Operating the CCD Camera

1995 Edition

Incorporates 'ccd' software for disk storage
This eliminates problems with 'cc200' software

1   Setting Up

Very little setup is required; the camera and its electronics unit are permanently mounted on the 20" telescope. The computer to run it is on a cart in the back room of the center bay of the observatory. The only setup you are likely to be required to perform is to install the appropriate filter slide. Note that the filter slides each contain two filters (or one filter plus a clear position). If you loosen the thumb-screws holding the filter slide in place, you can slide it from one side to the other, thereby inserting either of the two filters in the beam.

2   Turning On the Camera

The equipment should have been left turned off; turn it back on in this order. In the rest of these instructions, commands that you type into the computer will be shown in **bold-face**. Initiate the execution of commands by pressing the enter key.

1. Turn on the LC200 Liquid Cooling unit mounted on the telescope. The switch is a toggle switch next to the power cord. The pilot light next to the power switch should come on. Make sure there are no kinks in the coolant tubes which might restrict coolant flow. Re-check these periodically through the observing session, especially when you rotate the camera, such as while changing declination or hour angle of the telescope. *Restriction of cooling fluid flow may degrade the images taken by the camera, and can damage the camera if it continues for too long a time.*

2. Flip on the switch on the power strip on the electronics cart; all of the equipment on the cart should come on. If not everything comes on, check the power strip switches under the right monitor, and the power switches of the individual components.

3. Turn on the CE200 Camera Electronics unit mounted on the telescope. The switch is next to the power cord. Be sure both the AC and the DC power lights come on.

It takes an hour or more for the camera to completely cool down and stabilize. It is functional while it is cooling, but responsivity and bias will vary and even the focal position may vary. If you turn on the camera system first, then open up the roof, get the telescope ready, find the field of your source, etc., it will likely be well stabilized by the time you need reproducible responsivity and bias.

4. Turn on the telescope power.

5. After the computer has automatically booted, type **cd \ccd**.

6. Type **ccd**. An asterisk (*) prompt should appear on the computer screen.

7. To exit from the ccd program (after you have finished taking pictures and transferring them to hard disk), type **quit** as the very first characters after the asterisk prompt, and then press the enter key.

3   Taking a Picture = Operating the Electronics

To control the camera, type in commands at the asterisk prompt. Camera commands can be strung together on a line, using at least one space character to separate them. Some special commands, directed to the ccd program itself, such as **quit**, must be the first, and only, command on the line; not even an entered space may precede these special commands. Initiate the execution of a command or line of commands by pressing the enter key.

The camera can be run quite adequately using only two commands. You can do about everything you would ever want to do with about ten commands. The instrument knows about a hundred commands but most are seldom needed. Reverse Polish notation is used in all commands.

The basic commands are: **obs** and **fshow**. The syntax is as follows:

n obs Opens the shutter on the camera for 'n' deciseconds (don't ask). For example, **10 obs** takes a 1-second exposure.

fshow Displays the picture.

That's it; you can run the camera. If you want to do more, here are a few more useful commands.

n m show Redisplays the picture using the specified range of intensities. E.g., **300 1100 show** scales the displayed intensities such that 300 is black and 1100 is white. There are 256 levels of gray between black and white. The camera readout is digitized to 14 bits and so has 16,384 levels of intensity; the **show** command allows you to bring out the dim features in the picture.

maxmin Prints the maximum and minimum intensities in the image on the screen. This is helpful for choosing parameters for **show**.

n ci Selects an image cache. The program comes up in cache #1; an image will be stored there. If you take a second image, it will overwrite the first. You can save the first image by typing **2 ci**. The second image will then go into cache #2, etc. You can redisplay image #1 by typing **1 ci fshow**. The **1 ci** puts you back in cache #1 and the **fshow** displays it. If you record another image now without changing the cache it will overwrite cache #1. The caches must be opened in sequence.

qci Tells you what cache you are in and the size of the image (384x576 pixels).

The 'mouse' can be useful. Tap the right-hand button once and a cursor will show up on the screen. Move the cursor by moving the mouse. The position of the cursor and the intensity there will be displayed at the top of the screen. This is a good way to figure out what values to use in **show**. Tap the button twice more to get rid of the cursor.

A few more handy commands are:

n m focus This takes and displays n exposures of m deciseconds each. The display is of a 100x100 array centered on the cursor. It is used to focus the telescope. For example, **20 2 focus** displays 20 0.2-second exposures in succession.

n m zoom This magnifies the section of the image centered on the cursor by a factor of 'n' in x and 'm' in y. E.g., **5 5 zoom** magnifies it by a factor of 5 in both directions; **1 1 zoom** puts it back.

bias fshow This reads out the image and displays it without taking an exposure. It shows the readout noise and is useful for monitoring the CCD's temperature while it is cooling down. It is important to record bias frames whenever you take images from which you will want to extract photometric information.

There are commands for combining images, displaying intensities on cuts through the image, and much more. These can all be found in the glossary in the instrument manual located in the cabinet in the central room near the east bay door.

4   The Optical and Mechanical Aspects of Taking a Picture

All of the above merely tells you how to manipulate the electronic components of the camera. In addition, of course, you must choose an appropriate filter and point the telescope at the appropriate astronomical object. The filter holder allows you to switch between two different filters in the beam without removing the slide. Merely loosen the thumbscrews and slide the filter holder to one side or the other, noting the labels taped to the filter holder. Holders containing other filters are usually kept in the metal cabinet in the central room of the observatory, together with all other parts for the CCD camera system.

Centering an astronomical object is done with the eyepiece on the side of the camera. There is a flip-down mirror, operated by the round knob on the side of the camera, which can be used to divert the beam to the eyepiece. Remember to flip the mirror back up before you take a picture. There is a rectangular reticle in the focal plane of the eyepiece which more or less represents the position and size of the CCD in the focal plane. Unfortunately, this reticle is not yet illuminated and is thus hard to see.

While the orientation of the CCD on the sky is nominally fixed, it is always best to check the orientation. This is most easily done with a bright star in the field of view. Take an image with the star at the center of the field and then take images after driving the telescope several (5-10) seconds (at the slow or guide speed!) North, and then again after driving East. When you interpret the displays, remember that it was the telescope that you moved north and east, not the star. Since the 20" telescope incorporates a diagonal flat, the image of the sky in the focal plane is a mirror image (plus rotation) of the real sky. However, the display of the image from the CCD is controlled by the order in which the pixels are read out of the chip and can, in principle, be either a mirror image or a direct image.

The focusing procedure is to first focus the telescope onto the CCD and to then slide the eyepiece in and out until it is focussed. To focus the telescope, put a fairly bright star near the zenith in the center of the field. Then use the command **m n focus** to take a series of **m** exposures, each **n** deciseconds long, of just the center of the field. Adjust the focus of the telescope slightly between each image and watch how the focus changes. It is possible to determine the best focus to within ± 2 in the last digit of the digital readout of the focus position.

Exposures longer than several seconds should be guided since the drives on the telescope are not precise. Unfortunately, at the time of this writing, the guiding system based on the 4" guide telescope is not functioning.

Some key parameters that you might need at some time are as follows.

Plate Scale: The nominal plate scale in the focal plane of the 20" telescope is 27 arc-seconds per millimeter.

Pixel Size: The CCD chip has pixels which are $23 \times 23\mu$m.

5   Saving and Retrieving a Picture

It is possible to save an image in a permanent file and to retrieve it later. Be sparing in this because each picture takes up about a half million bytes. However, before saving an image, it is useful to know about a few more commands:

comment c This enters the comment 'c' into the header for the current image. The comment can be up to 99 characters long. E.g., **comment NGC 6720** enters 'NGC 6720' into the header.

qimages Prints out the cache #, image size, and any comment entered in all of the defined caches.

The actual saving and retrieving is done with a simple command. Before saving or retrieving an image, select the image cache using **n ci**. Verify that you have the right image cache by commanding, *e.g.*,**qimages** to review comments associated with the images or **fshow** to display the image. Now you are ready to save or retrieve an image. The following two commands are special commands which must entered as the very first characters on a line, immediately after the asterisk prompt:

dw imagename.img This command will write the current image cache to hard disk (**dw** stands for **d**isk **w**rite), into the file named imagename.img; be sure to include the '.img' extension. For example, typing **dw N6720.img** saves the image into file N6720.img on the PC's hard disk. The filename specification can include any permitted PC-DOS pathname which already exists on the hard disk, such as 'C:\CCD\IMAGES\N6720.IMG'.

dr newimage This command will read the image in newimage from the hard disk (**dr** is **d**isk **r**ead) into the present image cache.

Often you will wish to check the directory of image files on the PC's hard disk which may be read in, or the names of images already written out to disk. The command for

this is fairly simple, but requires some knowledge of PC-DOS file and path naming conventions for maximum effectiveness. For example, to get a listing of the '.img' files in C:\CCD\IMAGES, enter **! dir c:\ccd\images*.img** with the ! as the very first character on the line. The ! indicates to the computer that the remainder of the line is to be passed to PC-DOS to be interpreted and acted upon by the PC-DOS operating system; control passes back to the ccd program upon completion of the command. Note that commands to the camera system may not be added to the same line; a carriage return (enter key) is required to submit the DOS command and terminate the line. Of course, any DOS command may be submitted to the operating system via this method.

If you find that you are entering the same sequence of commands many times, and if you know enough about PC-type computers to create a text file, you can create a text file containing all the commands, and then re-direct input from that batch file to the ccd program by use of the command < **obslist** where obslist is the name of the file you have created. This command is also a special command to the ccd program which must be the very first, and only, command on a line. The results (or error messages) for each line are displayed on the monitor as the lines are executed. Control is returned to the CCD program when all commands have been completed, or when errors have terminated the execution of the batch file.

6 Problem Solving

Occasionally you will see bizarre behavior from the system. A common cause of bizarre behavior is using **CTRL C** to exit from a procedure. This can leave the camera or the camera controller in an abnormal state. Several commands are useful in this situation:

qimages asks the system to tell you the characteristics of all images that are defined in caches in memory.

format asks the system for the characteristics of the images that will be taken next by the camera.

reset is used to reset all the parameters of the system to their default values. This is often a convenient way to get rid of bizarre behavior.

If the **reset** command does not solve the problem, the first step is to exit from the ccd program by typing **quit** and then to restart the program. If this fails, it may be necessary to reboot the computer, the camera controller, or both. If none of these techniques solves the

problem, scream loudly to vent your frustration, but do not attack your partner because this leaves a mess in the observatory.

7   Shutting Down

Shutting down is basically a reversal of the procedure for turning on.

Before shutting down the system, save all images you wish to keep to hard disk and/or to tape (see separate description for procedure to save images to tape). Images not saved to hard disk will be lost when the CC200 is turned off.

1. To get out of the CCD program, type **quit** as the very first entered characters after an asterisk prompt.

2. Copy your images to a floppy disk for later processing with IDL routines on the Gateway Pentiums on campus.

3. Turn off the CE200 Camera Electronics first.

4. Turn off the power strip on the cart; everything on the cart should turn off.

5. Turn off the LC200 Liquid Cooling unit.

6. Turn off and stow the telescope, close the roof, turn out the lights, put out the cat, and close and double-lock the observatory door.

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