

Short Overview of Observational Astrophysics

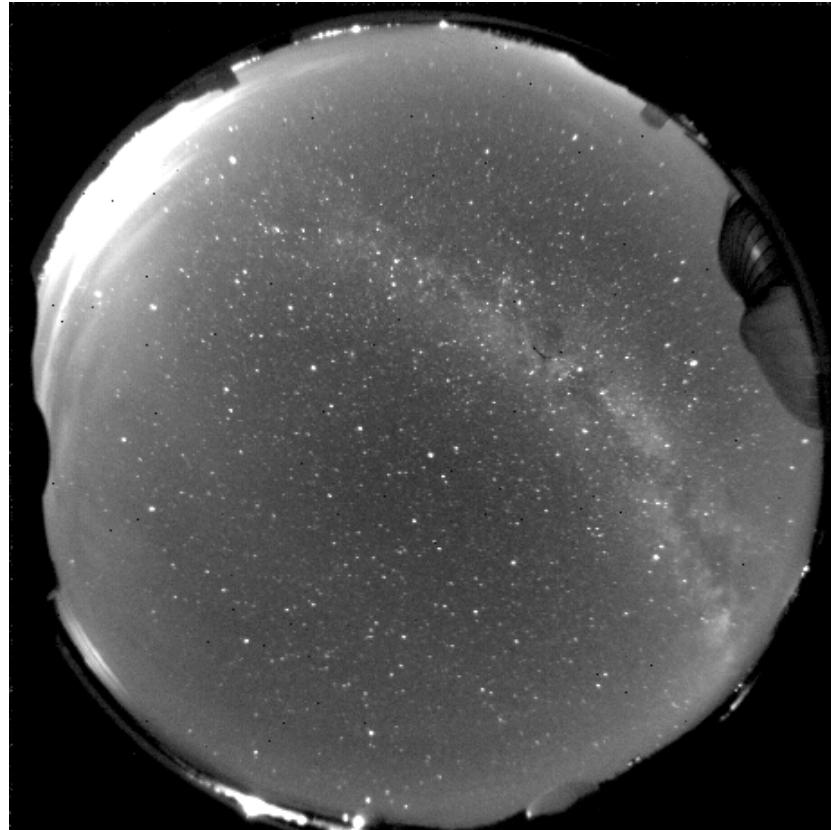
Dr. Mike Koss

Guest Lecturer for Prof. Schawinski
SNSF Ambizione Postdoctoral Fellow

Overview

1. Syllabus
2. Observational Astrophysics Techniques
 - Programming
 - Statistics
 - Specific Example Data and Reduction
3. Help with install
4. Lia Talk about Exercises

What's in the Night Sky?



Fish Eye Lens-Whole sky from ground in Arizona

Lots of points of light-Stars like our sun but more distant

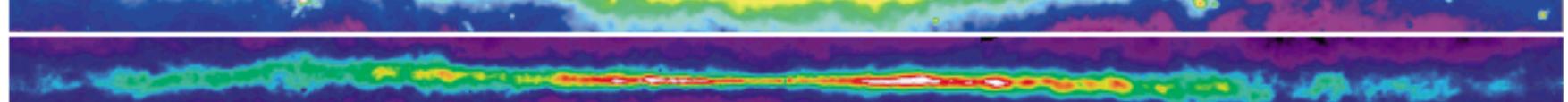
Fuzzy Diagonal Band- Galaxy in Greek means "milky circle" → Milky Way our galaxy

Observing Wavelengths

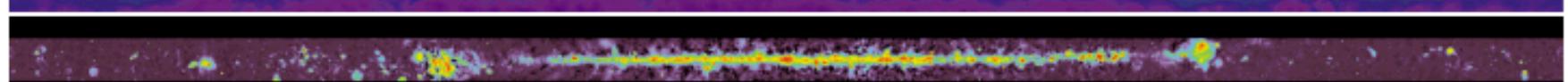
Radio (0.4 GHz)



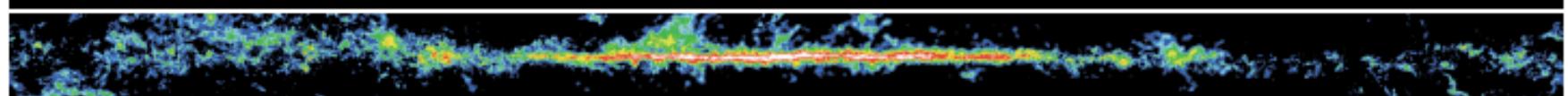
Atomic Hydrogen



Radio (2.7 GHz)



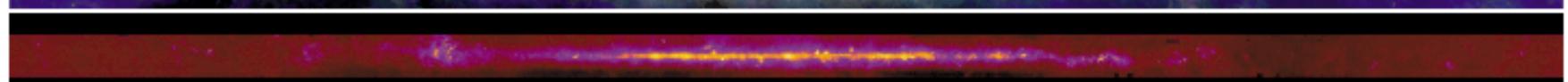
Molecular Hydrogen



Infrared



Mid Infrared



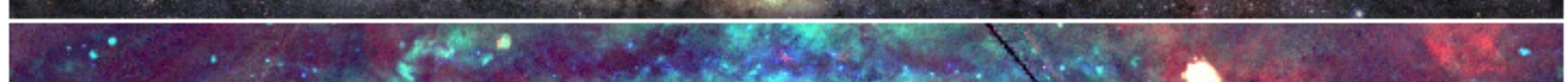
Near Infrared



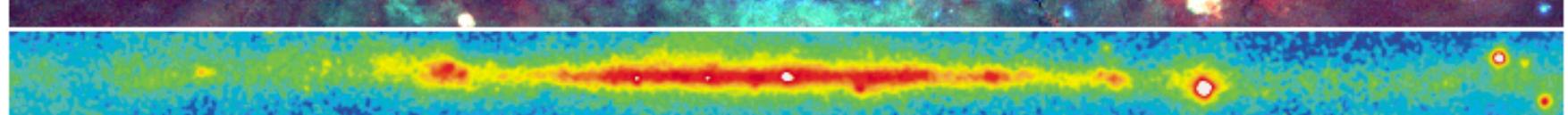
Optical



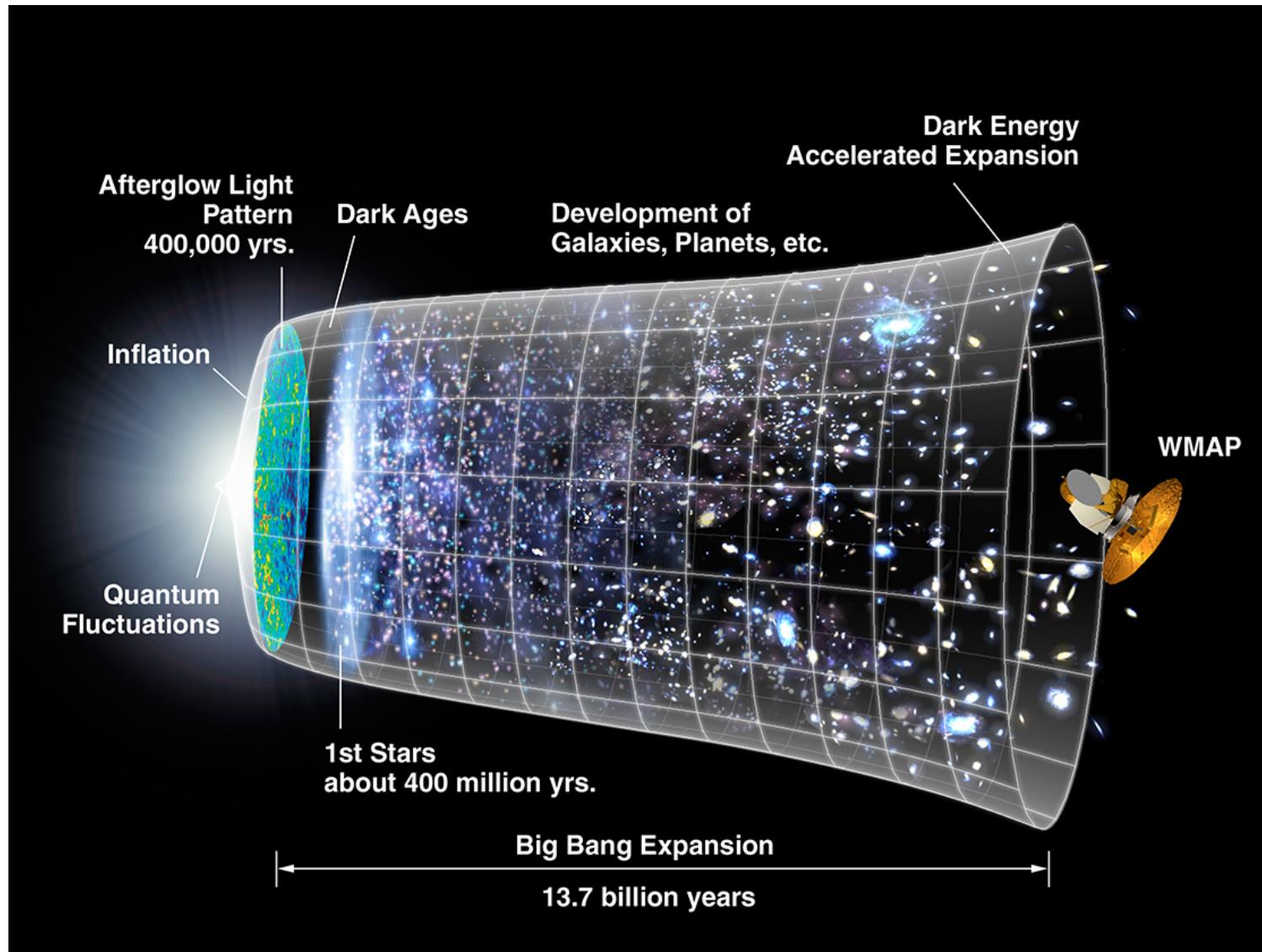
X-Ray



Gamma Ray

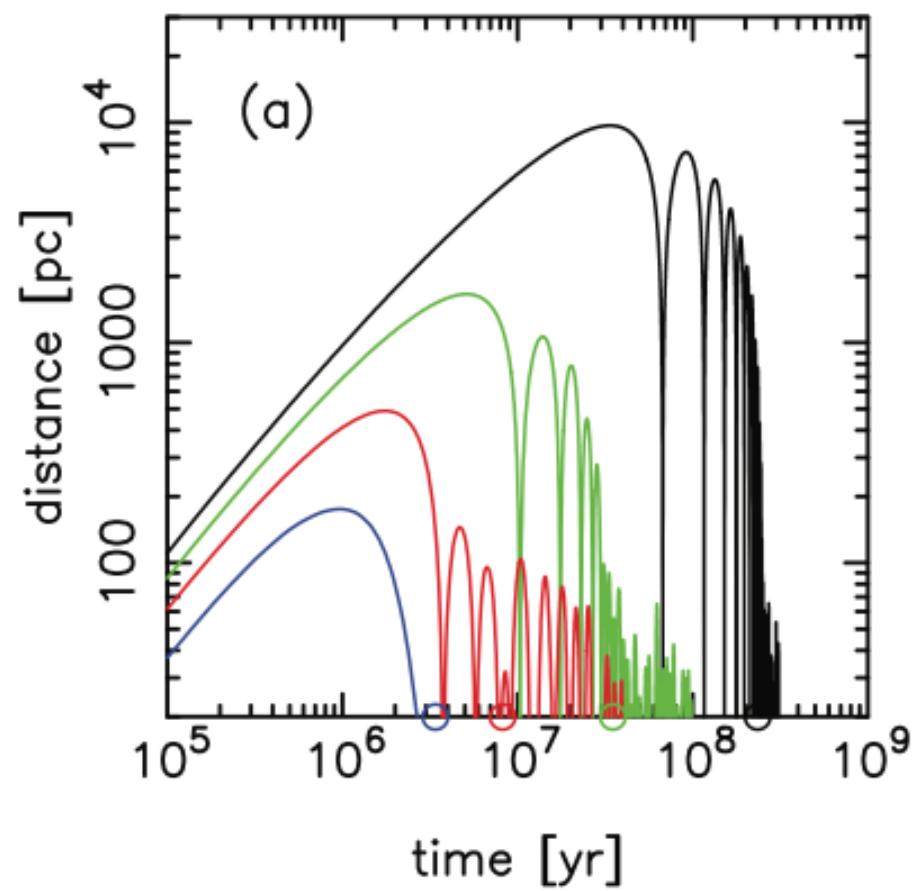
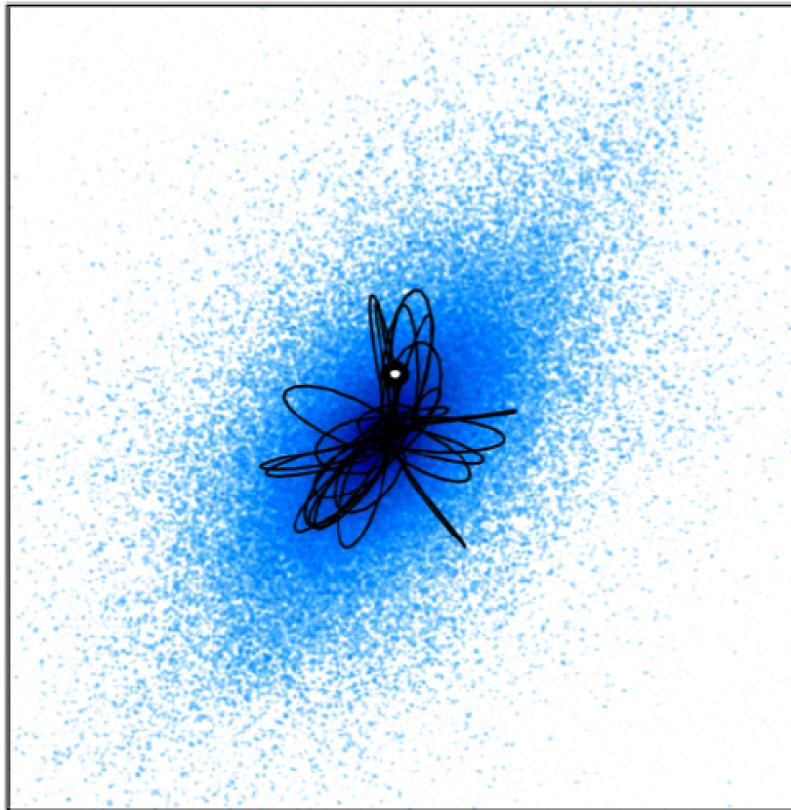


Because light takes time to travel, we can see the early universe by looking at distant objects

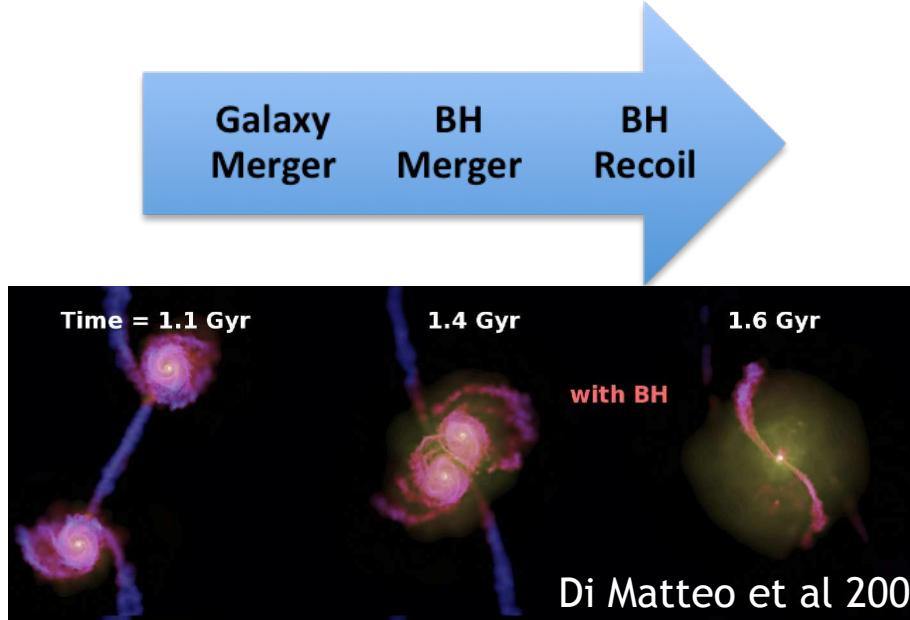


We have our own Time Machine !!!!!

Specific Example: BH Recoil Simulation

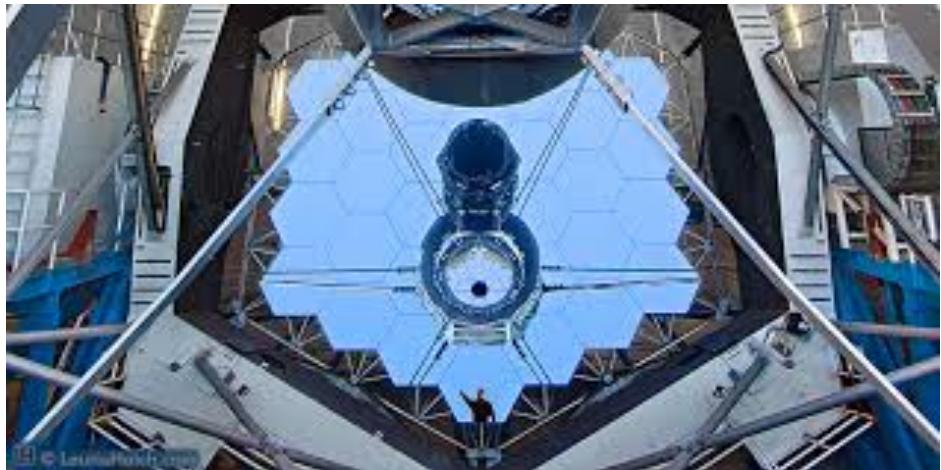


Galaxy Mergers and Recoiling Black Holes

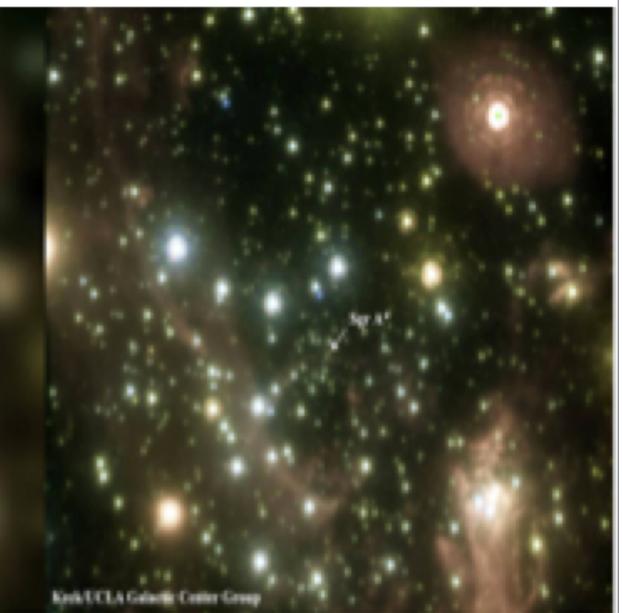
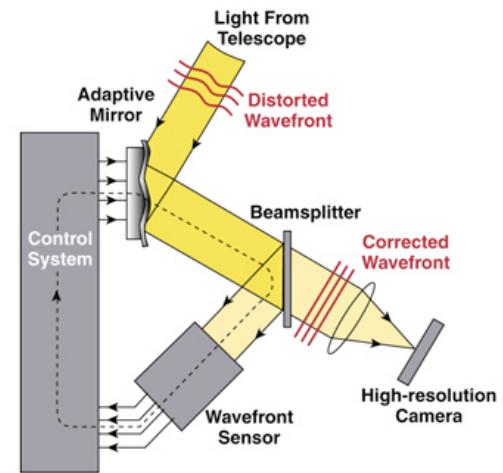


1. Is there Evidence of Recoiling BHs?
 - Indirect Method to detect GW emission

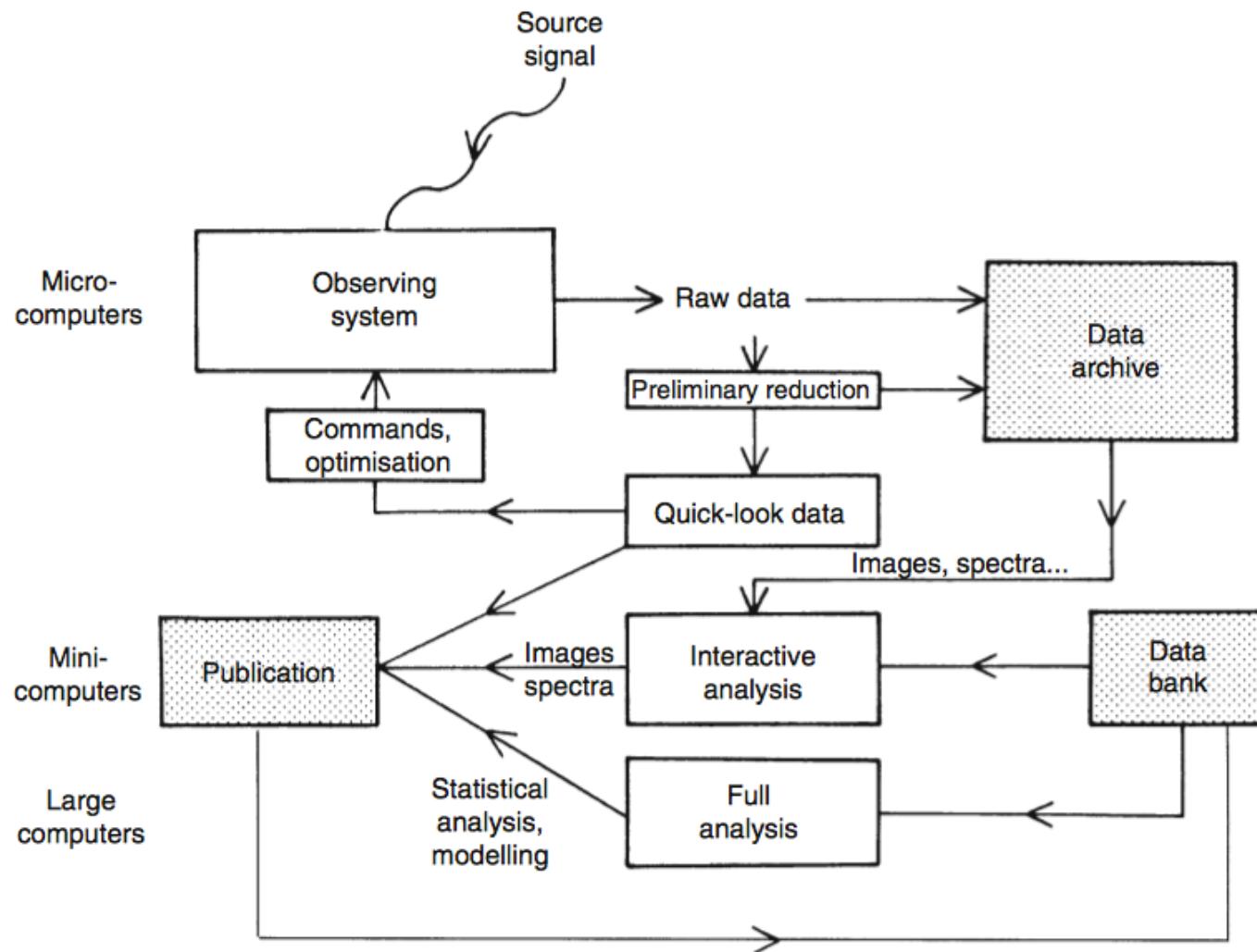
Specific Example: Adaptive Optics on Keck



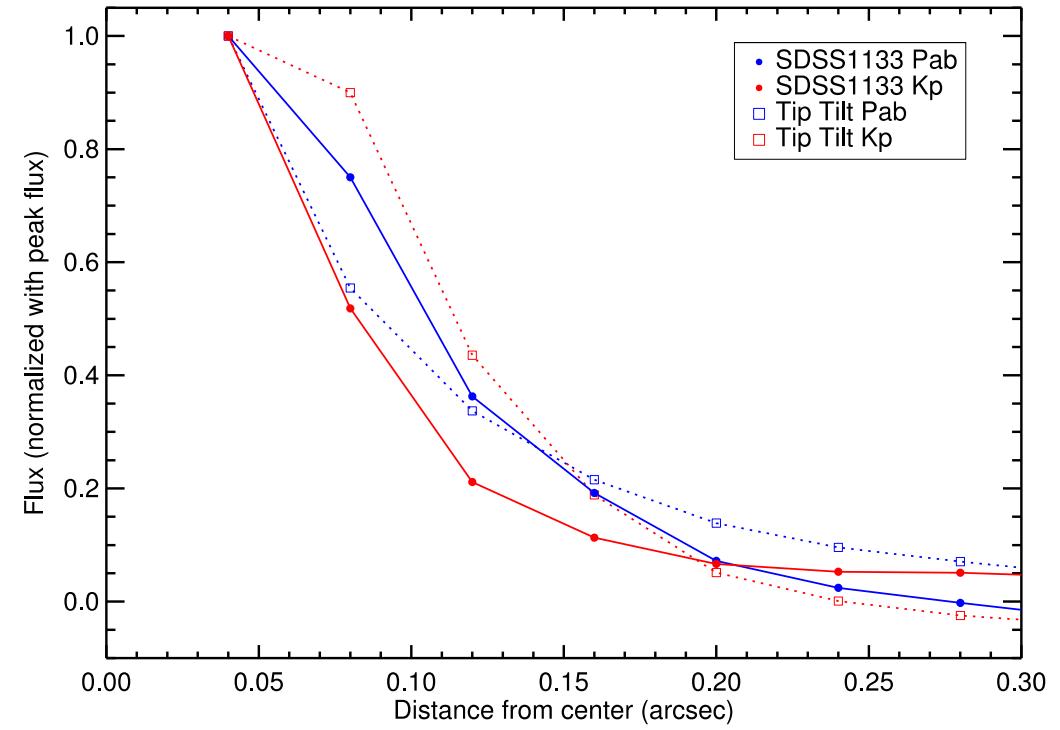
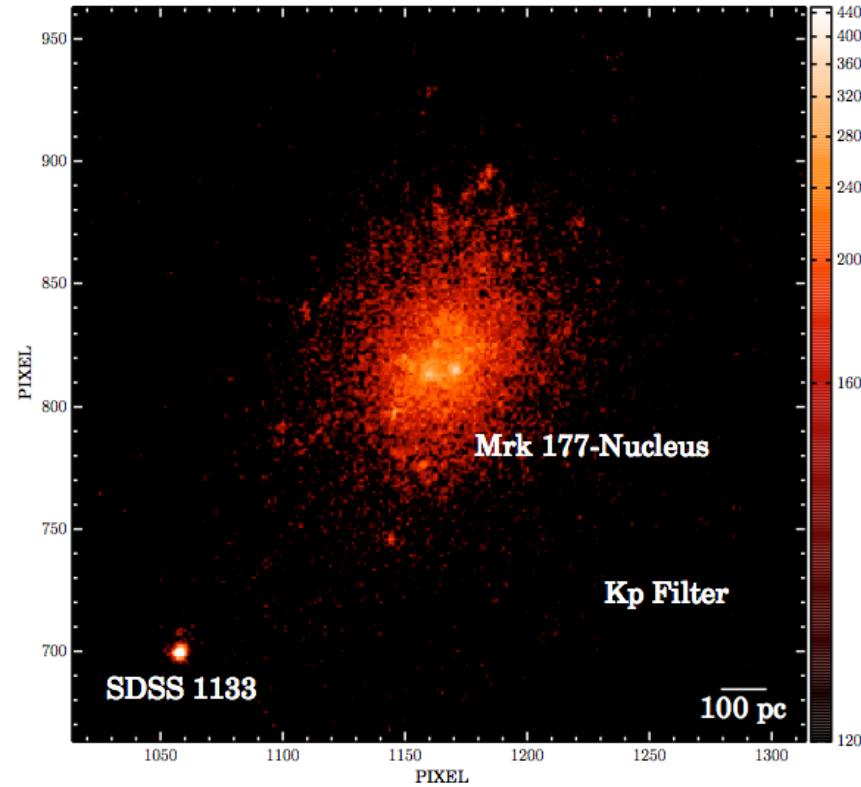
Feedback loop:
next cycle
corrects the
(small) errors of
the last cycle



Data Analysis

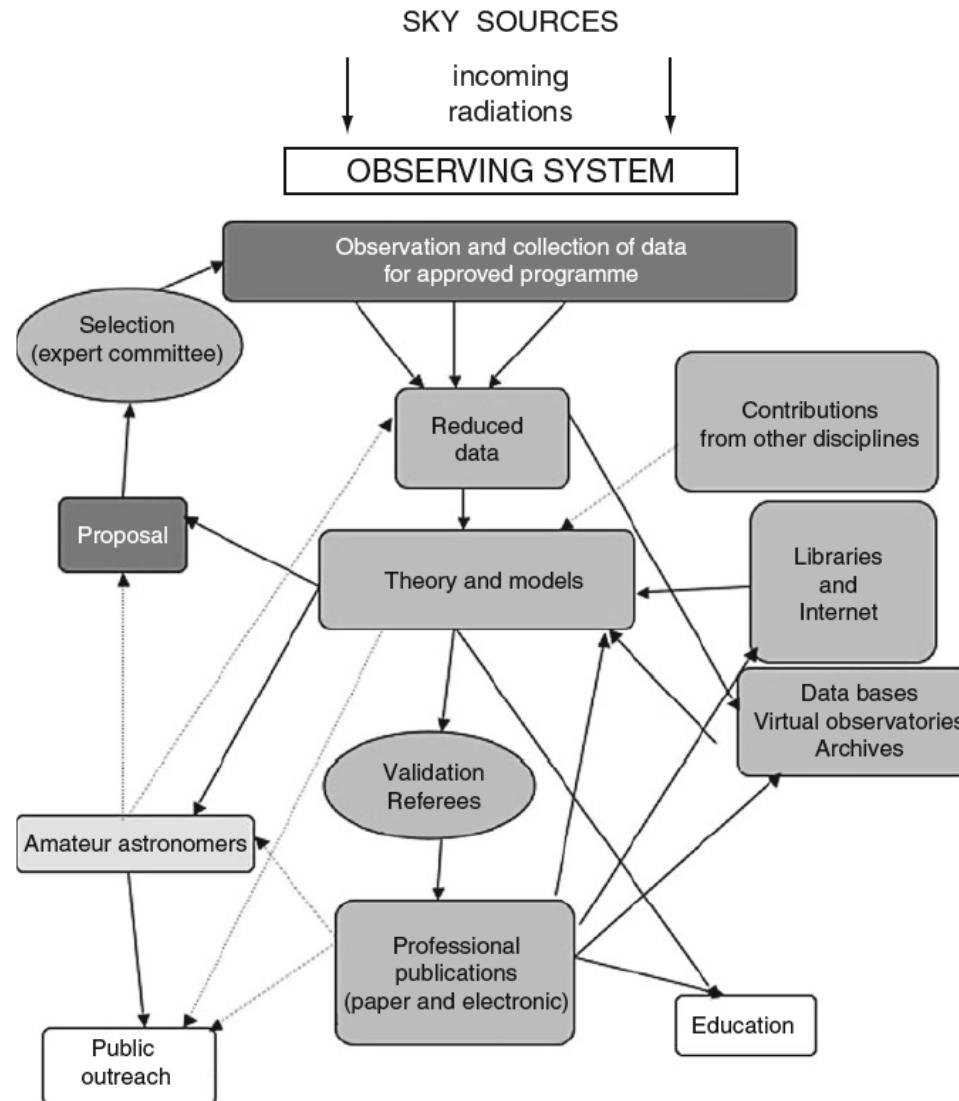


The First Definitive Recoiling Black Hole? SDSS1133 in High Resolution from Adaptive Optics



SDSS 1133 Consistent with telescope PSF imaging, Kp (12 pc), PaBeta (22 pc)
Shows expected Signature of Recoiling Black Hole (Koss et al. 2014)

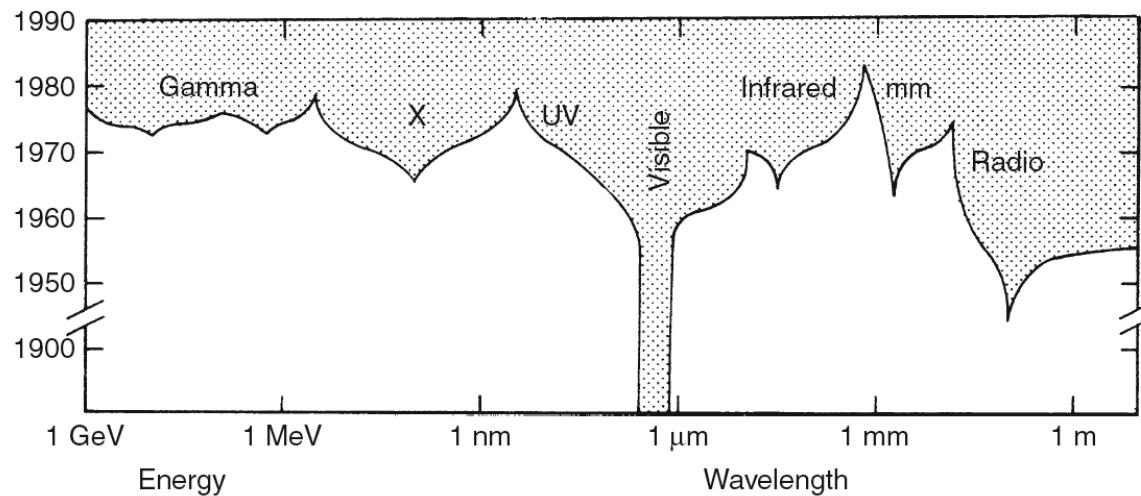
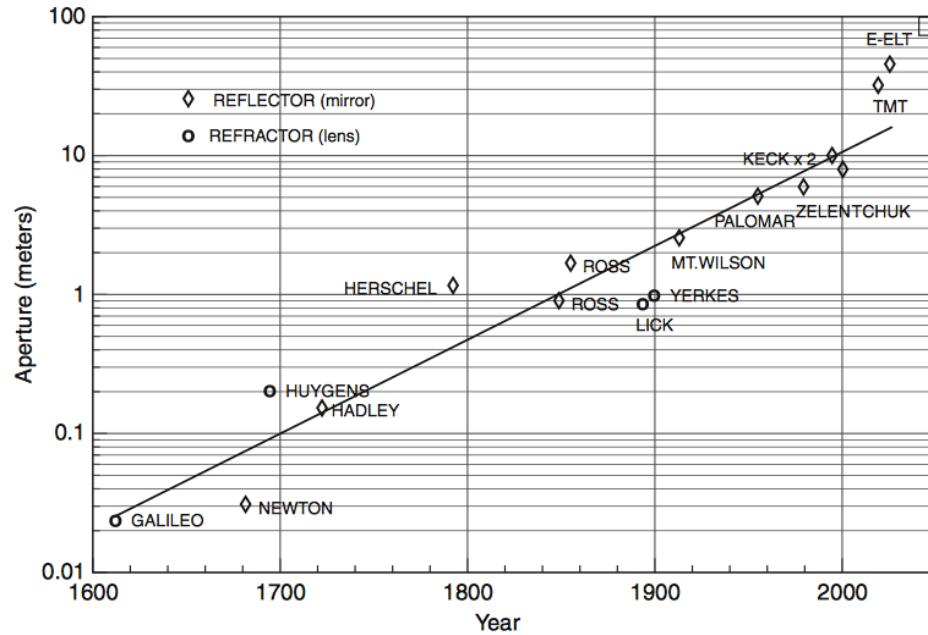
Full Cycle



Other Examples of Observing Proposals

	Instrument	Year	Role	PI	Time Awarded
Space Based					
SUCCESSFUL OBSERVING PROPOSALS	HST (COS)	2014	PI	M. Koss	4 orbits
	Swift (XRT/UVOT)	2014	PI	M. Koss	15 ks TOO
	XMM (EPIC)	2013	PI	M. Koss	115 ks
	NuSTAR	2013	PI	M. Koss	100 ks
	Swift (XRT/UVOT)	2013	PI	M. Koss	20 ks TOO
	NuSTAR	2013	PI	M. Koss	200 ks
	HST (WFC3/UVIS)	2013	2nd CoI	R. Mushotzky	8 orbits
	Chandra (ACIS)	2012	PI	M. Koss	Archival \$85k
	Herschel (PACS/SPIRE)	2011	CoI	S. Veilleux	35 hours
	Herschel (PACS/SPIRE)	2010	CoI	R. Mushotzky	56 hours
	Chandra (ACIS)	2012	CoI	C. Max	215 ks
	Chandra (ACIS)	2010-2011	Observing PI	M. Koss	358 ks, 2 Prop.
	Ground Based				
	ALMA	2013	2nd CoI	E. Treister	5 hours
OBSERVING PROPOSALS	VLT (SINFONI)	2013	CoI	R. Davies	5 nights
	Keck (NIRC2)	2012-2013	PI	M. Koss	7 nights, 3 Prop.
	VLT (XSHOOTER)	2013	CoI	R. Davies	4 nights
	CARMA	2013	CoI	S. Vogel	6 nights
	JCMT (SCUBA2)	2012-2013	PI	M. Koss	14 nights, 3 Prop.
	CARMA	2013	CoI	K. Nguyen	5 nights
	Gemini North (GMOS)	2011-2013	PI	M. Koss	3 nights, 2 Prop.
	IRTF (SPEX)	2010-2013	PI	M. Koss	10 nights, 4 Prop.
	UH 2.2m (SNIFS)	2012-2013	PI	M. Koss	22 nights, 4 Prop.
	JCMT (RXA3)	2012	PI	M. Koss	8 nights, 3 Prop.
	SOAR (GOODMAN)	2012	First Co I	M. Trippe	4 nights
	JCMT (HARP)	2011	CoI	E. Treister	8 nights, 2 Prop.
	Gemini South (GMOS)	2011	PI	M. Koss	0.5 night
	Gemini North (GMOS)	2011	First CoI	E. Treister	1 night
	KP 4m (FLAMINGOS)	2010	PI	M. Koss	12 nights, 2 Prop.
	KP 2.1m (GOLDCAM)	2008-2009	Observing PI I	M. Koss	14 nights, 2 Prop.
	KP 2.1m (T2KB-T1KA)	2008	Observing PI I	M. Koss	17 nights, 2 Prop.
Instrumentation					
	Balloon Star Cameras	2008	PI	M. Koss	\$15k

The Advance of History: Bigger, Better, More Wavelengths



Astrometry

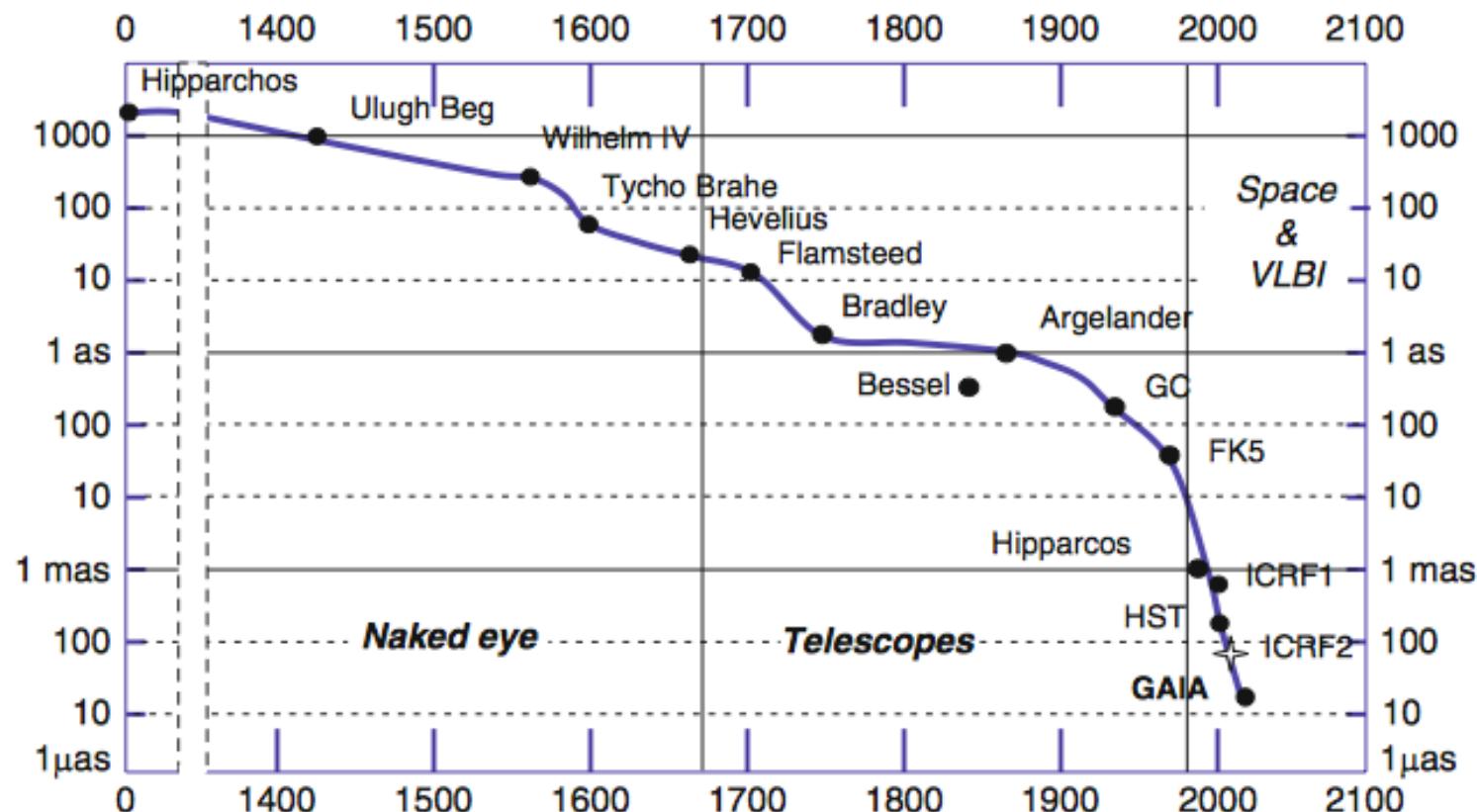
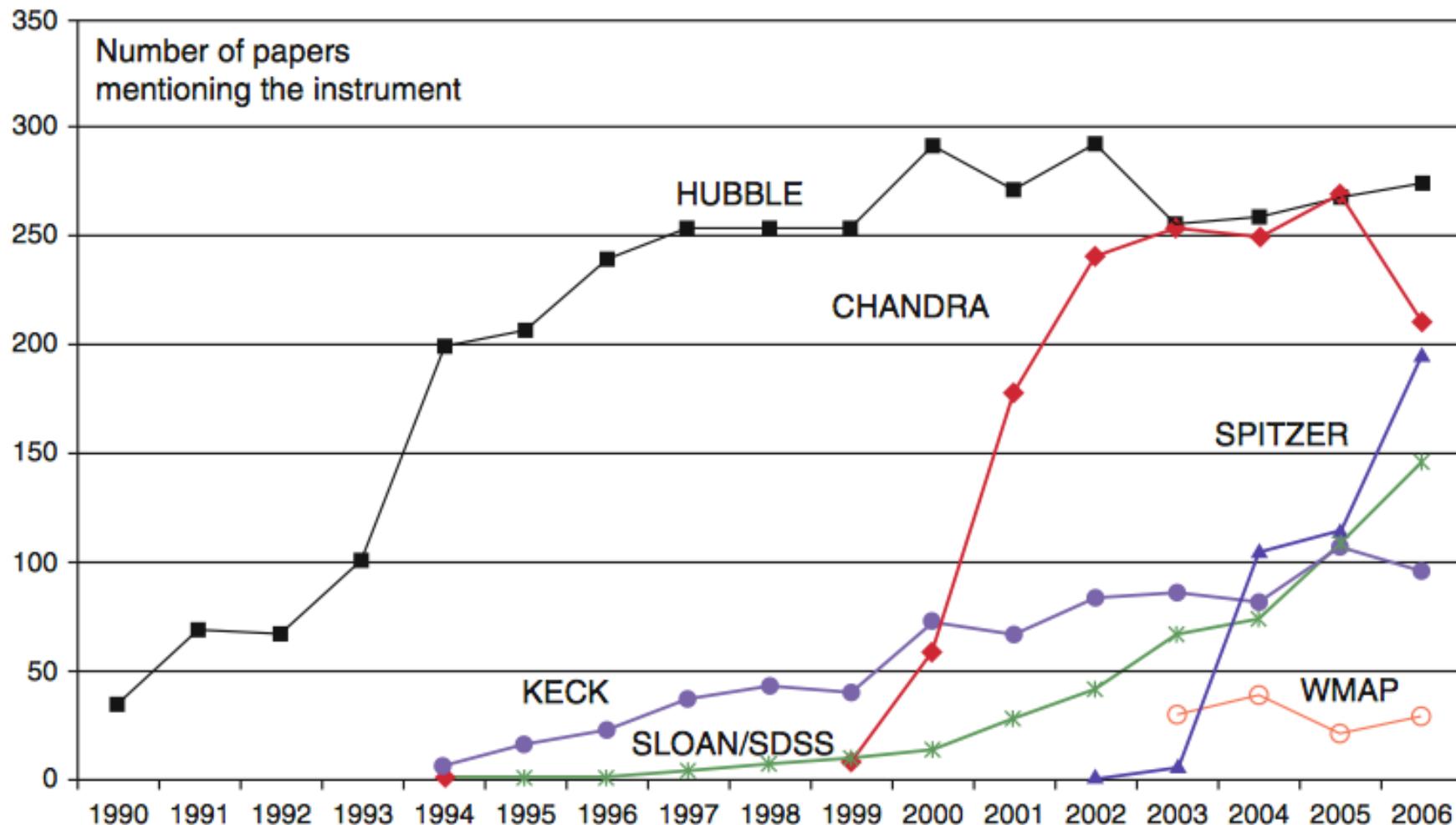
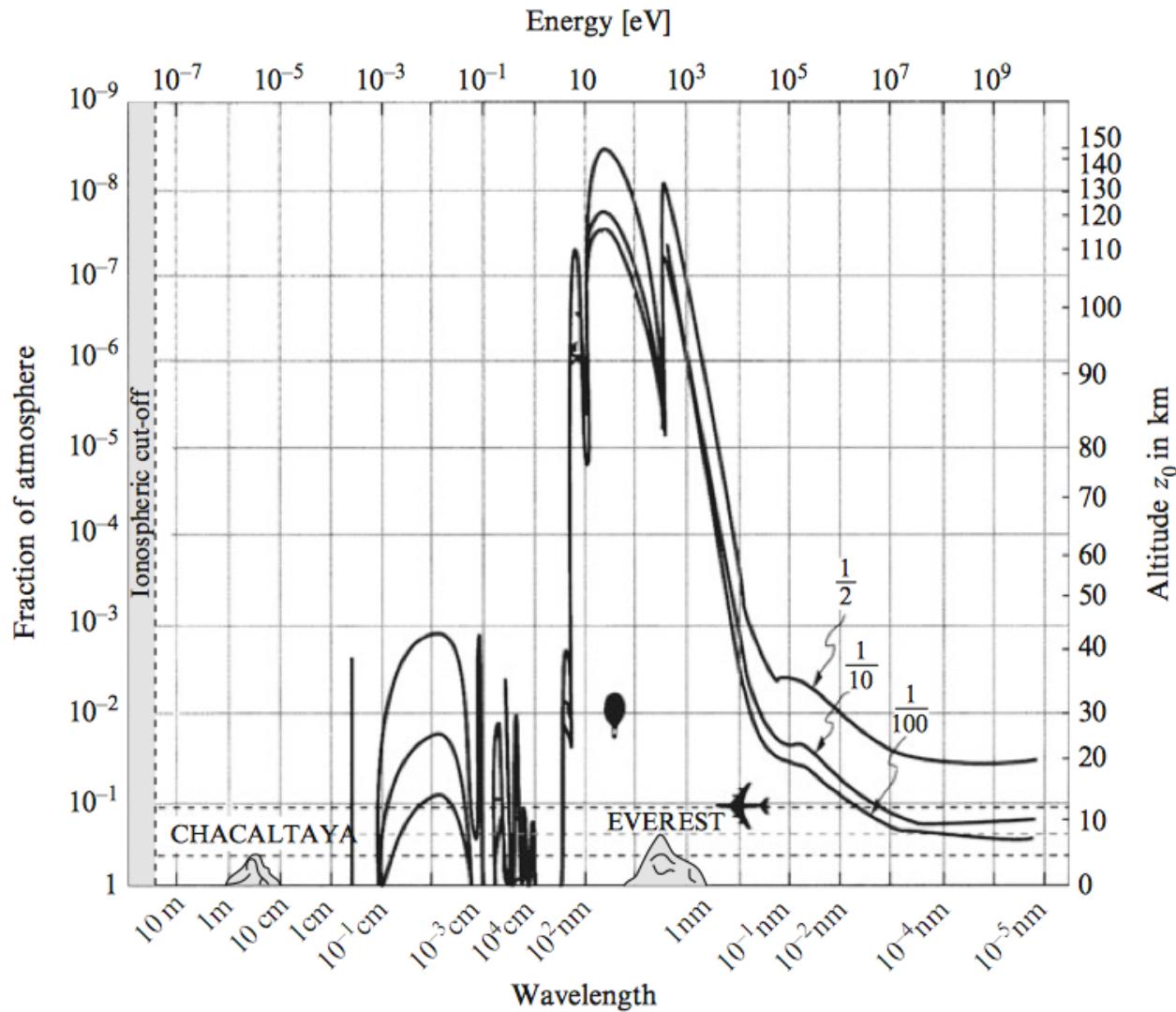


Fig. 4.1 Improving astrometric accuracy in the observations of stars and planets at different epochs

Types of Observatories



Why we use satellites



If you like this stuff and need a semester project come talk to us...

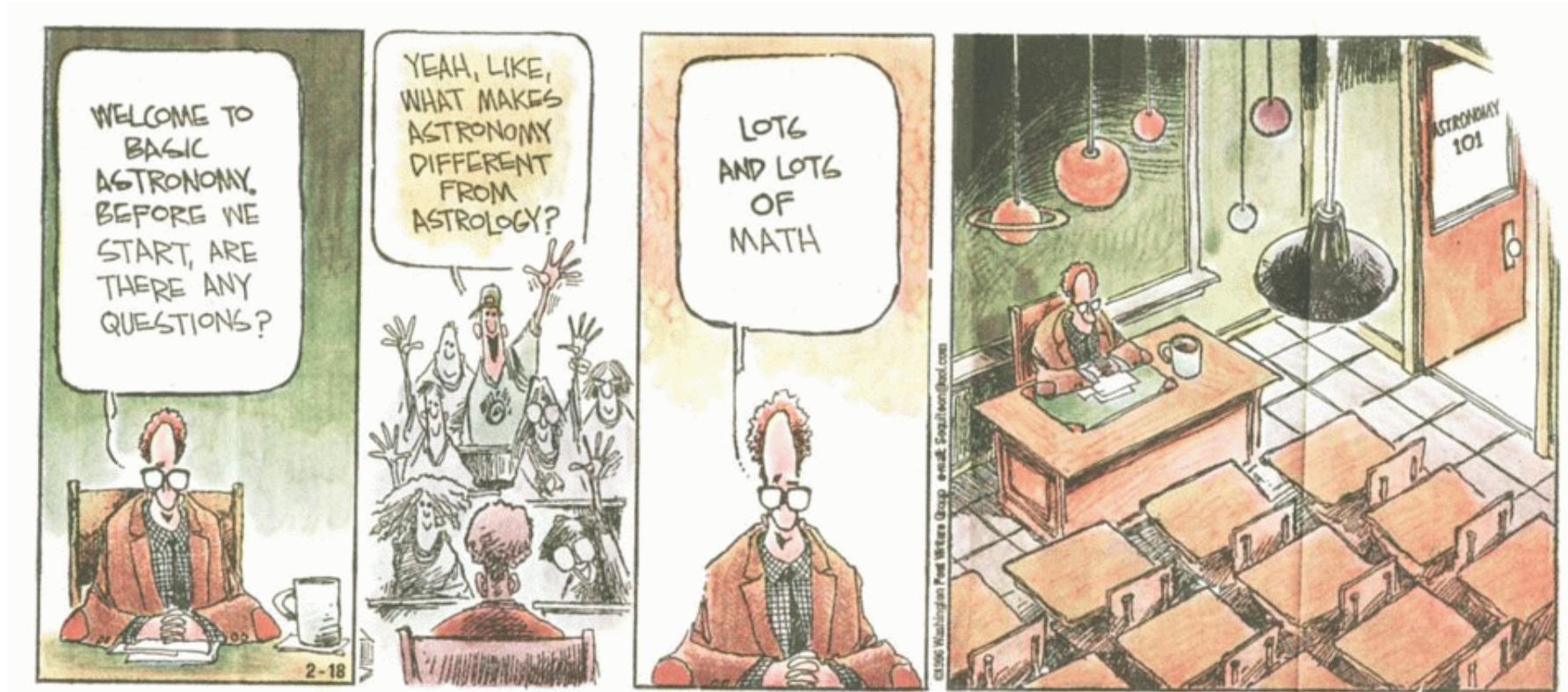
Left: JCMT submillimiter telescope on Mauna Kea in Hawaii (Credit JCMT). Middle: New SCUBA2 instrument, which saw first light in 2010. Right: Herschel and SCUBA2 instrument images at 500 and 450 um, showing the increased resolution of this instrument. The high resolution of SCUBA2 is critical to understanding the link between nuclear star formation and AGN in galaxy evolution. I am PI of the largest program of SCUBA-2 observations of nearby AGN with over 150 hours with the first ever complete large sample (>30).

Project GOALS

- 1). Determine the role of AGN and their co-evolution with galaxies.
- 2). Understand the importance of AGN to IR emission and it's link to molecular gas.
- 3). Use a sample selected by it's AGN emission.

Instruments: Herschel+Scuba2 +JCMT (CO)+BAT (X-ray)

A thought to leave you with...



Exercises

Exercise class: Tuesday, 11:45 - 12:30
HIT F 31.1

Assistant: Lia Sartori
Office: HIT J 33.2
email: lia.sartori@phys.ethz.ch

Requirements for the credits

- Submit reports for 50% or more of the exercise sheets (not necessarily perfect, but make some effort to do the exercises...)
- oral exam (winter session examination, 20 min)

Reports

- LaTeX is recommended (but not restricted)
- hand in a PDF via GitHub or email by the day before the next class

https://github.com/liasartori/ObsAstro_HS14

Did you already use one of the following tools or programming languages ? If yes, please write up your level (beginner, intermediate, advanced)

- Python
- IDL
- IRAF
- TOPCAT
- Galfit
- SExtractor
- CIAO
- Heasoft
- SAOImage DS9
- GitHub

Would you like to give a short presentation (~ 30 min) about one of these tools ?
The presentation will count as one exercise sheet.

.....

.....

Is there a specific analysis tool or observational technique that you would like to be discussed during the lecture and/or exercise classes ?

.....

.....

Preliminary schedule

subject to change, will be updated

DATE	TOPIC
16-Sep	Basics of scientific computing (guest lecturer: Dr. Mike Koss)
23-Sep	Basics of observing, Imaging I
30-Sep	Imaging II
07-Oct	Spectroscopy I (guest lecturer: Dr. Mike Koss)
14-Oct	Spectroscopy II
21-Oct	Spectroscopy III, stellar evolution & models
28-Oct	Virtual Observatory, catalogue generation
04-Nov	Spectral Energy Distribution fitting
11-Nov	X-ray Astronomy
18-Nov	<i>cancelled/guest lecture</i>
25-Nov	Radio/sub-mm/FIR Astronomy
02-Dec	Proposal planning
09-Dec	Presentation of Proposals
16-Dec	TBD

[http://www.astro.ethz.ch/education/courses/
Observational_Techniques_in_Astrophysics](http://www.astro.ethz.ch/education/courses/Observational_Techniques_in_Astrophysics)

Useful web resources

Stackoverflow

stackoverflow Questions Tags Tour Users Ask Question

Search how to plot with python search Advanced Search Tips

2,916 results relevance newest votes active

Q: xkcd style graphs in MATLAB
So talented people have figured out how to make xkcd style graphs in Mathematica, in LaTeX, in Python and in R already. How can one use MATLAB to produce a plot that looks like the one above ...
98 votes 4 answers matlab plot asked oct 3 '12 by natan

Q: How do you change the size of figures drawn with matplotlib?
How do you change the size of figure drawn with matplotlib? ...
100 votes 4 answers python graph matplotlib plot visualization asked dec 1 '08 by t Wright

Q: How can I smooth a set of 3D points?
this question is an extension of my previous question that you can find here: How to plot a data cube in python The thing is that I have a 3D plot of point but if I follow the method of my previous ... question I could get an overflow error when I have too many points to plot. I have to plot millions of points so I need to smooth the 3D distribution, otherwise it takes a huge amount of time ...
2 votes 1 answer python plot asked aug 17 '11 by Matteo

Q: How to make a 3D plot in python?
I am currently have a $n \times 3$ matrix array. I want plot the three columns as three axes. how can I do that? I have googled and people suggested using matlab, but I am really having a hard time ... with understanding it. Can someone teach me? Thanks in advance sorry for the missing information. It's in python and I want a scatter plot. ...
5 votes 3 answers python plot asked dec 31 '09 by user211037

A: Python plot line linking values seems circle back from last point to the first one
This is how matplotlib's line plotting works: it starts with the first data point in the list, then draws a line to the next data point in the list, and so on, until it gets to the last point ... matplotlib will accordingly draw a line from the point at $x = 139$ to the point at $x = 68$. If you don't want this to happen, just sort the data points by their x coordinate before plotting them. Or you can ...
1 vote answered feb 21 by David Z

Q: learning python multiple plots on the same set of axis
How would I setup this plot up in Python? Here is what I do in Mathematica: `myvalue = Table[k, {k, 0, 10, 1}]; u[r_, k_] = 1/(2*r^2) + k/(2*r^2); Plot[u[r, myvalue], {r, 0, 5}, PlotStyle -> {Red}, PlotRange -> {{0, 5}, {0, 2}}] ...`
0 votes 2 answers python plot asked apr 10 by dustin

... CAREERS 2.0

IT Programmer / Project Manager / Self-Starter AIM - Accelerate Innovation... Geneva, Switzerland

Informatiker / Softwareentwickler (w/m) Java / .NET Zühlke Engineering AG Schlieren, Schweiz

Back-end Software Engineer at AgFlow AgFlow SA Geneva, Switzerland / remote

<http://starckoverflow.com/>

NASA Astrophysics Data System

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The SAO/NASA Astrophysics Data System

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Watch your query being generated as you type in the form below

Databases to query: Astronomy Physics

OR AND SIMPLE

Object name/position search (not yet available)

OR AND

Authors (Last, First M, one per line)

Publication date between MM / YYYY and MM / YYYY

OR AND BOOLEAN

Title words

OR AND BOOLEAN

Abstract words/keywords

Refereed only Select only articles

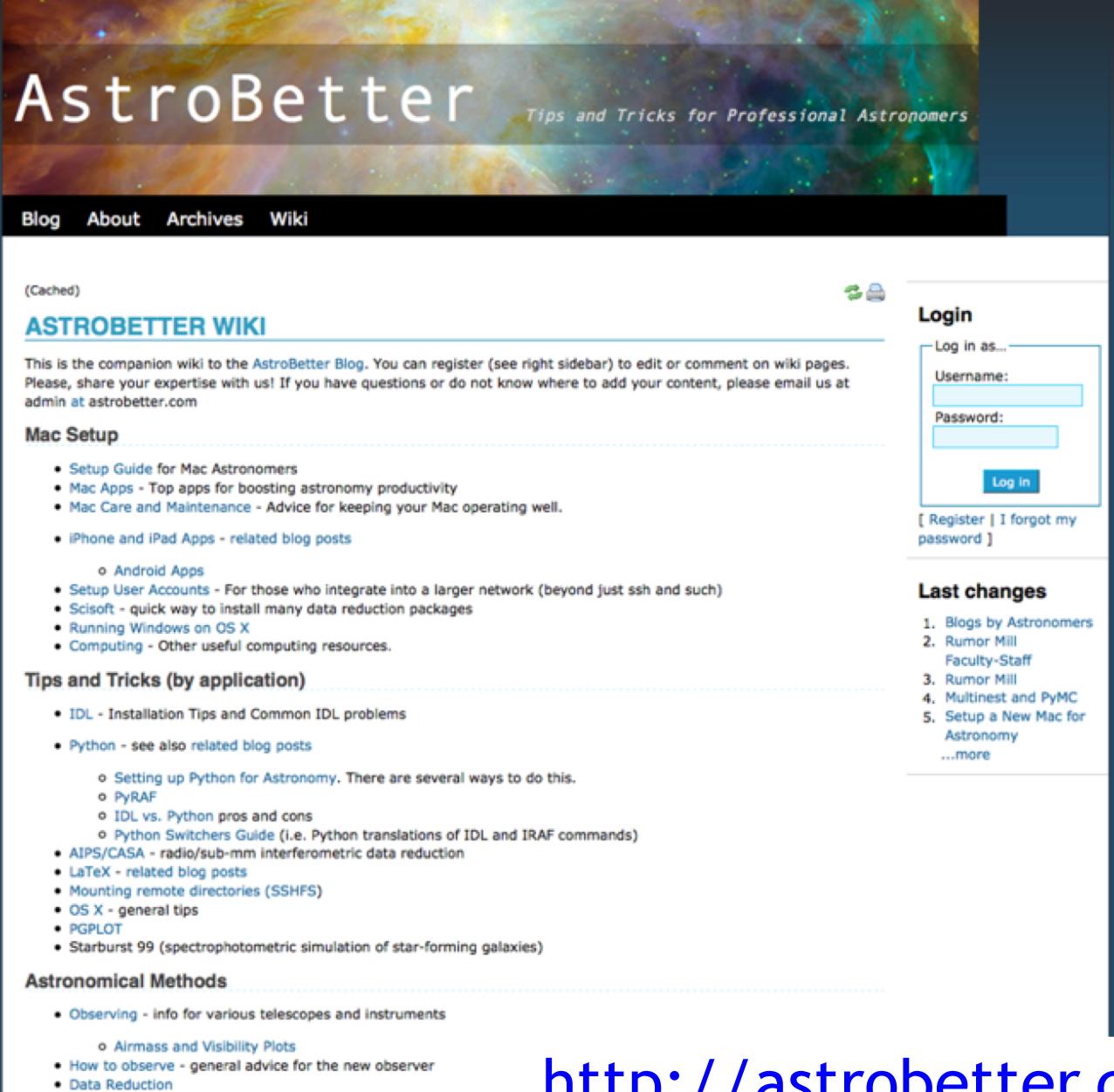
Comma-separated bibstems of journal titles (with autoselect)

Search will return 20 results per page

Database: Astronomy
Results per page: 20
Refereed ORNon-refereed

<http://adslabs.org/adsabs/search/classic-search/>

Astrobetter wiki



The screenshot shows the homepage of the AstroBetter wiki. The header features a colorful nebula background with the text "AstroBetter" in large white letters and "Tips and Tricks for Professional Astronomers" in smaller white text below it. A black navigation bar at the top includes links for "Blog", "About", "Archives", and "Wiki". Below the header, there's a "Cached" message and a "Login" form with fields for "Username" and "Password" and a "Log in" button. To the right of the login form is a link "[Register | I forgot my password]". On the left side of the main content area, there are three sections: "Mac Setup", "Tips and Tricks (by application)", and "Astronomical Methods". Each section contains a bulleted list of links to various resources. The "Mac Setup" section includes links for Mac Apps, Mac Care, iPhone/iPad Apps, and other computing resources. The "Tips and Tricks" section covers IDL, Python, LaTeX, and various astronomical software like AIPS/CASA and Starburst 99. The "Astronomical Methods" section covers Observing, Airmass and Visibility Plots, and Data Reduction.

(Cached)

ASTROBETTER WIKI

This is the companion wiki to the AstroBetter Blog. You can register (see right sidebar) to edit or comment on wiki pages. Please, share your expertise with us! If you have questions or do not know where to add your content, please email us at admin@astrobetter.com

Mac Setup

- [Setup Guide for Mac Astronomers](#)
- [Mac Apps - Top apps for boosting astronomy productivity](#)
- [Mac Care and Maintenance - Advice for keeping your Mac operating well.](#)
- [iPhone and iPad Apps - related blog posts](#)
 - [Android Apps](#)
- [Setup User Accounts](#) - For those who integrate into a larger network (beyond just ssh and such)
- [Scisoft](#) - quick way to install many data reduction packages
- [Running Windows on OS X](#)
- [Computing](#) - Other useful computing resources.

Tips and Tricks (by application)

- [IDL](#) - Installation Tips and Common IDL problems
- [Python](#) - see also [related blog posts](#)
 - [Setting up Python for Astronomy](#). There are several ways to do this.
 - [PyRAF](#)
 - [IDL vs. Python pros and cons](#)
 - [Python Switchers Guide](#) (i.e. Python translations of IDL and IRAF commands)
- [AIPS/CASA](#) - radio/sub-mm interferometric data reduction
- [LaTeX](#) - related blog posts
- [Mounting remote directories \(SSHFS\)](#)
- [OS X](#) - general tips
- [PGPLOT](#)
- [Starburst 99](#) (spectrophotometric simulation of star-forming galaxies)

Astronomical Methods

- [Observing](#) - info for various telescopes and instruments
 - [Airmass and Visibility Plots](#)
- [How to observe](#) - general advice for the new observer
- [Data Reduction](#)

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Password:

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Last changes

1. [Blogs by Astronomers](#)
2. [Rumor Mill Faculty-Staff](#)
3. [Rumor Mill](#)
4. [Multinest and PyMC](#)
5. [Setup a New Mac for Astronomy](#)

[...more](#)

<http://astrobetter.com/wiki/>

Practical Python for Astronomers

[Python4Astronomers 1.1 documentation](#) »

[next](#) | [index](#)

Practical Python for Astronomers

Practical Python for Astronomers is a series of hands-on workshops to explore the Python language and the powerful analysis tools it provides. *The emphasis is on using Python to solve real-world problems that astronomers are likely to encounter in research.*

- The workshops immediately make use of the full suite of plotting, analysis, and file reading tools.
- Along the way elements of the Python language such as data types, control structures, functions, and objects are introduced.
- This is an interactive experience using tutorial examples run by participants on their laptops.

Workshop topics

- [Introduction and Motivation](#)
- [Python Installation and Understanding Packages](#)
- [Core packages for analysis: IPython, NumPy, and SciPy](#)
- [CONTEST: Make a fun bouncing balls demo](#)
- [Plotting and Images](#)
- [Reading and Writing files](#)
- [Fitting and Modeling 1-D and 2-D Data](#)
- [Online Astronomy and the virtual observatory](#)
- [Astropy](#)
- [Analyzing UVES Spectroscopy with Astropy](#)

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Practical Python for Astronomers

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- [About the Workshops](#)
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Next topic

Introduction and Motivation

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Enter search terms or a module, class or function name.

Astropy

astropy

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A Community Python Library for Astronomy

The Astropy Project is a community effort to develop a single core package for Astronomy in [Python](#) and foster interoperability between [Python](#) astronomy packages. Development is actively ongoing, with major packages such as [PyFITS](#), [PyWCS](#), [vo](#), and [asciitable](#) already merged in, and many other components are under development. For more details, on the plan for the Astropy project, you can read the [original vision](#), or the [documentation overview](#).

The current stable version is [Astropy 0.2.4](#).

Stay updated by following [@astropy](#) on Twitter, and sign up for the [astropy](#) mailing list, where you can ask python astronomy questions of all sorts! If you want to get involved in Astropy development efforts, or other more technical discussions of Astropy, join the [astropy-dev](#) list.

Please note: If you use Astropy for work/research presented in a publication, please read [Acknowledging the use of Astropy](#).

Documentation

The documentation for the astropy core package is available at the websites listed below. The first is for the most recent released version. The second is for a version of the documentation that is automatically updated any time a change is made to the [astropy source code repository](#).

- [Stable version \(docs.astropy.org\)](#)
- [Latest developer version \(devdocs.astropy.org\)](#)
- [All versions](#)

<http://astropy.org/>

Installing

Detailed up-to-date installation instructions are provided in the [latest documentation](#), but we have included a simplified version here.

Astropy requires [Python](#) 2.6, 2.7, 3.1, 3.2, or 3.3, and [Numpy](#) 1.4 or later. The best way to install astropy is to use [pip](#):

```
pip install astropy
```

Or alternatively, you can download the source from the current version ([Astropy 0.2.4](#)), and install the source code in that archive using:

```
python setup.py install
```

Coyote's Guide to IDL Programming

The screenshot shows the homepage of Coyote's Guide to IDL Programming. The header features a coyote howling at the moon. The title "COYOTE'S GUIDE TO IDL PROGRAMMING" is prominently displayed, with "Discovering the Possibilities" below it. A navigation bar at the top includes links for Home, Tips, Programs, On-Line Help, Books, Plot Gallery, Store, Courses, IDL Links, Book Reviews, and Contact.

Coyote's Guide to IDL Programming

IDL Programming Tips

- [IDL Programming Articles](#)
- [IDL Programming Libraries](#)
- [Coyote Gallery and Code Examples](#)

What's New?

- [Meaning of Chi-Square Keyword](#) New!
- [Contours and Contour Colors Explained](#) New!
- [Converting UTM to Lat/Lon Coordinates](#) New!

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- [IDL Training Courses from Coyote](#)
- [Coyote Library On-Line Documentation](#)

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- [IDL Powerpoint Presentations](#)

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- [IDL Programming Books](#)
- [Recommended IDL Books](#)
- [What's Coyote Reading Now?](#)

Coyote's Adventures

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Most Popular Articles

- [Using the Coyote Graphics System](#)
- [What If My Coyote Program Doesn't Work?](#)
- [Do You Have IDL Example Programs?](#)
- [Can I Use Greek Symbols in IDL?](#)

<http://idlcoyote.com/>

IDL Astronomy User's Library



GODDARD SPACE FLIGHT CENTER

- + NASA Homepage
- + Sciences & Exploration Directorate
- + Astrophysics Science Division

SEARCH THE UNIVERSE

enter search terms

... this could take a while...

The IDL Astronomy User's Library

The IDL Astronomy Users Library is a central repository for low-level astronomy software written in the commercial language [IDL](#). The Library is not meant to be an integrated package, but rather is a collection of procedures from which users can pick and choose (and possibly modify) for their own use. Submitted procedures are given a cursory testing, but are basically stored in the Library as submitted. Instrument-specific software is generally not included in the IDL Astronomy Library, but can be found at the [Links to Other Astronomy and IDL related sites](#).

The entire contents of the Library can be downloaded in a tar file or in a .zip file from the the [download site](#) . Additional software, not included in the tar files, is available in a `contrib` directory. Individual procedures can be copied by browsing through a list of [one-line descriptions](#). Changes to the contents of the Library are recorded in a [news](#) file.

The plotting routines in the IDL Astronomy Library make use of programs in the [Coyote Graphics Library](#), which must be downloaded separately. Alternatively, one can download [coyote_astron.tar.gz](#) which contains a subset of the Coyote procedures needed for the Astronomy library.

Documentation is available describing the various options for working with [FITS data in IDL](#).

The IDL Astronomy Library requires at least IDL V6.4. However, separate (frozen) versions of the Library that work with earlier versions of IDL are available at the [/old](#) download site.

The success of the IDL Astronomy User's Library depends on the willingness of users to give as well as take. Please inform Wayne Landsman of any possible contributions to the Library, programming bugs or documentation errors, or of relevant web sites.

- [One-line descriptions of procedures](#)
- [Links to Other Astronomy and IDL related sites](#)
- [IDL Astronomy Library download site](#)
- [Searchable index of all IDL Astronomy Library procedures](#)
- [Chronological list of changes to the Library](#)
- [Frequently Asked Questions \(FAQ\)](#)

<http://idlastro.gsfc.nasa.gov/>

A service of the Astrophysics Science Division (ASD) at NASA's GSFC

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