Open window now also lists *.sky files by default.
- ✓ Supported mounts now list the Deep Space Navigator and Orion Sky Quest.
- ✓ On Vista/Windows 7, the daily build installer prompts to be run as administrator when not.
- ✓ The daily build installer is digitally signed.
- ✓ TheSkyX.exe file distributed by the daily build installed is digitally signed.
- ✓ The longitude displayed in TheSkyX's Location,Date,Time windows is now correct for iOptron mounts.
- ✓ Removed unnecessary parenthesis in SGT alignment star list.
- ✓ TheSkyX now does a basic, automatic, import of TheSky6 files. At this time, the location, date, time, and Sky Chart position recorded in the sky6 file is imported (TheSky6's font, line, fill colors are not (yet) imported). 1) TheSkyX's File, Open window now lists *.skyx and *.sky files (TheSkyX and TheSky6 files respectively). 2) Choosing a .sky file automatically imports the file, changes the extension to .skyx and does not alter the original file.

- ✓ Fixed two overlapping error codes with CCDSoft.
- ✓ It is now “easy” to abort an exposure delay.
- ✓ Changes to parameters that affect Paramount slew speed based on temperature are now applied immediately (changes to this setting previously required a disconnect/reconnect from the control system).
- ✓ Fixed a bug introduced in the prior build where slewing a mount turned tracking off.
- ✓ Changes for PDS.
- ✓ Fix two misspellings (typos) on synchronization dialog.
- ✓ Expose sky6DirectGuide to the TheSkyX's java Script engine (and sockets as well).
- ✓ Changed reading of text file for X2 driver list to accommodate both Mac and or Windows native text files.
- ✓ Fixed bug where “waning” text for the moon on the object information window was wrong.
- ✓ By default, in the hardwarelist.txt, put the space into MapsTo field for X2 developers.
- ✓ Faster dome slit rendering with OpenGL. Also put back dome shading removed in prior daily build.
- ✓ Fixed a bug introduced in prior daily build 5249 that prevented Paramount southern hemisphere slews.
- ✓ For GEMs, when beyondThePole(), syncing into an existing TPoint model gives better results.
- ✓ In the TPoint window, “Term Abbreviation” is now “Term”.
- ✓ Modified the TPoint polar alignment report to reference knob tics (not arcminutes) for azimuth adjustments on the MX.
- ✓ Fixed a bug where the Polar Alignment report was reporting the incorrect azimuth adjustment for MX's when the adjustment was less than one full turn (was reporting only half the required value when less than one turn).
- ✓ Slightly enhanced the accuracy of syncing into a an existing model with the MX (not very common).
- ✓ Display an error if Read All Parameters ever has one in Bisque TCS.
- ✓ Lessen the likelihood of Paramount errors with “bad Id” or “bad sequence”.
- ✓ “Socket connection refused” error was incorrectly mapped to “Socket first error”.
- ✓ Implemented PECArray in TheSkyXAdaptor.
- ✓ Better fps when rending dome slit on chart.
- ✓ Some TPoint window clean up.
- ✓ Some Bisque TCS window clean up.
- ✓ Updated AP default backlash compensation to 0.
- ✓ Added .mpl extension for listing imported asteroid text files.
- ✓ Changed advanced setting from ‘Comets/MPLs By Name’ to ‘Comets and Asteroids By Nam’.
- ✓ Updated list of supported mounts.
- ✓ Updated FOVI list.
- ✓ Fixed a bug introduced in the prior daily build that made ERR_MKS_MAIN_AT_LIMIT more likely instead of less likely.
- ✓ Changed “Comets/MPLs” to Comets and Asteroids in the User Guide's Advanced Preferences tab.
- ✓ Likely fixed a rare occurrence of Paramount slews producing error ERR_MKS_MAIN_AT_LIMIT (22007).
- ✓ Added addition logging to isolate ERR_MKS_MAIN_AT_LIMIT.

- ✓ Put reasonable bounds for pressure on Atmospheric Refraction Parameters entry.
- ✓ The reminder window that "netbook" type settings were made is now modeless.
- ✓ Fixed a bug where RASCOMTele.SlewToAzAlt was always Asynchronous.
- ✓ Allow Dragging Flip Hour Angle option is now saved and restored.
- ✓ Bisque TCS Window clean up 1) no longer bring up edit item double clicking on tree roots 2) don't allow editing items in show status tab.
- ✓ Bisque TCS Window, Utilities Tab, Hand Controller, Calibrate button now works. Press this button *once* to Calibrate the joystick - without calibrating the joy stick, doing a FindHome might immediately abort. The common symptom would be the telescope status would immediately go from "Finding Home" to "Not Homed" (more likely in cold temperatures).
- ✓ Movie fixes.
- ✓ Movie making with more error checking.
- ✓ Fixed ME orientation for the virtual mount when in southern latitudes.
- ✓ Ability to bring asteroid YUH into TheSkyX as a satellite using ephemeris data and track on it.
- ✓ Fixed slew limit error for Southern hemisphere slews – must clear synchronization history and restore control system defaults.
- ✓ Added Meade LX200 ACF to telescope list.
- ✓ Added OK/Cancel buttons to Observer Log dialog.
- ✓ Cleaned up Observer Log (repeated word, always add observer to text box, other minor changes).
- ✓ TheSkyXAdaptor.RASCOMTele.SetTracking() is now implemented identically to TheSky6.
- ✓ Object paths now save phase for each point.
- ✓ Fixed bug where labels were incorrect.
- ✓ Tour dialog box tweaks.
- ✓ Telescope commands tweaks.
- ✓ When parking programmatically through the RASCOMTele.Park() interface, don't disconnect if there is an error.
- ✓ When the Bisque TCS logging is on, don't clear the log upon disconnect.
- ✓ Corrected a limit error when slewing a GT-1100S's with TheSkyX.
- ✓ Fits keywords APTAREA APTDIA were swapped when acquiring images with the camera add on.
- ✓ Fixed memory leak with new FITS display engine introduced in prior daily build.
- ✓ Added Copy button to Communications Log window.
- ✓ Epoch to Equinox in Navigation window in Edit Comet window.
- ✓ Hide Graphics View tab on Export window.
- ✓ Removed duplicate accelerators in Edit Comet dialog.
- ✓ Added an Edit Attributes button to the Custom Horizon tab.
- ✓ Target Object was missing from the list of exported Sky Chart layers list.
- ✓ When downloading satellites resulted in an error, the error message was behind the window.
- ✓ Added a Log Slews checkbox that allows logging to be turned on/off directly from Logging window on the Bisque TCS.
- ✓ Updated sbpyxisrotator driver.
- ✓ Super Model no longer changes ME more than it ought to.
- ✓ DST applied properly for sites in Southern Australia now.

- ✓ Fixed a bug where the guide rate could not be set in the Bisque TCS.
- ✓ Focuser textual status wasn't always correct in the Imaging System Setup window.
- ✓ Implement built-in focuser settings generally so that it applies to other built in focusers like ap, lx200, gemini, teleapi, etc.
- ✓ Minimum size of mount control on the Virtual Observatory window is 150 x 150 pixels.
- ✓ Virtual mount selection is saved/restored.
- ✓ Initialize iOptron firmware version.
- ✓ Added instructions for adjusting Virtual Mount to the Virtual Mount window.
- ✓ Alphabetize mount list.
- ✓ Saving all parameters to the legacy MKS3000 prevented subsequent communications.
- ✓ LX200 classic now uses high precision positions.
- ✓ TheSkyX displays the correct declination for iOptron mounts (missing leading zero in this protocol caused decs to be "incorrect").
- ✓ Virtual mount's latitude wasn't correct.
- ✓ Find multiple harmonics in MX/ME periodic error.
- ✓ Fixed a bug that prevented saving PEC data to the Paramount (introduced in build 5080).
- ✓ Display the Paramount's firmware version consistently.
- ✓ ACL Dome
    - o Allow setting the acl address for an ACL dome.
    - o Now defaults to not needing elevation.
- ✓ Paramount's Exercise mount defaults to 80% max slew rate (was 99%).
- ✓ Changing the Paramount's maximum slew rate percentage int the Bisque TCS window applies immediately (before this build, a disconnect/reconnect was required before a maximum slew rate change was applied).

Version 10.1.11 Build 5080

New Features, Improvements and Enhancements

- ✓ Added Paramount MX support.
- ✓ Added Virtual Mount command to Tools pop-up on the Telescope window that simulates the telescope.
- ✓ Added the ability to automatically save photos (Camera Add On).
- ✓ Added a focuser simulator (Camera Add On).
- ✓ Added a filter wheel support (Camera Add On).
- ✓ Added SBIG ST-i support (Camera Add On).
- ✓ Added Pyxis rotator support.
- ✓ Under Tools, Run Java Script added enable/disable debugger. Scripts run over a socket that threw an exception without a try catch would launch the debugger - solutions are to disable the debugger or put a try catch around script code intended to be run over a socket.
- ✓ Improved the RunQuery.js java script example.
- ✓ The fits header is dynamically populated when photo is acquired.
- ✓ Added the Pole Indicators and Zenith Indicator SDBs to the Optional SDBs.
- ✓ Updated common star names sky database.
- ✓ Updated Common Non-Stellar sky database.
- ✓ Updated FOVI Detectors (Canon models).

- ✓ Added the following (additional) information to the fits header: LST, latitude, longitude, instrument, mount, telescope az/alt, hour angle, beyond the pole, air mass. observer, origin, telescope description, focal length, aperture area, aperture diameter.
- ✓ Dome control window displays the selected dome.
- ✓ Dome control windows has a "Show Log" when device supports logger interface.
- ✓ X2 optional mount interfaces are re-queried after connection.
- ✓ When selecting a TPoint calibration point either 1) graphically by clicking on the point on the TPoint scatter diagram or 2) by selecting it in TPoint list, the corresponding point on the sky display is highlighted with the target bulls eye and identified.
- ✓ Documented TheSkyXAction object.
- ✓ Dome is now polled for azimuth when parked.
- ✓ When adding a pointing sample, an error message is displayed if the point is too low.
- ✓ On Windows, when possible, show friendly names associated with COM ports.
- ✓ Added the ability to put a background image on the camera, dome and telescope dialogs by placing images named camera.png, dome.png and mount.png respectively in the root of "<My Documents>\Software Bisque\TheSkyX Professional Edition" (exit and restart). Sample.
- ✓ Allow larger semi-major axis for asteroids so that orbital elements for trans-Neptunian objects like Sedna are accepted.
- ✓ Added an “Atmospheric Refraction Parameters” button and window on the Imaging System Setup window (Telescope > Telescope Setup).
- ✓ Added “Sync back into model” type of TPoint re-calibration.
- ✓ Added an option to recalibrate portable mounts.
- ✓ Added a state to TPoint calibration runs.
- ✓ Add an “Undo Recal” button to TPoint.
- ✓ Released a “TheSkyXDailyBuildInstaller” to simplify installation of TheSkyX Daily Builds.
- ✓ Paramount's can be exercised for up to 1000 cycles.
- ✓ Multiple satellite files can now be imported.
- ✓ Added Set Lunar Rate and Refresh buttons to Temma window.
- ✓ Added sky6Dome scriptable object.
- ✓ Temma supports SetTrackingRates command when possible.
- ✓ Moon, Sun, and planets can now be drawn transparently.
- ✓ Added keyboard accelerator for the Field of View Indicators command.
- ✓ Added the Check for Updates command to all Editions (Pro, Serious, Student, First Light and Theater).
- ✓ Added ability to set AP Slew Rate. Rate is restored each session.
- ✓ AP Backlash compensation settings are saved and restored each session.
- ✓ The OTA end of the declination axis for AP mounts is always on the West side when Slewing to the AP park position #1 from TheSkyX.
- ✓ Most recent tracking rate sent to the mount is displayed on AP window.
- ✓ Implemented software-based parking for the AP mounts so that third-party applications can park it via script.
- ✓ Added : /Resources/Common/User/Java Scripts/MountTrackingOff.js script.

Changes and Bug Fixes

- ✓ Fixed a bug introduced in prior daily build where TPoint displayed RMS PSD as zero.

- ✓ Default the *first* recalibration attempt to be for a permanent mount, from then on, the recalibration type is persistent.
- ✓ Show “Run Date” for a TPoint calibration run.
- ✓ To avoid confusion, bring “Pointing Data” tab forward when appropriate (as opposed to "Recalibration Data").
- ✓ sky6RASCOMTele.SlewToAzAlt now obeys the Asynchronous property (prior to this, all SlewToAzAlt were asynchronous).
- ✓ Don't allow identifying a TPoint calibration point unless it is visible (either by path or point).
- ✓ Choosing Connect from the Telescope menu, prompts to Find Home if not homed.
- ✓ Regression fix: Uncommented FindMosaic so that mosaics can be accessed via script
- ✓ On Preferences window, "criterion" replaces "criteria"
  - o For the Bisque TCS:
  - o Fixed crash pressing Revert with no sync history, Updated device and driver descriptions based on selection.
  - o Flip HA now is in hours.
  - o Bug Fix - turning off tracking on the MX status says "Tracking Off"
  - o Added some wiggle room for TheSkyX's UI to say "Tracking Off"
- ✓ Graphical pointing samples were plotted in the wrong location - did not affect pointing, just a display item (the object info was therefore corrected as well).
- ✓ New pointing samples were added to the top of the list instead of the bottom, now added correctly.
- ✓ TPoint displays "N/A" for RMS and PSD when appropriate.
- ✓ To avoid confusion, after finishing a TPoint recalibration, the scatter diagram is for the recalibration data, not the original pointing data.
- ✓ Finishing a calibration run didn't always set all terms to fixed, it does now.
- ✓ Fixing a term no longer results in the term going to zero.
- ✓ Can now find 61 cyg.
- ✓ TPoint re-calibration did not work when initiated without using the TPoint dialog's Start calibration button (like pressing "Add Pointing Sample" with an existing model in place).
- ✓ 1x1 Mosaics no longer cause a crash.
- ✓ Don't allow a scale of zero for image link.
- ✓ Image Link now always shows a success or failure message in the status text (on failure the error description goes into status text).
- ✓ Set/get southern hemisphere site information to/from Gemini correctly.
- ✓ Bug fix for dynamic telescope menu.
- ✓ Added ability to update firmware to Bisque TCS window.
- ✓ Firmware updates are checked based on the filename.
- ✓ Increase transparency of limit regions on the Mac.
- ✓ Updated default settings for AutoPointingRun.sxt and DSS.sxt.
- ✓ Daily Build installer didn't work if unzipped to a folder using long filenames.
- ✓ Added speed percentage to exercise mount window on the Bisque TCS window.
- ✓ When clicking on TPoint graphic to identify pointing samples, only one sample is highlighted.
- ✓ Bug fix - when clicking on an "TPoint calibration point" the object id target bulls eye didn't coincide with the graphic at small FOVIs (high magnification). Did not affect pointing, just a display fix.

- ✓ The textual azimuth displayed for an identified "TPoint calibration point" was incorrect. Note, this does not affect pointing and would primarily cause confusion for those attempting to correlate a already collected pointing sample with azimuth/altitude using the displayed azimuth (the graphically plotted azimuth for the point was correct).
- ✓ Display error message if the format of a pasted PEC table is incorrect.
- ✓ Added CR/LF to exported (Copy) PEC table for Mac happiness.
- ✓ Bisque TCS control text tweaks.
- ✓ Added CR/LF to Bisque TCS text files (not just LF) for Mac compatibility.
- ✓ Command text tweaks.
- ✓ The Image Link Search tab is forward by default (so .ui changes don't put, say, All Sky tab first)
- ✓ When using the new gear icon, the wrong preference page might have been displayed.
- ✓ Added a device setup “”gear icon next to device name on control dialogs.
- ✓ When No OpenGL is selected, show more meaningful messages for commands that require OpenGL.
- ✓ Tweak wording of Preference options.
- ✓ TPoint graphic is now dark red in night vision.
- ✓ Prevent choosing a SBIG filter wheel unless the camera is an SBIG camera.
- ✓ Filter wheel filter selection goes blank when connecting to a filter wheel with less filters then a previously connected filter that had, say the last filter selected.
- ✓ On Windows, wasn't initializing the filter wheel and rotator threads for possible COM calls in case COM used in x2 driver implementations.
- ✓ When scripting sky6Dome, errors on asynchronous operations throw an exception in the context of the corresponding monitoring function.
- ✓ When scripting TheSkyX’s mount, errors on asynchronous operations are now thrown within the context of IsSlewComplete.
- ✓ Made camera’s AutoSave file name match CCDSoft’s convention w/r/t when AutoDark is turned on.
- ✓ Image scroll bars appear when reusing a image going from small to large or large to small.
- ✓ Added changes for Centurion to mount list.
- ✓ Updated filter wheel, mount and detector geometry list (file may not be included with daily build).
- ✓ Parking Gemini now also turns tracking off.
- ✓ Bug fix: camera’s status text might become blank after encountering an error when attempting to connect.
- ✓ Added and "Auto Selection" for SBIG filter wheels (file may not be included with daily build).
- ✓ Possibly fixed erroneous ProTrack display values by limiting declination near poles.
- ✓ Fixed a crash when taking a photo after aborting then changing binning to result in a larger image. Also fixed a misaligned image when taking a photo after aborting then changing binning so that had a smaller image resulted.
- ✓ The state of the “Fit To Window” option of the FITS viewer is maintained while the windows stays open (across open/close and when a new CCD image appears).
- ✓ Satellite sgp4sdp4 code fix.
- ✓ OutputSplash.txt has more information on error to aid in debugging.
- ✓ Updated remaining minor planet center URL references

- ✓ Fixed a bug that would cause Image Links to fail when doing automated pointing calibration runs.
- ✓ When the *camera* simulated a DSS photo, going to the fits header displayed in the FITSViewer was for the 3 HDU, not the primary HDU.
- ✓ Click to find an object no longer removes focus from the Camera tab.
- ✓ Updated TheSkyX's default URLs for the Minor Planet Center downloads (from .org to .net)
- ✓ Any error that prevented start up while creating TheSkyX's model would incorrectly by mapped to error code 1.
- ✓ Gemini window controls are now updated upon connect/disconnect.
- ✓ Attempting to open a .hrz file that was generated by TheSky6 (and is incompatible with TheSkyX) from the Telescope Limits window no longer causes a crash.
- ✓ TheSkyX would crash on start or when choosing Tools, Image Link. Made opening an all sky database robust (*.allsky), as customers where choosing, say a FIT file for the all sky database file.
- ✓ ProTrack clean up – status not updated after disconnection.
- ✓ TCFS settings now persistent.
- ✓ Updated sky6DataWizard documentation.
- ✓ When editing a comet's orbital element data, TheSkyX now correctly shows the epoch day when the value exceeds 31 (for example: Hale-Bopp).
- ✓ Added text “CWD” (counterweight down) to Gemini's “Slew to Start Position” button.
- ✓ Added configurable park position for Gemini mounts.
- ✓ Put a run time limit on any log file of 0.5 MB.
- ✓ Exposed sky6Raven object to java script engine (oversight).
- ✓ Fixed crashes when TheSkyX was *not* running OpenGL and CCDSoft did a Comparison Star Chart or Insert Minor Planets or running TheSkyXGrabScreen.js — OpenGL is required for these features.
- ✓ Introduced in daily build 4626 when connecting to some SBIG cameras would result in “SBIG driver: Bad parameter.”
- ✓ CCDSoft's @Focus2 would fail if either the “slew to” or “auto exposure” options where turned on which required integration with TheSkyX.
- ✓ *Selectable* focuser support - focuser support existed previously, but didn't allow an ad hoc focuser.
- ✓ The SerXInterface of the X2 Standard allows parity to be configured in third-party drivers.
- ✓ The FilterWheelDriverInterface has been published for the X2 Standard.
- ✓ For java script, the result of sky6DataWizard.RunQuery now resolves to a sky6ObjectInformation (was not a problem on Windows via COM).
- ✓ New Zealand DST now begins on the first Sunday of April.
- ✓ Fixed a bug that would cause TheSkyX to crash when editing the date and time format to include a large number of abbreviations.
- ✓ Moon's features are no longer found when the Moon was not on the Sky Chart.
- ✓ Include a note about the differences in TheSkyX vs. Telescope Time Zone on the Location,Date,Time window.
- ✓ Setting a Celestron hand paddle's location is correct the southern hemisphere.
- ✓ Changed BisqueTCS dialog to show Common and Advanced settings.
- ✓ Fixed getting bad temperature from the Paramount MX.
- ✓ Handle error condition caused by unplugging USB Paramount ME/MX more gracefully.

- ✓ Fixed regression bug that prevented Temma's tracking rate from being turned on via script.
- ✓ Save and restore the state of PEC for the Paramount across exit/restart of TheSkyX.
- ✓ Cycles/second displayed for version 2 satellite tracking is now correct.
- ✓ Drawing the horizon with the telescope works correctly.
- ✓ Save and restore the state of PEC for the Paramount across exit/restart of TheSkyX.
- ✓ Fixed random hang at “Displaying Photo” with TheSkyX camera add on.
- ✓ Paramount obeys Home After Connect option.
- ✓ Paramount now restores the state of ProTrack.
- ✓ Slew prior now works correctly.
- ✓ Fixed crash creating the All Sky Image link database.
- ✓ TheSkyX now retrieves a “more accurate” version of OpenGL for NVIDIA graphics hardware.
- ✓ On Labels window, changed the wording on the checkbox option from “Number of Labels on Chart" to "Maximum Number of Labels on Sky Chart”.
- ✓ TheSkyX's DATEOBS keyword no longer include the "Z".
- ✓ Fixed a Qt regression bug where QFileInfo's isWritable now returns false for files that do not exist, so that new movie files can now be created.
- ✓ Updated movie creation error messages.
- ✓ Fixed a display bug for southern hemisphere longitudes on AP mounts.
- ✓ Disable Super Model during recalibration runs.
- ✓ Enabled settings for the Paramount’s built-in focuser which allowing changing the current position, min and max limits.
- ✓ Show “Run Date” for a TPoint calibration run.
- ✓ To avoid confusion, bring “Pointing Data” tab forward when appropriate (as opposed to "Recalibration Data").
- ✓ Changed default viewing orientation of the virtual mount to be in front of the mount looking south.
- ✓ Don't allow identifying a TPoint calibration point unless it is visible (either path or point).
- ✓ Choosing Connect from the Telescope menu, prompt to Find Home if not homed.
- ✓ Show “Recalibration” TPoint graph when appropriate.
- ✓ Fixed a crash when pressing Revert with no sync history.
- ✓ Turning off tracking on the MX status says "Not Tracking"
- ✓ Updated device and driver descriptions based on selection.
- ✓ Paramount’s flip HA is displayed in hours (not minutes).
- ✓ Updated common star label database /Resources/Common/Core SDBs/star labels.SDBX and /Resources/Common/Core SDBs/star labels.txt.
- ✓ Changed Paramount MX default “flip hour angle” to 1.5 hours from 2.5 hours
- ✓ Added command for programming MKS 5000 firmware,
- ✓ Added “Tonight's Observing Parameters” dialog under Imaging System Setup. Allows a TPoint pointing run to have a set of observing parameters and TheSkyX to have a “nightly” set of observing parameters. Allows a pointing run where star ra dec is identical to scope ra dec when setting pressure to zero. (IOW, TheSkyX's general purpose refraction calculations are accessible via the new UI.)
- ✓ Changed the criteria as to when to apply telescope modeling if one or more terms is fixed (critical for recalibration case).

- ✓ Fixed a bug where graphical pointing samples were plotted in the wrong location (applying precession twice) - did not affect pointing, just a display item (the object info was therefore corrected as well).
- ✓ Allow re-cal on 15 points instead of 50 (makes testing recalibration easier).
- ✓ When dragging the flip hour angle using the star chart graphic, the Bisque TCS window reflects the new value.
- ✓ Bug fix for AP in southern hemisphere using TPoint.
- ✓ LX200 sync command now more flexible for other like protocols.
- ✓ Don't fail connection for LX200 when ACK command fails.
- ✓ The Paramount ME/MX dynamic flip HA gripper now always on screen. When dragging the flip HA, the value is shown near the gripper.
- ✓ Added Create Bitmap tab to Print Export dialog to TheSkyX Serious Astronomer Edition.
- ✓ When updating Bisque TCS motor firmware files, filter for *.bin and *.out, the latter is for the MKS 4000.
- ✓ Bisque TCS – edited TCS parameters go from red to black upon “Save All Parameters.”
- ✓ Possibly fixed a bug where the ProTrack status could display erroneous values.
- ✓ Daily Build Installer is now Mac compatible.
- ✓ Daily Build Installer provided improved status messages during install.
- ✓ Bug fix - LX200 remains responsive after a long period of communication.
- ✓ Bug Fix - AutoDark now works for Camera Add On, X2 drivers using rm_Image.
- ✓ The relay graphic on the Bisque TCS dialog is now correct.
- ✓ Daily build installer will prompt for TheSkyX's installation folder as a last resort.
- ✓ Added a clear button to satellite passes.
- ✓ Added text to error 22010 (invalid PEC table).
- ✓ Several minor Paramount MX PEC improvements.
- ✓ The Orientation of the virtual mount for the Paramount ME is now rendered correctly.

Version 10.1.10 (Build 4470) February 2011

New Features, Improvements and Enhancements

- ✓ The TPoint Add On includes a Super Model feature that creates an optimal pointing model with a single button click.
- ✓ TheSkyX can now perform blind, *All Sky Image Links* using the All Sky Image Link tab on the Image Link window. Your imaging system will never be “lost in space” again. Point your ininitialized telescope anywhere, take a photo. TheSkyX can quickly determine the exact astrometric solution for the photo. (Professional Edition only)
- ✓ New and improved Moon rendering that dynamically simulates crater and terminator shadows (this feature requires OpenGL 3.0 or later. The present Moon rendering technique is applied on computers running earlier versions of OpenGL).
- ✓ The Moon approximates the effects of earthshine.
- ✓ TheSkyX can now display galaxies from the PGC 2011 (Hyperleda).
- ✓ TheSkyX can now act as a TPC/IP server with the TCPServer command on the Tools menu. (Professional Edition only)
- ✓ TheSkyX can now run and debug Java scripts using the Run Java Script on the Tools menu. (Professional Edition only)

- ✓ Documentation for scriptTheSkyX released. TheSkyX Scriptable Objects documentation is available at: http://www.bisque.com/scripttheskyx.
- ✓ A Check for Update command in the Help menu helps ensure you are running the most latest update.
- ✓ Added Sun Transit to Set Special Times menu on the Date and Time window.
- ✓ Meade telescope driver provides simulated, software-based handbox key presses to access any handbox command.
- ✓ Meade telescope driver now includes the hardware-specific Park command.
- ✓ Added support for SBIG STX model cameras to the Camera Add On.
- ✓ Added support for SBIG ST-4000XM cameras to the Camera Add On
- ✓ Released X2GUI type interfaces, documenation can be found at www.bisque.com/x2.
- ✓ TheSkyX can now use the Meade telescope driver's native Park command to park telescope (by pressing the Park button on the Meade window). Using the native park command is required for proper shut down and subsequent mount initialization.
- ✓ Add a general purpose, thread safe, function for going from mount mechanical coordinates to topocentric (the Adjust T case). (Professional Edition only)
- ✓ Added a way to get to beyondThePole from the RASCOMTele interface (TheSkyX only, not TheSky6). (Professional Edition only) Sample script:

```
**********
Option Explicit
Const beyondThePoleCmd = 11
Dim result
Dim T
Set T = CreateObject("TheSkyXAdaptor.RASCOMTele")
T.Connect
Result = T.DoCommand(beyondThePoleCmd,"")
MsgBox Result
**********
```

- ✓ Added Civil and Nautical Twilight Times to Set Special Times list.
- ✓ Astronomical, Civil and Nautical Twilight Times are shown in the Sun report.
- ✓ TheSkyX now periodically updates the NexStar's tracking rate setting (to, for example, detect and display changes made directly on the hand paddle).
- ✓ Improved Moon's libration calculations.
- ✓ Added/Updated Alignment Star Databases:
    - Argo Navis Alignment Stars
    - Arp Globular Clusters
    - Gemini Alignment Stars
    - iOptron Alignment Stars
    - JMI Alignment Stars
    - JMI SuperMax Alignment Stars
    - Live Video Calibration Stars TMB
    - Meade Alignment Star LabelsX
    - NexStar Alignment Stars
    - Orion Intelliscope Alignment Stars
    - Sky Commander Legacy Alignment Stars
    - SkyCommander Alignment Stars

- Tele Vue Sky Tour Alignment Stars
- TPoint Stars
- Ultima 2000 Alignment Stars
- Vixen-Sphinx Alignment Stars

Changes and Bug Fixes

- ✓ Updated radio source SDB.
- ✓ Updated Double Double Companion Stars.
- ✓ TheSkyXAdaptor update that must be paired with TheSkyX.exe – methods alphabetized for (better/easier) "ScriptTheSkyX" documentation.
- ✓ Improved Image Link Results report layout.
- ✓ DST end date for UK after 1996 is now correct.
- ✓ Updated star labels (corrected two misspellings)
- ✓ Updated telescope and detector databases.
- ✓ Changed "Chart Rotation" to "Position Angle".
- ✓ Added data for additional Takahashi scope (FC-76), and two additional Canon cameras (500D/550D).
- ✓ Adjusted position of Rosette color photo and common name label.
- ✓ Added Double star companion SDBX.
- ✓ Reading in a set of Bisque TCS Parameters from a TCS file now works.
- ✓ The Slew Between Limits command now slews the RA axis in both directions.
- ✓ Updated the URL to get comets/minor planets by name from IAU.
- ✓ Laser pointer now highlights Iridium flares (regression).
- ✓ The *Whats Up?* report no longer includes solar system objects that are below the horizon.
- ✓ Zoom Tool now works when clicking inside the elliptical regions above and below the + and – signs, respectively.
- ✓ Fixed an issue where Paramount ME/DirectGuide using live video would occasionally fail.
- ✓ Starting a pointing calibration run no longer filters bright stars automatically. There is now a buttons on the Pointing Calibration Run tab of the TPoint Add On window that can be used to Show Only Bright Stars, which makes collecting and recording calibration data less error prone.
- ✓ Show Pointing Samples checkbox is now always in sync on the Celestial Objects tab and TPoint Add On window.
- ✓ Fixed an issue that prevented NGC and PGC labels from appearing on the Sky Chart.
- ✓ Fixed an issue that prevented the Digitized Sky Survey thumbnails and ellipses from appearing on the Sky Chart.
- ✓ Fixed plotting of SDB photos when No OpenGL is turned on.
- ✓ Native UCAC3 can be now be compiled properly (regression).
- ✓ Changed the Eclipse Viewer so that the eclipse list always starts on the first eclipse of the selected type.
- ✓ When searching for lunar eclipses, TheSkyX now backs up the date by one lunation.
- ✓ Going to Camera, Settings show the message "This device has no additional settings" when appropriate.
- ✓ Made minor changes to Photo menu.
- ✓ Possible bug fix to parking – (was writing as an int and read as a double).
- ✓ The non-DST time zone is set correctly from TheSkyX for iOptron and LX200 mounts.

- ✓ Fixed spelling error on satellite dialog.
- ✓ Added textual string to SBIG driver errors.
- ✓ Obey the “Home required for slews” TCS option for Paramounts.
- ✓ Cleaned up TheSkyX’s PEC curve fitting (PrecisionPEC equivalent).
- ✓ Setting the UseComputerClock Julian date didn't work. Also fixed a bug where the StarChart's UseComputerClock property wasn't correct.
- ✓ The To Google Map button was formatting latitude and longitude with local specific decimal point which Google does not want.
- ✓ The ra dec returned by RASCOMTele interface wasn't correct when tpoint was active.
- ✓ Renamed “Fix Time to the Computer Clock” checkbox text to “Prohibit all time changes…”
- ✓ Automatically turn off the “Prohibit All Time Changes…” checkbox when disconnecting the telescope.
- ✓ Show HardwareInfoInterface and DriverInfoInterface for domes, cameras, rotators.
- ✓ Fixed crash or memory leaks when choosing a new device (camera, dome, telescope) when the existing device was connected.
- ✓ Save individual constellation options (for example, click the Zodiac button, restart and there’s restored).
- ✓ Resolve an issue that could cause Image Link on Mac to crash occasionally.
- ✓ Separated Status Bar and Chart Status settings and abbreviated the text labels for parameters that appear in the Status Bar.
- ✓ Minimize Gemini window to fit in 600 pixel height screen.
- ✓ Press Zodiac and turn on “Show constellation drawings” works.
- ✓ The term’s sigma value in the TPoint Add On sigma value is shown correctly.
- ✓ Fixed a bug that caused the wrong NexStar tracking rate to be set and displayed by TheSkyX (NexStar dialog).
- ✓ Fixed bug setting AP mount GMT for southern hemisphere.
- ✓ Fixed a bug that prevented tracking rate for LX200 to be set to zero (turn tracking off).
- ✓ Minimize rounding errors when setting AP mount’s location.
- ✓ Fixed a bug in ProTrack so that the pointing correction output is updated.
- ✓ Fixed a bug that caused a crash when an object path was loaded.
- ✓ Telescope model sets “beyond the pole” status.
- ✓ TheSkyX no longer shows the message “Error 703 – Cannot open file” message when the Input > Small Solar System Bodies > Asteroid (Large Database tab) > “Load Large Database Asteroids Each Time TheSkyX is Started” checkbox is turned on, and no large asteroid database file name is present.
- ✓ Hawaii locations have been correctly to ingnore DST changes.
- ✓ Mosaic dialog is now modeless; cleaned up some issues when creating mosaics.

Version 10.1.9 (Build 4160) September 20, 2010

- ✓ Added an application setting to grow the Observing List up to 20,000 objects.
- ✓ Changed the Tools > Object Paths dialog considerably, including changing the Animate checkbox to Interactive and addressing numerous bugs.
- ✓ The mount simulator can now simulate park and unpark.
- ✓ Added the Object Paths command to the Tools menu.
- ✓ Fixed a bug where using the Equal To comparator in SDB queries failed due to whitespace.
- ✓ Fixed position of Object Path labels.

- ✓ Moon no longer disappears when its center is off the Sky Chart.
- ✓ Fixed a bug where some Tycho stars were not being labeled with Extended Labeling.
- ✓ Improved the orthographic plotting of horizons.
- ✓ Fixed a bug where the Edit Chart Elements dialog was snapping back to the last position (restored) when the dialog was used.
- ✓ Sped up the interaction when Magnitude sliders are used in Edit Chart Elements.
- ✓ Fixed a bug where FlipHourAngleMinutes was showing as 0 instead of the actual value that was in ImagingSystem.ini.
- ✓ Fixed a bug where the Navigate dialog showed the incorrect equatorial coordinates and constellation when moving the mouse.
- ✓ Connecting to an SBIG-402 no longer results in a “No Device Selected” error.
- ✓ Text (the edition feature comparison list) was incorrectly being copied to the Clipboard when TheSkyX was launched.
- ✓ Fixed bug that caused some lunar eclipses to be missed.
- ✓ Fixed a clipping bug for the orthographic horizon.
- ✓ Fixed a trail plotting bug for satellites in Orthographic Projection.
- ✓ Fixed a bug where Raven.SlewDomeToTelescope would return ERR_NOT_IMPL.
- ✓ Changed Horizon Photos Dialog so the supplied horizon photos and the custom horizon photos (in Application Support folder) are separated in a tree list.
- ✓ The Horizon Photos list in the Horizon & Atmosphere dialog is automatically updated when horizon photos are added to the *Horizon* Application Support folder.
- ✓ Bug Fix – legacycominterfaces.txt didn't include TheSkyXAdaptor.dll (relied only upon installation registration).
- ✓ Improved plotting of custom horizon in Gnomonic Projection.
- ✓ ProTrack tab is now available on the TPoint Add On window.
- ✓ BC years can now be entered by pressing the “–” key when the year (YYYY) portion of the date/time is highlighted.
- ✓ The telescope Mask FOVI transparency can now be changed on the Edit FOVI dialog.
- ✓ Parking the Paramount now works.
- ✓ TheSkyX.RASCOMTele’s park now disconnects the telescope like TheSky6 does.
- ✓ You can now double click on the Status Bar and the Preferences dialog will be displayed with the Status Bar options.
- ✓ New Feature – Mount simulator's az/alt position is persistent.
- ✓ RASCOMTele's connect also unparks (if parked) so it behaves like TheSky6.
- ✓ LX200 unpark now sets location/date/time/time.
- ✓ Aborting a telescope slew with the dome coupled, didn't abort the dome slew too.
- ✓ RASCOMTele's lastSlewError wasn't always correct.
- ✓ Changes to the Mosaic are now updated immediately, allowing interactive sizing, etc.
- ✓ Added a button to save a .hrz file that is linked with a horizon photo file so that the photo file can be loaded in the proper orientation.
- ✓ LX200 unpark puts in polar mode right before syncing to ra/dec of parked position.
- ✓ Can now search for stars using their DM designation such as B+19 2777 for Arcturus.
- ✓ Added an option to the Advanced tab of the Database Manager creates the optimized TheSkyX plot file from the native UCAC3 text files.
- ✓ The angular separation that is shown on the Find dialog now recomputes continuously so that the correct value is shown when two moving objects are selected.

- ✓ Changed the graphic on the Create Pointing Targets so that it is clear which “node” is which.
- ✓ Large database asteroid on Sky Chart queries are no longer clipped to 18 magnitude.
- ✓ Fixed a bug in the Small Screen Toolbar where keyboard input was being ignored.
- ✓ Fixed a bug where the Telescope toolbar was not showing up in the list of Toolbars for customization.
- ✓ Camera simulator default width and height are now both 800.
- ✓ Changing the camera’s Reduction option applies to automated pointing runs without having to take a photo from the Camera tab.
- ✓ Fixed bug where Moon's shadow could not be turned off.
- ✓ Fixed OpenGL flickering problem that occurs on some graphics cards/driver combinations.
- ✓ Optionally have AutoDark subtraction use all available processor cores.
- ✓ Optionally allow mount drivers’ establish link to be called from the user interface thread, rather than a background thread. See *LinkFromUIThreadInterface* documentation.
- ✓ Added the Slew Prior command. This command appears in the Tools Menu on the telescope tab and can be added to a toolbar.
- ✓ FOVI grips now disappear when the FOVI disappears due to changes in the FOV.
- ✓ Fixed bug where right-clicking on stellar extended labeling was not working.
- ✓ Added Connect and Disconnect buttons to the camera dialog.
- ✓ Added two FOVI options to the Image Link dialog. The first for adding a FOVI that matches the computed scale and position angle of the image link. The second option allows automatically rotating all active FOVIs to the computed position angle each time a on image link is performed.
- ✓ New Feature-Dome setup has a configurable *update interval*.
- ✓ Fixed a bug where large database asteroid queries of the asteroids visible on the Sky Chart was clipping to 18 magnitude.
- ✓ Fixed a bug in the Small Screen Toolbar where keyboard input was being ignored.
- ✓ Fixed a bug where the Telescope toolbar was not showing up in the list of Toolbars for customization.
- ✓ Fixed two bugs related to time skips from twilight to twilight. After midnight twilight cases are now handled correctly, and the DST also now handled correctly.
- ✓ Added an app setting that allows stopping all rendering/updating when TheSkyX is minimized (Windows only) for both OpenGL and Non-GL plotting.
- ✓ The Sleep button now correctly shows the state of the sleep for all states.
- ✓ Fixed bug where constellation label state was not updated properly.
- ✓ Automatically save panoramic horizon settings for each photo.
- ✓ Automatically import TheSky6's .horizon file to restore panoramic horizon photo position.
- ✓ The Create Tours dialog now has file saving and opening that places the tours (which are just .skyx settings files) in the Tours folder.
- ✓ Automated pointing run files are saved into the correct support files folder.
- ✓ Added better handling of graphics when the frame rate is set below 20 FPS, or a slow computer is in use.
- ✓ Made changes to ImageLink so that NOMAD is ignored unless a very small FOV is used.
- ✓ Downloaded Satellites, Comets, Asteroids files go to <Application Support> folders instead of the <AppData> folder. The consequence is that users will now backup these files, but going to shows etc where there is no Internet connection, going to file open should display the last downloaded file so users can select it.

- ✓ Fixed a bug where the NOMAD catalog was not used properly for ImageLink.
- ✓ Added the "Log current telescope position to" option for backward compatibility with TheSky6.
- ✓ Treat the Gemini as a GEM for TPoint pointing calibration convention.
- ✓ TheSkyX's Dome Add On now has a DomeAPI driver selection. This means DomeAPI drivers written for AutomaDome for Windows now work with TheSkyX directly, independent of AutomaDome. This makes AutomaDome for Windows a legacy application.
- ✓ ImageLink is now accessible from scripting languages.
- ✓ Bug Fix – ImageLink "Close FITS" now clears the dialog title, dialog image and chart image.
- ✓ List Bisque TCS and Bisque TCS Professional in list of supported mounts.
- ✓ Bug fix – Find Flares now works even when all satellites from web (4000+) are loaded.
- ✓ Fixed bug where turning off an SDB with the items tab displayed caused a crash.
- ✓ Use mono-spaced font in Telescope Communications Window and made telescope log output more human readable.
- ✓ Correctly save and restore the positions of many dialogs.
- ✓ New Feature – Automated pointing run now highlights the active target while running.
- ✓ Adjusted position of Jupiter's Great Red Spot.
- ✓ Added a button to get the image scale from a successful Image Link to the Known scale.
- ✓ Added a GEM checkbox for NexStar telescopes so that TPoint pointing calibration works properly for Celestron GEMs.
- ✓ Fixed Hercules in H.A. Rey Constellation lines.
- ✓ Automated pointing run bug fix when Auto Darks on.
- ✓ Changing the camera's Reduction option applies to automated pointing runs without having to Take a photo from the camera tab.
- ✓ Bug Fix – No longer encounter a "Command in Progress" message when running @Focus2 from CCDSoft (focuser go to's were being performed asynchronously from the RASCOMTele interface when they should have been synchronously).
- ✓ Tools > Open FITS command and Image Link's Open FITS command now use the same folder.
- ✓ Horizon Photos can now be 8-bit and lower photo formats (with no transparency or "alpha channel").
- ✓ Crash on connect to DomeAPI.
- ✓ Bug Fix – TeleAPI wrapper now uses "int" for parameters originally declared as BOOL.
- ✓ The LX200 driver no longer requires a response from the ACK command (Autostar III LS do not respond to this command).
- ✓ Camera's Take Photo uses the TheSkyX's "current target" for coordinates if there is no telescope connection.
- ✓ Fixed a bug where various magnitude filters were being reset to star values on startup.
- ✓ Camera simulator has light and dark frame values.
- ✓ Bug Fix – Reduction set to AutoDark when using "CCDSoft's Camera" now works.
- ✓ Added AppSettings to edit the "fast" and "slow" focuser sizes of the RASCOMTele interface (used by CCDSoft's @Focus).
- ✓ Changed the transition field of view when larger planets switch from the small symbol to an extended ellipse so that the planet is visible at all fields of view.
- ✓ Bug Fix – The Image Scale Helper *Take Photo And Image Link It* button wouldn't work after aborting a pointing run with the error "Process Aborted".

- ✓ Bug Fix – TheSkyX can now set the LX200 classic's date (was reporting a command failed message).
- ✓ Prevent pointing calibration samples from being added to the model when the telescope is slewing.

Version 10.1.8 (Build 3919) Released June 18, 2010

- ✓ Changed the minimum value for the Residual Filter on the Astrometry dialog from 0.20 to 0.10.
- ✓ Printed charts now show equatorial grid line labels.
- ✓ Added the ability to edit the printed chart title on the Export Chart dialog.
- ✓ Fixed a bug with MyFOVs.Property reading if skMyFOVProp_Visible was 1 or 0 didn't work.
- ✓ Added Chart Center RA/Dec 2000 as an option for chart status window.
- ✓ Observing list labeling now includes the last object in the list.
- ✓ Added an action (that is available via a customized toolbar) for toggling the linked photos.
- ✓ The *Database Add On* node now shows a graphic indicating the *TheSkyX Database Add On* path is set and that the databases are present at that location.
- ✓ When the DB add on path is set, the NOMAD and UCAC3 catalogs are turned on, and the tree is rebuilt and expanded to show this.
- ✓ Removed 0.50 pixel convention when absorbing CCDSoft sources.
- ✓ Right mouse clicks now work in No OpenGL mode.
- ✓ *TheSkyX* no longer crashes upon restart when <My Documents> folder has Unicode characters.
- ✓ When choosing the Database Add On drive/volume, it is automatically selected by default when possible.
- ✓ Improved the scripting error architecture.
- ✓ Allow negative values on dome geometry.
- ✓ The min/max FOV settings on SDBS is now ignored when doing an SDB query.
- ✓ Gemini mounts are now treated as a GEM w/r/t TPoint model.
- ✓ The state of extended labels is now saved within the .SKYX settings file.
- ✓ Now reset the Find dialog's auto-completer when satellites change.
- ✓ The *ObjectInformation* object returned by DataWizard.RunQuery is now populated correctly.
- ✓ When attempting to set MyFOVI reference frame, the exception ERR_INDEX_OUT_OF_RANGE is no longer thrown.
- ✓ All mounts are slewed to refracted coordinates (except LX200).
- ✓ Good pointing samples are no longer flagged as likely being in error.
- ✓ Jog amounts now show arcseconds not seconds.
- ✓ No longer show angular separation in calibration run spread sheet - not meaningful information in light of modeled verses raw telescope coordinates.
- ✓ Added message in TPoint when editing fixed terms.
- ✓ The To Clipboard command in Mosaic now copies the centers to the Clipboard.
- ✓ For TPoint Add On, the Remove Term now works on selected terms (instead of deleting all additional terms).
- ✓ Suggest and Remove term buttons are now disabled while "Suggest Terms" is iterating.
- ✓ Added icon for Imaging System Setup dialog.
- ✓ Editing a color now shows its alpha channel (Windows) or Opacity (Mac).

- ✓ *TheSkyX* now properly sets Astro-Physics mount's local date and time.
- ✓ *TheSkyX* now sets the time zone properly in Daylight Saving Time for mounts that use, or use a subset of, the LX200 command protocol (Astro-Physics, Meade, iOptron and Gemini).
- ✓ Changed the layout of the Find dialog box to always show the object name, symbol and object-specific buttons.
- ✓ Added slew time estimate to slew to loop for Paramount mounts.
- ✓ Dates between 001 and 999 now appear correctly in the Chart Status window.
- ✓ Displaying Multiple Graphs in the TPoint Add On now works.
- ✓ Added a Suspend Telescope Connection command in the Telescope Setup dialog.
- ✓ DSS Setup dialog has a Close button instead of an OK/Cancel buttons.
- ✓ DSS Setup dialog now remembers the tab that was last used.
- ✓ Added an application setting for specifying whether or not the Observing List is automatically saved/loaded on exit/startup.
- ✓ GSC identifiers are now being set on database queries.
- ✓ NOMAD and UCAC3-specific magnitudes are now shown in the Object Information report.
- ✓ Added a Log tab to the Find Dialog that shows Observers Log information for the current target object and allows adding Observations (page 65). Previously, observing logs could only be accessed through the Observers List.
- ✓ LX200 mounts can unpark successfully now.
- ✓ Added Paramount GT-1100S and Paramount MX to the list of supported mounts.
- ✓ The TPoint Add On Polar Alignment Report now employs a less restrictive criteria for detecting a poor model for polar alignment recommendations.
- ✓ The frame around photos in Photo Viewer and on preview window on the Photo window is now smaller.
- ✓ Changed Linked Image text to Linked Photo.
- ✓ Telescope jogs now use the raw telescope coordinates; they do not include refraction or modeling.
- ✓ Telescope tab is brought forward upon telescope connection.
- ✓ Move is default tab on the Telescope dialog.
- ✓ Jog default amount is now 10 arcminutes.
- ✓ The list of jog distances is now sorted smallest to largest.
- ✓ Image Link now works for FITS photos with the height greater than the width.
- ✓ *TheSkyX's* installer now registers *TheSky6* type library so that third-party applications can access *TheSkyX's* scripting model.
- ✓ Fixed a bug where the Observing List filter's "equals" string comparator was not trimming the Sky Database (SDB) field string, so exact matches were not found.

Version 10.1.7 (Build 3828) May 7, 2010

- ✓ Fixed a bug that prevented entering FOVIs with multiple elements.
- ✓ Height of Object Information Report now scales to the height of the font.
- ✓ TheSkyX's StarChart object is now applying RA and Dec sets properly.
- ✓ Added camera temperature regulation to the Basic Camera Add On.

Version 10.1.6 (Build 3784) April 19, 2010

Note: This was the initial release of TheSkyX Professional Edition

- ✓ Added a Planet Report that includes a variety of Sun, Moon and planet ephemerides and other body-specific data.
- ✓ Video driver incompatibility workaround—changed OpenGL calls so that horizon and other graphics items do not disappear when using Intel display adaptors.
- ✓ Bug fix—Added Cepheus constellation line for Wil Trion set.
- ✓ Bug fix—For locales where decimal and separators differed from US (“.” and “,” respectively), custom locations floating point numeric values were being truncated at the decimal level.
- ✓ Bug fix—FOVIs: No longer allow click OK while selecting a root item in the list of telescopes, which isn't a valid selection which was confusing.
- ✓ Bug fix—Julian date displayed in Find tab is now shown to a more appropriate number of significant figures.
- ✓ Bug fix—mirror photos when the Show Mirror Image command is turned on.
- ✓ Added NexStar-specific telescope commands dialog.
- ✓ Added Sky Commander/ServoCAT support.
- ✓ Bug fix—The Edit Chart Element dialog wasn’t in sync with changes that happen outside of it.
- ✓ Added Cross Hair Update Interval option to the Telescope > Telescope Setup dialog.
- ✓ Bug fix—horizon/equatorial lines fonts/widths are now correct.
- ✓ Bug fix—changes to time zone and elevation are now immediately applied.
- ✓ Bug Fix—mounts that cannot report which side of the pier they are on will now point “better” w/r/t TPoint.
- ✓ Bug fix—“Software imposed slew limits” can be over-ridden.
- ✓ Bug fix—Display > Non-Stellar Options dialog, the Hollow Deep Sky option is no longer ignored.
- ✓ Bug fix— Display > Non-Stellar Options dialog, a “fuzzy” value of 0 is now applied correctly.
- ✓ Sky Database pens and brushes can now have an alpha channel.
- ✓ Setting the pen color now works in a drawing Sky Database.
- ✓ The Status Bar can now be configured to show Sky Chart Status information. To optimize screen real estate, items placed in the Status Bar do not include a text prefix, as they do in the Chart Status window. For example, the date in the Status Bar appears as just: *12/22/2020*.
- ✓ Added angular separation and position angle from prior object to Object Information Report on the Find dialog.
- ✓ Corrected AP Park Positions (labels were wrong).
- ✓ Moon's Long/Lat are shown separately from the Moon Feature Information text box.
- ✓ Fixed a regression bug that prevented showing Moon Viewer photos.
- ✓ Changed name of *TheSkyX* supplied Sky Databases from “System” to “Core Sky Databases” in the Database Manager dialog.
- ✓ All negative values for offsets in FOVIs.
- ✓ Added TeleAPI to list of supported telescopes.
- ✓ Corrected spelling of the star Alnair.

- ✓ Updated/added SBIG detectors and corrected the relative position of the autoguider for the SBIG STL-4020M model camera.
- ✓ Corrected misspelling of Sirius in tour description.
    - o Enabled the app option to turn off AutoSave (was forced to on and disabled) and added an option to turn off being prompted to save modified settings. Sky Chart settings are “dirtied” better now, but not “perfectly” (on the conservative side). These changes allow customers more flexibility w/r/t multiple charts and is more like what TheSky6 Pro offers.
- ✓ The format of the date and time that is displayed in *TheSkyX*’s custom Date & Time control can now be configured. Right-click on the control to edit the format.
- ✓ Bug fix—prevent loading large database asteroids while load in progress.
- ✓ Bug fix—Percent status is now correct while converting large database asteroid text file.
- ✓ Cleaned up Asteroid (Large Database) dialog.
- ✓ Night Vision Mode under Windows no longer requires Windows themes.
- ✓ Fixed printing of ellipses (galaxies, etc.)
- ✓ When FOVI groups are selected (like Telescopes+Eyepieces) the Combine message now correctly displays the number of combinations.
- ✓ Bug fix—Positions of the galactic poles are now precessed to the current equinox.
- ✓ Version 10.1.3 (Build 2930) July 24, 2009
- ✓ Higher accuracy computations for Jupiter’s and Saturn's moons.
- ✓ Shadows of Jupiter’s major moons now appear on the planet.
- ✓ Jupiter and Saturn’s moons can now be locked on.
- ✓ Jupiter’s and Saturn’s major moons can be located using the Find command.
- ✓ Added pulse focuser support for mounts that support pulse focusers through the telescope protocol (LX200/Autostar/AP GTO/Gemini).
- ✓ Comet perihelion date now uses full precision from orbital elements.
- ✓ Stereographic spelled correctly in Projections dialog.
- ✓ Double-clicking tree list to add a “My FOVI” now works correctly.
- ✓ Clicking Cancel button when editing a new FOVI no longer creates the FOVI.
- ✓ Press Insert/Delete keys to add/remove My FOVIs.
- ✓ The type Circle no longer appears in the Shape List when editing FOVIs.
- ✓ Can double-click My FOVI list to edit them.
- ✓ Increased the minimum size of the FOVI edit fields for better readability on the Mac.
- ✓ E/W offset option renamed to East/west offset; N/S offset renamed to North/south offset on the Edit Detector dialog.
- ✓ Center telescope cross hair now corrects for coordinate offset caused by TPoint model.
- ✓ Corrected location for observatory in India.
- ✓ Fixed a bug that caused *TheSkyX* to crash when connecting to the Temma.
- ✓ Fixed a bug that caused the Temma to hang on connection.
- ✓ The “Always keep telescope crosshairs on screen” option is now saved.
- ✓ On the Mac, after a crash, re-starting *TheSkyX* and clicking cancel when prompted for a serial number would keep incrementing the multi-instance index. It is also possible that this fix might lessen the cases when starting again on the Mac after a crash goes to a new instance. On Mac (Unix OS) shared memory can survive a crash. Restarting the computer is the only way to free it.
- ✓ Turning on/off FOVI’s from Chart Elements tab now works.

- ✓ The “Slew button always disabled after slew” issue with Vixen HTTP telescopes is fixed.
- ✓ Set both date and time in Gemini and LX200 driver (date was not always set correctly).
- ✓ Reboot Gemini command now works.
- ✓ Button text “Find Now” changed to “Find” on the Find window and Telescope window.
- ✓ “Find” text on Telescope window changed to “Search For” for consistency with Find window.
- ✓ Increased default width of SDB manager window.
- ✓ Changed the maximum size for FOVI to 50 degrees.
- ✓ *TheSkyX* Windows installer no longer allows individual features to be selected when there’s insufficient space on a drive.
- ✓ Stellar catalogs are now saved and restored when opening an observing list query.
- ✓ FOVI’s now drawn after Photo SDBs.
- ✓ Constellation label checkbox in Chart Elements now works.
- ✓ Numerous bug fixes related to changing the magnitude limits of single and multiple chart elements.
- ✓ Fixed bug where clicking on planet moon reverted to Earth’s Moon.
- ✓ The Tools > Show Satellites > Find Best Passes option now works (regression bug).
- ✓ NexStar telescope cross hair position is now always correct.
- ✓ Increased NexStar’s time out time to 3.5 seconds (per protocol specifiction)
- ✓ Changed *My Chart Element #* heading to Element #.
- ✓ Jupiter’s major moons can now by located from the Display > Find window.
- ✓ Herschel and Caldwell labels are no longer filtered when the corresponding NGC/IC has already been plotted.
- ✓ Renamed “Allow scrolling below the horizon picture” to “Allow Sky Chart to be scrolled below the horizon" (Display > Horizon and Atmosphere dialog).
- ✓ The ***Allow Sky Chart to be scrolled below the horizon*** option can be accessed when either “Photograph” or “Custom Horizon” is selected.
- ✓ FOVIs fill color can now be edited.
- ✓ The default fill for circular FOVIs in Map-Like View is transparent.
- ✓ For object types that cannot be turned on or off, the state of the Visible checkbox in the Chart Elements list is set to “indeterminate”.
- ✓ Telescope can be slewed to any ra/dec or az/alt coordinate from the Telescope windows Tools > Slew To Coordinates command. (Or the Enter Coordinates tab of the Orientation > Navigate window).
- ✓ Disabled diagonal move buttons for telescopes that do not support this feature.
- ✓ Added the native Set Sidereal Tracking Rate and Turn Tracking Off commands to the AP-Specific dialog.
- ✓ Changed the text “Related Find Results” to "Related Search Results" on the Display > Find window.
- ✓ Updated telescopes listed in FOVI telescope database (including RCOS telescopes).
- ✓ Searching for Asterisms now works (recompiled Asterisms.txt).
- ✓ Changed moonlit side of symbol on date calendar for first and last quarter Moon.
- ✓ Add a provision to (externally) abort serial operations that may timeout.
- ✓ For mounts that can set tracking rates, but not get/read them, provide a convention so that an agnostic (non bias) status message may result.
- ✓ Telrad Finder is now the correct size.

- ✓ Added the Telescope Simulator to the list of supported telescopes (under Software Bisque).
- ✓ Improved Telescope Simulator's cross hair motion (slews now simulate acceleration and deceleration).
- ✓ The automated location look up via IP is now more robust wrt invalid http responses.
- ✓ The LX200 can now automatically synchronize at the home position after a park and reconnection to *TheSkyX*.
- ✓ Added an abortable progress indicator window that appears when loading observing lists with large numbers of objects.

Version 10.1.2 (Build 2845) May 7, 2009

- ✓ Initial Release of *TheSkyX Serious Astronomer Edition* for both Mac and Windows.

Appendix I: Keyboard Shortcuts

The table below lists *TheSkyX's* main menu commands and the appropriate Mac and Windows keyboard shortcuts. Menu commands without a keyboard shortcuts are left blank.

Menu	**Command or Pop-Up Menu**	**Keyboard Accelerator Mac**	**Keyboard Accelerator Windows**
TheSkyX (Mac only)			
	About TheSkyX		
	Preferences	COMMAND+, (⌘,)	
	Hide TheSkyX	COMMAND+H, (⌘H)	
	Hide Others	SHIFT+COMMAND+H (⌘H)	
	Show All		
File			
	New	COMMAND+N (⌘N)	CONTROL+N (CTRL+N)
	Open	COMMAND+O (⌘O)	CONTROL+O (CTRL+O)
	Save	COMMAND+S (⌘S)	CONTROL+S (CTRL+S)
	Save As	SHIFT+COMMAND +S (⇧⌘S)	CONTROL+SHIFT+S (CTRL+SHIFT+S)
	Print	COMMAND+P (⌘P)	CONTROL+P (CTRL+P)
	Print Setup	SHIFT+COMMAND +P (⇧⌘P)	CONTROL+SHIFT+P (CTRL+SHIFT+P)
	Export Chart		
	Exit	n/a	CONTROL+Q (CTRL+Q)
Edit			
	Find	COMMAND+F (⌘F)	CONTROL+F (CTRL+F)
	Paste Photo	COMMAND+V (⌘V)	CONTROL+V (CTRL+V)
	Copy	COMMAND+C (⌘C)	CONTROL+C (CTRL+C)
Display			
	Photo Like	OPTION+COMMAND+P (⌥⌘P)	CONTROL+ALT+P
	Map Like	OPTION+COMMAND+K (⌥⌘K)	CONTROL+ALT+K (CTRL+ALT+K)
	Celestial Objects Pop-Up		
	Show Stars		
	Show Variable Stars		
	Show Double Stars		
	Show Clusters		
	Show Galaxies		
	Show Nebulas		

Menu	Command or Pop-Up Menu	Keyboard Accelerator	
		Mac	Windows
	Field of View Indicators	COMMAND+6 (⌘6)	CONTROL+6 (CTRL+6)
	Show Mirror Image		
	Full Screen	COMMAND+F8 (⌘F8)	CONTROL+F8 (CTRL+F8)
	Show Daylight	OPTION+COMMAND+A (⌥⌘A)	CONTROL+ALT+A (CTRL+ALT+A)
	Show Night Vision Mode	OPTION+COMMAND+J (⌥⌘J)	CONTROL+ALT+J
	Constellation & Asterism Options		
	Horizon & Atmosphere Options		
	Star Options		
	Milky Way Options		
	Find		
	Date And Time		
	Labels		
	Photos		
	Chart Elements		
	Tours		
	Observing List		
	Chart Status		
	Telescope-Specific Commands		
	Nexstar		
	Meade		
	Astro-Physics		
	iOptron		
	Gemini		
Orientation			
	Look Pop-Up		
	Look North	OPTION+COMMAND+N	CONTROL+ALT+N
	Look South	OPTION+COMMAND+S	CONTROL+ALT+S
	Look East	OPTION+COMMAND+E	CONTROL+ALT+E
	Look West	OPTION+COMMAND+W	CONTROL+ALT+W
	Look Up	OPTION+COMMAND+Z	CONTROL+ALT+Z
	Zoom To Pop-Up		
	Minimum 30'	OPTION+COMMAND+END (⌥⌘↘)	CONTROL+ALT+END

Menu	Command or Pop-Up Menu	Keyboard Accelerator	
		Mac	Windows
	Telescope 1°	OPTION+COMMAND+T (⌥⌘T)	CONTROL+ALT+T (CTRL+ALT+T)
	Finder 10°	OPTION+COMMAND+F (⌥⌘F)	CONTROL+ALT+F (CTRL+ALT+T)
	Binocular 50°	OPTION+COMMAND+B (⌥⌘B)	CONTROL+ALT+B (CTRL+ALT+B
	Naked Eye 100°	OPTION+COMMAND+Y (⌥⌘Y)	CONTROL+ALT+Y (CTRL+ALT+Y)
	Wide Field 180°	OPTION+COMMAND+I (⌥⌘I)	CONTROL+ALT+I (CTRL+ALT+I)
	Maximum	OPTION+COMMAND+HOME (⌥⌘↖)	CONTROL+ALT+HOME (CTRL+ALT+HOME)
	Move Pop-Up		
	Move Up	SHIFT+↑ (⇧↑)	SHIFT+UP ARROW (SHIFT+UP)
	Move Down	SHIFT+↓ (⇧↓)	SHIFT+DOWN ARROW (SHIFT+DOWN)
	Move Left	SHIFT +← (⇧←)	SHIFT+LEFT ARROW (SHIFT +LEFT ARROW)
	Move Right	SHIFT +→ (⇧→)	SHIFT+RIGHT ARROW (SHIFT+RIGHT ARROW)
	Navigate Pop-Up		
	Zoom In	SHIFT+PAGE DOWN (⌥⌘⇟)	SHIFT+PAGE DOWN (SHIFT +PGDOWN)
	Zoom Out	SHIFT+PAGE UP (⌥⌘⇞)	SHIFT+PAGE UP (SHIFT +PGUP)
	Terrestrial Sphere	OPTION+1 (⌥ 1)	ALT+1
	Celestial Sphere	OPTION+2 (⌥ 2)	ALT+2
	Free Rotation		
	Rotate Clockwise	OPTION++ (⌥ +)	ALT++
	Rotate Counterclockwise	OPTION+– (⌥ –)	ALT+–
Input			
	Location	COMMAND+L (⌘L)	CONTROL+L (CTRL+L)
	Date and Time	COMMAND+T (⌘T)	CONTROL+T (CTRL+T)
	Small Solar System Bodies	COMMAND+1 (⌘1)	CONTROL+1 (CTRL+1)
	Satellites	COMMAND+2 (⌘2)	CONTROL+2 (CTRL+2)
	Database Manager	COMMAND+3 (⌘3)	CONTROL+3 (CTRL+3)
	Create Sky Database	COMMAND+4 (⌘4)	CONTROL+4 (CTRL+4)

Menu	Command or Pop-Up Menu	Keyboard Accelerator	
		Mac	Windows
	My Chart Elements	COMMAND+5 (⌘5)	CONTROL+5 (CTRL+5)
Tools			
	Manage Observing List	COMMAND+M (⌘M)	CONTROL+M (CTRL+M)
	Rotate Tool	COMMAND+R (⌘R)	CONTROL+R (CTRL+R)
	Angular Separation & Position Angle	SHIFT+COMMAND+R (⇧⌘R)	CONTROL+SHIFT+R (CTRL+SHIFT+R)
	Tours		
	Create Tour		
	Conjunction Finder		
	Solar and Lunar Eclipse Viewer		
	Calendar		
	Moon Photo Viewer		
	Reports		
	Iridium Flares		
	Object Paths		
	Solar System		
	3D Stars		
	Satellites From Above Earth		
	Image Link	SHIFT+COMMAND+I (⇧⌘I)	CONTROL+SHIFT+I (CTRL+SHIFT+I)
	Mosaic Grid		
	Place Photo		
	Time Skip Pop-Up		
	Computer Clock	OPTION+N (⌥N)	ALT+N
	Go Forward	OPTION+> (⌥>)	ALT+>
	Step Forward	OPTION+] (⌥])	ALT+]
	Stop		
	Step Backward	OPTION+[(⌥[)	ALT+[
	Go Backward	OPTION+< (⌥<)	ALT+<
	Object Paths		
	Verify TheSkyX Time		
	Open FITS	SHIFT+COMMAND+O (⇧⌘O)	CONTROL+SHIFT+O (CTRL+SHIFT+O)
	Digitized Sky		

Menu	**Command or Pop-Up Menu**	**Keyboard Accelerator**	
		Mac	**Windows**
	Survey		
	Preferences (Windows Only)		CONTROL+, (CTRL+,)
Telescope			
	Telescope Setup		
	Connect		
	TPoint Add On		
	Telescope Limits		
	Digital Setting Circles		
Help			
	Search (Mac only)		
	TheSkyX Help		
	TheSkyX User Guide		
	About TheSkyX (Windows only)		
FITS Viewer Window			
	Photo Pop-Up		
	Open		
	Save		
	Save As		
	Print		
	File Information		
	Zoom In	COMMAND+= (⌘=)	CONTROL+= (CTRL+=)
	Zoom Out	COMMAND+– (⌘–)	CONTROL+- (CTRL+–)
	Zoom Normal		
	Actual Pixels	OPTION+COMMAND+0 (⌥⌘0)	CONTROL+ALT+0 (CTRL+ALT+0)
	Clear		
	To Image Link		
	Close		

Mac Keyboard Key Accelerator Symbols

Symbol	Equivalent Keyboard Key
⌘	Command key
⌥	Option/Alt key
⇧	Shift key
⇟	Page down
⇞	Page up
↖	Home
↘	End

Appendix J: Object Properties

TheSkyX includes a myriad of standard astronomical catalogs with a wide-range of information on each object in the catalog. It also provides the ability to create observing lists using open-ended database queries as well as customize the information that is displayed for each object.

The table below lists the breakdown of database parameters that can appear in observing list reports, on tool tips and on the Object Information Report.

Object Property	Description
Active	Specifies whether the *object type* (satellites and asteroids only) is visible on the Sky Chart. 0 = Not active 1 = Active
Air Mass	Estimate of air mass at the current position.
Alt Rate (arcsecs/sec)	Rate at which the object is moving, in altitude.
Altitude	The angular distance from horizontal.
Altitude w/Refraction	The angular distance from horizontal, including refraction.
Angular Separation (Prior Object)	The angular separation from the previous target object.
Apparent Angular Diameter	The apparent angular diameter of the object.
Apparent Magnitude	The object's apparent magnitude.
Astronomical Twilight End	The time of day when the sun is 18° below the horizon after sunset (evening).
Astronomical Twilight Start	The time of day when the sun is 18° below the horizon before sunrise (morning).
Axis Position Angle	The position angle, in degrees, of the extended object, measured counterclockwise from north.
Az Rate (arcsecs/sec)	The rate, in arcseconds per second, at which the

Object Property	Description
	current target is moving.
Az Rise	The azimuth of the target object when it rises.
Az Set	The azimuth of the target object when it sets.
Azimuth	The azimuth of the target object.
Catalog	The name of the astronomical catalog that is used to display information about the target object.
Catalog Identifier	The astronomical catalog's name or abbreviation that can be used by the Find command to locate objects. For example, M is the designation for objects from the Messier catalog. Enter M1 in the Find text box locates Messier object number 1.
Catalog Number	A number or set of characters that uniquely identifies the target object in an astronomical database. For example, M42 is the forty second object in the Messier catalog.
Celestial Type	Displays the celestial object's type, for example, planet, satellite, galaxy, spiral cluster, double star, etc.
Civil Twilight End	The time of day when the sun is 6° below the horizon after sunset.
Civil Twilight Start	The time of day when the sun is 6° below the horizon before sunrise.
Click Distance	The number of screen pixels between successive mouse clicks.
Comet Eccentricity	The measure of an ellipse's distortion from a circle. This defines the shape of the comet's orbit.
Comet Ecliptic	The standard year (1950 or 2000) to which the orbital elements refer.

Object Property	Description
Comet Inclination	The tilt of the comet's orbital plane relative to the plane of the ecliptic.
Comet Long. of the Asc. Node	The angle, as viewed from the Sun, between the comet and the first point of Aries, when the comet passes through the plane of the ecliptic from below.
Comet Longitude of Perihelion	The comet’s longitude at the perihelion point.
Comet Magnitude 1	The brightness of the comet as seen by a viewer at a standard distance.
Comet Magnitude 2	A value which represents the change in the comet's brightness during its orbit.
Comet Perihelion Day	The day at which the object is closest to the Sun. This date should be in Universal Time (UT).
Comet Perihelion Distance	The distance, in astronomical units, of the comet's closest approach to the Sun.
Comet Perihelion Month	The month at which the object is closest to the Sun. This date should be in Universal Time (UT).
Comet Perihelion Year	The year at which the object is closest to the Sun. This date should be in Universal Time (UT).
Constellation	The name of the constellation in which the target object resides.
Constellation (Abbrev.)	The abbreviation of the constellation in which the target object resides.
Constellation Number	The constellation number (11-88) in which the target object resides.
Date	The current date.
DB Field 1	The contents of the custom Sky Database field number 1.

Object Property	Description
DB Field 10	The contents of the custom Sky Database field number 10.
DB Field 11	The contents of the custom Sky Database field number 11.
DB Field 12	The contents of the custom Sky Database field number 12.
DB Field 13	The contents of the custom Sky Database field number 13.
DB Field 14	The contents of the custom Sky Database field number 14.
DB Field 15	The contents of the custom Sky Database field number 15.
DB Field 16	The contents of the custom Sky Database field number 16.
DB Field 2	The contents of the custom Sky Database field number 2.
DB Field 3	The contents of the custom Sky Database field number 3.
DB Field 4	The contents of the custom Sky Database field number 4.
DB Field 5	The contents of the custom Sky Database field number 5.
DB Field 6	The contents of the custom Sky Database field number 6.
DB Field 7	The contents of the custom Sky Database field number 7.
DB Field 8	The contents of the custom Sky Database field number 8.
DB Field 9	The contents of the custom Sky Database field number 9.

Object Property	Description
Dec (2000.0)	The target object's declination at equinox 2000.0.
Dec (Topocentric)	The target object's topocentric declination.
Dec Rate (arcsecs/sec)	The arcseconds per seconds rate of motion in declination for the target object.
Declination of Earth	The current declination of Earth.
Declination of Sun	The current declination of the Sun.
Defect of Illumination	A measure of the widest non-illuminated portion of a celestial object, in arcseconds.
Depth of Eclipse	
Earth Altitude	
Earth Distance (au)	Target object's distance from Earth, in astronomical units.
Eccentricity	A measure of an orbit's distortion from circular.
Ecliptic	Asteroid's ecliptic epoch.
Epoch Day	Day of the epoch (asteroid).
Epoch Month	Month of the epoch (asteroid).
Epoch Year	Year of the epoch (asteroid).
Flamsteed-Bayer	Target object's Flamsteed and Bayer designation (when available).
Frame Size (arcmins)	Minimum angular size, in arcminutes, of the field of view that can frame the object.
Geocentric Latitude	Target object's Earth-centered latitude.
Geocentric Longitude	Target object's Earth-centered longitude.
Geocentric Mean Latitude	Target object's Earth-centered mean latitude.

Object Property	Description
Geocentric Mean Longitude	Target object’s Earth-centered mean longitude.
Geocentric Mean Radius	Target object’s Earth-centered mean radius.
Geocentric Radius	Target object’s Earth-centered radius.
GSC Block	Stars in the GSC are separated into 9537 blocks that represent a small region of the sky. This value is the target object’s Guide Star Catalog block offset number.
GSC Num	Target object’s Guide Star Catalog identifier, for example, GSC 9520:526
Height	The height, in pixels, of the target object (photos only).
Heliocentric Latitude	The target object’s heliocentric latitude.
Heliocentric Radius	The target object’s radius when observed from the center of the Sun.
Hour Angle	The target object’s hour angle.
Inclination	The target object’s inclination.
Index	The target object’s catalog index number.
Julian Date	The current Julian date.
Latitude	The target satellite’s longitude.
Light Years	The distance, in light years, of the target object from Earth.
Long. of the Ascending Node	The target asteroid’s longitude of the ascending node parameter.
Longitude	The target satellite’s longitude.
Longitude of the Central Meridian	The longitude of the target object’s central meridian.

Object Property	Description
Longitude of the Central Meridian (II)	The longitude of the target object’s central meridian (system II).
Longitude Perihelion	The target asteroid’s longitude of perihelion.
Mag. 1st Component	The magnitude of the first component of a binary system.
Mag. 2nd Component	The magnitude of the second component of a binary system.
Magnitude	The target object’s apparent magnitude.
Magnitude 1	The target asteroid’s absolute magnitude (g).
Magnitude 2	The target asteroid’s magnitude constant (k).
Magnitude B	The target object’s apparent blue magnitude.
Magnitude R	The target object’s apparent red magnitude.
Magnitude V	The target object’s apparent violet magnitude.
Major Axis	The target object’s major axis, in arcseconds.
Maximum Mag.	The target variable star’s maximum magnitude.
Mean Anomaly	The target asteroid’s mean anomaly parameter.
Minimum Mag.	The target variable star’s minimum magnitude.
Minor Axis	The target object’s minor axis, in arcseconds.
Moon Alt w/Refraction	The Moon’s altitude including refraction.
Moon Angular Diameter	The Moon’s angular diameter.
Moon Distance (km)	The Moon’s distance from Earth, in km.
Moon Ecliptic Latitude	The Moon’s ecliptic latitude.

Object Property	Description
Moon Ecliptic Longitude	The Moon’s ecliptic longitude.
Moon Ecliptic Radius	The Moon’s ecliptic radius.
Moon Optical Libration b	The Moon’s optical libration (b).
Moon Optical Libration l	The Moon’s optical libration (l).
Moon Parallax	The Moon’s parallax.
Moon Phase Angle	The Moon’s phase angle.
Moon Physical Libration b	The Moon’s physical libration (b).
Moon Physical Libration l	The Moon’s physical libration (l).
Moon Pos. Angle of Bright Limb	The position angle of the Moon’s bright limb.
Moon Position Angle	The Moon’s position angle.
Moon Topocentric Ang. Diameter	The Moon’s topocentric angular diameter, in arcseconds.
Moon Total Libration b	The Moon’s total libration (b).
Moon Total Libration l	The Moon’s total libration (l).
Moon True Dec	The Moon’s true right declination.
Moon True RA	The Moon’s true right ascension.
Moon’s Age (Days Past New)	The age of the Moon’s phase, in days past the new Moon.
Name 10	One of up to ten different aliases for the target object.
Name 2	One of up to ten different aliases for the target object.
Name 3	One of up to ten different aliases for the target object.
Name 4	One of up to ten different aliases for the target object.

Object Property	Description
Name 5	One of up to ten different aliases for the target object.
Name 6	One of up to ten different aliases for the target object.
Name 7	One of up to ten different aliases for the target object.
Name 8	One of up to ten different aliases for the target object.
Name 9	One of up to ten different aliases for the target object.
Nautical Twilight End	The time of day when the sun is 12° below the horizon after sunset.
Nautical Twilight Start	The time of day when the sun is 12° below the horizon before sunrise.
NGC/IC	This parameter is reserved for future use.
Non-stellar Fields	This parameter is reserved for future use.
Object Name	The target object's common name.
Object Type	The target o
Observing Notes	This parameter holds observing notes for the target object.
Parallax	
Parsecs	The distance to the target object, in parsecs.
Penumbra Diameter	The diameter of the Earth's penumbra.
Period	The target object's orbital period.
Phase (%)	The current phase of the target object.
Phase Correction	The target object's phase correction.

Object Property	Description
Point 3D X	The target object’s x-axis position.
Point 3D Y	The target object’s y-axis position.
Point 3D Z	The target object’s z-axis position.
Polar Diameter	The target object’s polar diameter.
Position Angle (Prior Object)	The position angle measured between successive mouse clicks on the Sky Chart.
Position Error Dec	The target object’s position error in declination.
Position Error Parallax	The target object’s parallax error.
Position Error RA	The target object’s position error in right ascension.
Proper Motion Dec	The target object’s proper motion in declination.
Proper Motion Error Dec	The target object’s proper motion error in declination.
Proper Motion Error RA	The target object’s proper motion error in right ascension.
Proper Motion RA	The target object’s proper motion in right ascension.
RA (2000.0)	The target object’s equinox 2000.0 right ascension.
RA (Topocentric)	The target object’s topocentric right ascension.
RA Rate (arcsecs/sec)	The target object’s rate, in arcseconds per second, in right ascension.
Radius	The target object’s radius.
Range	The target satellite’s range, in meters.
Range Rate	The target satellite’s range rate.

Object Property	Description
Ring Axis (a)	Saturn’s A ring axis.
Ring Axis (b)	Saturn’s B ring axis.
Rise Time	The target object’s rise time.
Rise/Set Notes	Notes indicating whether or not Daylight Saving Time is in effect.
Satellite Eclipse	This value is set to true when the satellite is eclipsed by the Earth.
Satellite Extended	This value is set to true when the satellite is extended.
Satellite Julian Date	The Julian Date used to compute the satellite’s position.
Satellite Name	The name of the satellite.
Satellite TLE1	The satellite’s two line element parameter (line 1).
Satellite TLE2	The satellite’s two line element parameter (line 2).
Satellite Visible	This value is true when the satellite is visible from the current location.
Scale	Photo’s image scale, in arcseconds per pixel.
Screen X	The x position of the mouse click, in screen coordinates.
Screen Y	The y position of the mouse click, in screen coordinates.
Semi-Major Axis	The target object’s semi-major axis.
Set Time	The time at which the target object sets (below the horizon).
Sidereal Time	The current sidereal time.

Object Property	Description
Skip Index	The zero-based index for the object in the object path.
Source Catalog	The source catalog used to display information about the target object.
Spectral	The target object's spectral class.
Spectral Type	The target object's spectral type.
Star Identifier	The target star's catalog identifier.
Sun Distance (au)	The target object's distance from the Sun, in astronomical units.
Sun Position Angle	The Sun's position angle.
Text Record	Text-based information about the target object.
Text Record Start	The starting position of the text record.
Time	The current time.
Transit Time	The time at which the target object transits.
True Dec	The target object's true declination.
True RA	The target object's true right ascension.
Type of Variable	The variable star's classification.
Umbra Diameter	The diameter of the Earth's umbra.
Width	The width, in pixels, of the target object (photos only).

Index