

CCD User's Guide

SBIG ST7E CCD camera and Macintosh iBook control computer with
Meade flip mirror assembly mounted on LX200

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CCD Kit Checklist

Use the following checklists to

1. Alert the instructor or TA about missing pieces before beginning a night's observing and
2. Ensure that the kit is complete for use by your classmates next time.

Items inside the case

1. SBIG ST7E CCD camera
2. Camera power supply (large one with cords out either end)
3. Parallel-to-SCSI converter box (small black box)
4. Converter box power supply (small one)
5. Parallel cable (long tan one)
6. SCSI cable (short gray one)
7. SCSI-to-USB adapter/cable (short white one)
8. Meade flip mirror

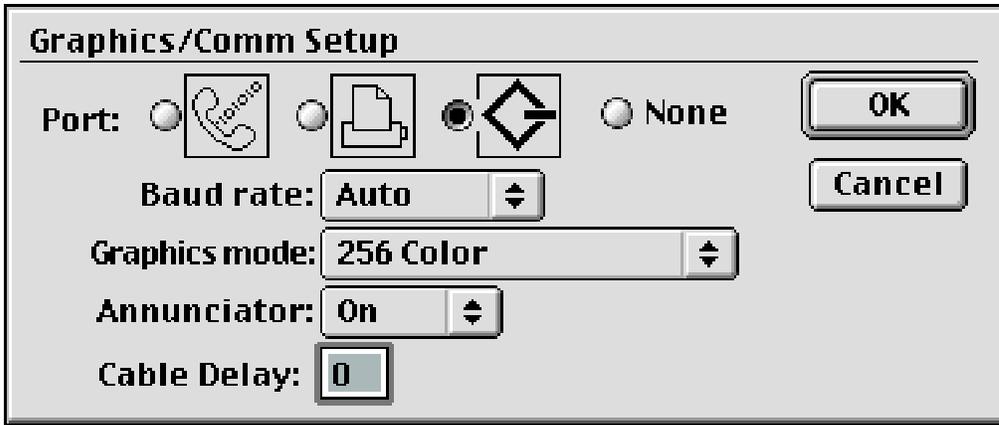
Equipment Setup Procedure

1. Setup and align the telescope.
2. Attach flip mirror to visual back (**do not attach camera yet**)
3. Connect camera to SCSI box with parallel cable (long tan one)
4. Plug power cord into camera (**but do not plug the other end to power yet**)
5. Attach camera to telescope (**do not attach the camera to the telescope before all cords have been plugged into the camera or you risk ruining your telescope alignment**).
6. Mount and adjust counterweights on telescope
7. Connect SCSI box to USB adapter cable (short white one) with SCSI cable (short gray one)
8. Plug in and power SCSI box
9. Plug in camera power cord to power (this powers the camera, there is no switch)
10. Check that computer is on, not sleeping, and plugged in (**DO NOT ATTEMPT TO CONTROL CAMERA WITH COMPUTER USING BATTERY POWER**)
11. Connect USB cable to computer
12. Start CCDOps software (double click CCDOps icon on computer desktop). You should see a window similar to that below: If you get an error message that requires you to restart your computer, do so and then drag the CCDOps preference file from the preferences folder inside the System folder to the trash and restart CCDOps.



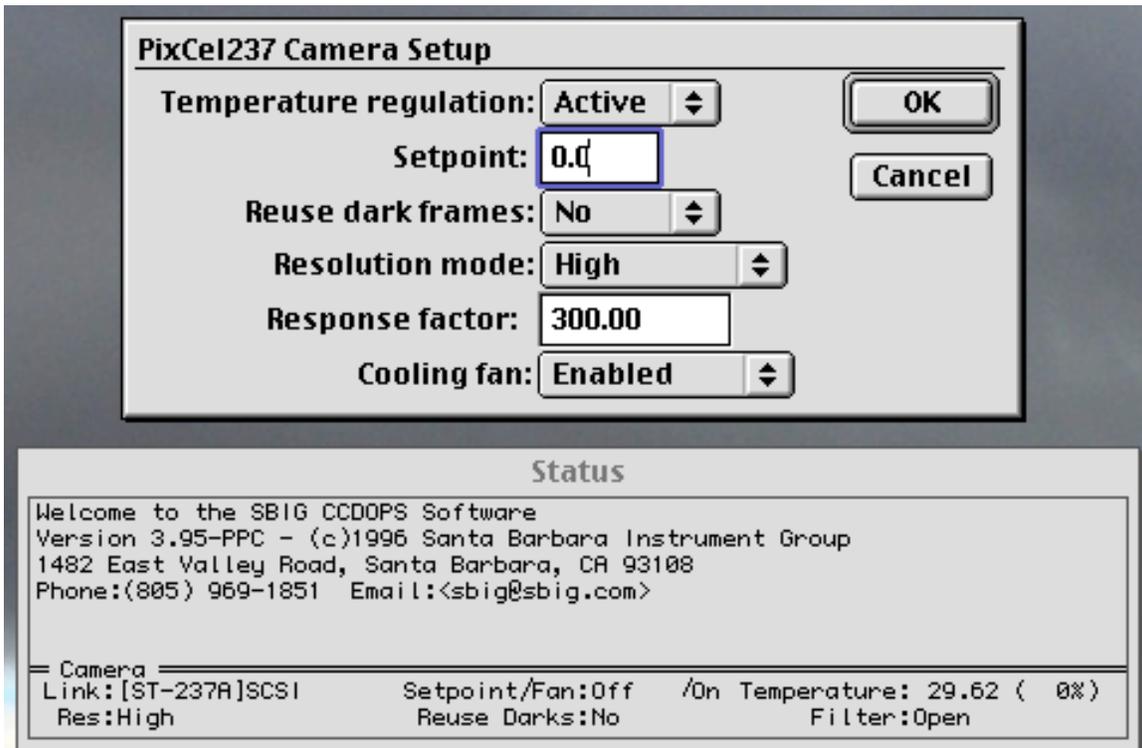
If you see *Not found* next to *Link:* in the lower left corner of the above window, check the following:

- Under the *Misc menu*, select *Graphics/Comm Setup...*
- The following window will be displayed



- Check that SCSI is the selected Port (it is the third symbol) and click OK
- Now under the *Camera menu*, select *Establish COM Link*

13. Under the *Camera menu*, select *Setup...* The following window will pop up:



Set the *Temperature regulation* to *Active*. The *Setpoint* should be about 30C below ambient. Set *Reuse dark frames* to *Yes*. After you gain some experience with CCD imaging and what calibration frames you will need for a nights worth of imaging you will want to turn this option off.

A word about which resolution mode to run in. In High resolution mode the camera is configured for the smallest pixels and the highest resolution. In Low resolution mode, pixels are binned together in 3x3 boxes to produce the largest effective pixels and thus

the lowest resolution. This results in smaller data files and thus faster download times from the camera to the computer.

Resolution	Binning	Approx. Saturation Level
High	None	40,000
Medium	2x2	65,000
Low	3x3	65,000

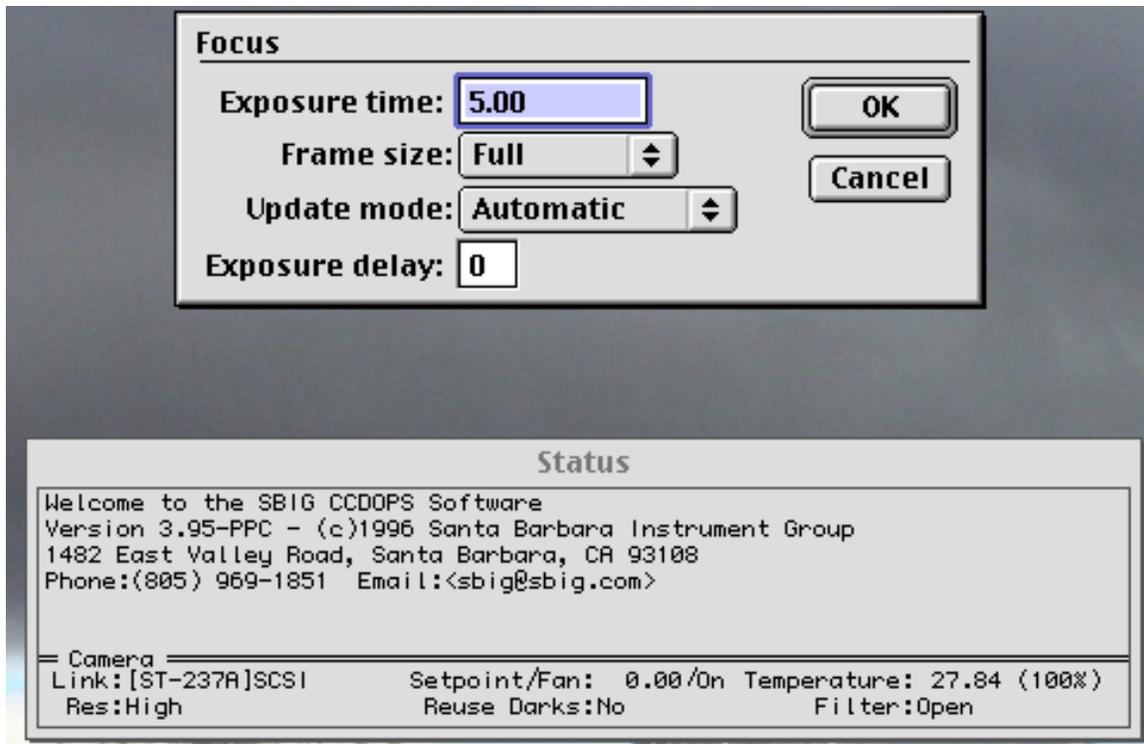
Once you press okay the camera will begin to cool and you should see the temperature begin to drop. It will stabilize in a short time, you should see the % next to the temperature value drop below 100%. You want to let the temperature stabilize before you focus or take data. If the percentage does not drop below 100% in 10 minutes, you should raise your set point. Monitor the percentage throughout the night, you can make it lower as the ambient temperature drops to reduce thermal noise.

Focusing

In order to obtain the best possible data from your image, you must pay some attention to getting the best focus possible. Unlike focusing when viewing through an eyepiece, when you focus the CCD camera you can't directly observe the image to determine its quality. Thus it may take a little practice to get the knack of dealing with the display because of the time lag between making a focus adjustment and being able to see its effect on the display screen. You can reduce this delay by choosing a focus star that is bright enough to be well exposed with only a short (~0.1 sec) integration time and also by only digitizing the small part of the image that contains the star.

Focus Procedure

1. Select a relatively bright star (+2.5 to +3.5) that is well above the horizon (that way you are looking through less atmosphere, less seeing or scintillation problems closer to the zenith). You want something that is bright enough to focus with in a short time, but dim enough not to saturate the detector (see approximate saturation counts in table on previous page).
2. With the flip-mirror in the "visual" position, acquire the star in center of the FOV and do a preliminary focus by eye in the acquisition eyepiece. The focus of the CCD will be quite a bit different from this focus so this does not need to be done carefully...its just to get you in the right ballpark.
3. Now, flip the mirror so that the light goes to the CCD rather than your eye. Under the *Camera* menu, select *Focus...* to bring up the focus control window (example shown below). The exposure time is measured in seconds. Change the exposure time to something short, like 0.1. There are three options under frame size, *Full*, *Planet*, or *Dim* Choose *Full* to begin with so you get the entire image and can figure out where your star is located. Choose *Manual* for the *Update Mode*. This allows you to tell it when to take and exposure manually. *Automatic* will simply keep taking exposure after exposure until you tell it to stop. Click ok -- the computer will tell you the image is being taken and then displayed.



4. The focus mode displays the image as well as the peak value in brightness of the brightest object in the FOV. Make sure the star is in the FOV and check for saturation and adjust exposure time or find another dimmer if necessary. Make sure to record the exposure time in your notebook!
5. After you get your first image, you can significantly shorten your download time by using *Planet* mode. It will take a full size image and then ask you to move a box (in both placement and size) to the part of the image you want to download. Click on the box and move it to where your star is located. Then press *Resume*. Again it will take a image, but this time only of the small area you have selected.
6. Now the general idea is to adjust the focus knob on the telescope, take an image, inspect it and iterate on this until you achieve the best focus possible. It is best to start with fairly rough adjustments in one direction (say 1/2 turns of the focus knob). If the focus gets worse, then go in the other direction. Go past a good focus and then come back. A sufficiently out-of-focus image will appear as a "doughnut" shape owing to the secondary mirror obstruction of this Schmidt-Cassegrain design of telescope. Adjust the focus knob so as to maximize the peak brightness value (without saturation) and minimize the size of the star image. If saturation occurs you will need to choose a dimmer star if you can't decrease the exposure time enough prevent saturation. The peak brightness value can vary by 30% or so due to seeing variations so when you are getting close to good focus you should take several images before deciding whether you need to adjust further.
7. When you get close to good focus, it may help to use the *Automatic Update Mode* so that the system will continually take images until you tell it to stop.
8. Once you are happy with the focus in the CCD camera, adjust the position of the eyepiece in its seat in the flip-mirror. To do this, first flip the mirror back to the

“visual position”. Then loosen the set screw for the eyepiece and slide the eyepiece in and out of the flip mirror seat until what you see in the eyepiece looks focused. **Do not adjust the focus knob after you have set it for the CCD.**

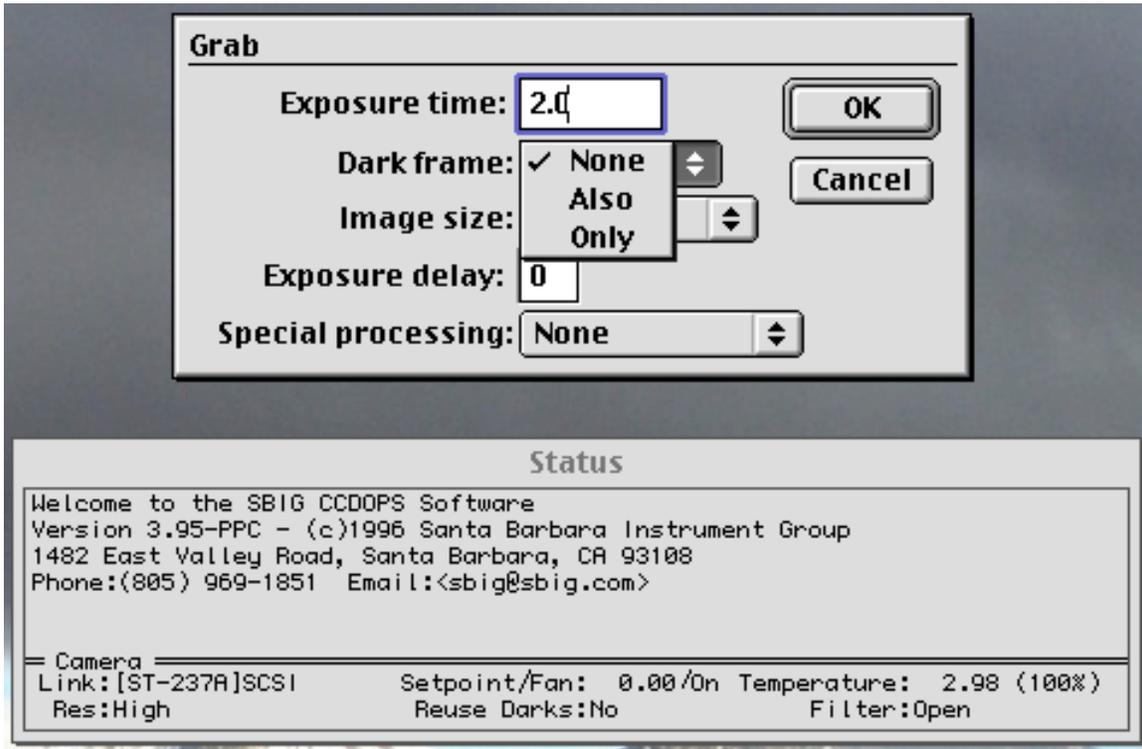
Observing Information

Target Acquisition

Now you are ready to acquire your target and take some data! Remember that the view through the eyepiece is left-right reversed, because the flip mirror has an internal diagonal mirror. Sometimes it may be helpful to use the *Dim Focus Mode* until you have found and centered your target in the CCD FOV. This is a full chip 3x3 binned mode which allows fast downloads making the setup go a bit faster.

Imaging

1. Once you have acquired your target, dismiss the focus window. Under the *Camera* menu, select the *Grab...* command for taking individual images. The window below will pop up. Set your exposure time and choose your image size, *full*, *half*, or *quarter* of the CCD array. When you first start imaging, you can choose *Also* for *Dark frame*. This will take a dark frame each time you take an image and subtract it before displaying it. As you get more experienced, it will become more efficient to take your dark frames at the beginning or end of your imaging session (see the Calibration section below for more info).



2. Under the *Edit* menu, you can select *Show icon bar* to provide shortcuts to some common commands:



You may find this useful.

3. Saving an Image:

Use the *File/Save As* command, rather than *Save*. This is a safeguard so you don't overwrite an image. Use the *compressed* or *uncompressed* file format (if you choose another format CCDOps will not be able to open this file).

Create a folder in the data files directory on the machine with your name. Inside this folder, create a folder with the date. Inside this you can save your images. Make sure you choose a useful name for each image and create a paper log file with the pertinent information about the image.

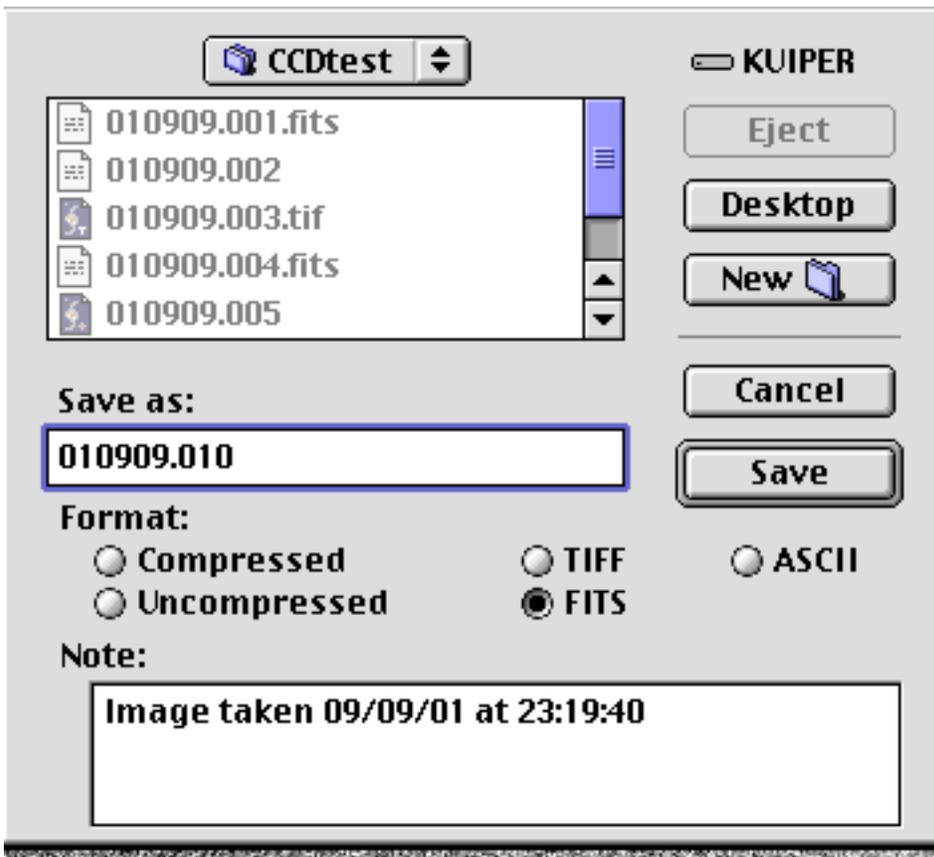
Example directory path:

Data Files:AndyR:20020110:

For example an image name might be:

date.imagenumber.sb(YYMMDD.XXX.sb) or some other descriptive title like:

Saturn1.sb (the sb stands for SBIG image format which is the only format the CCDOps can read)



4. Additional things to be aware of:

- While observing, keep an eye on the size of your stellar images. If they seem to have gotten blobbier over time, then either the focus has changed, the seeing has deteriorated, or both.
- Try to keep your target away from the edge of the array.
- As you work through your observing program, be aware of and check frequently for possible over-exposure.
- Be very careful to check what you have entered for your exposure time. At this point, we don't know the outcome of aborting an integration process. If you want to start a 60-sec exposure and accidentally type in 600-sec you may have to wait a bit for the longer exposure to finish. Whenever you enter a new exposure time, double-check for typos *before* hitting ok or <return>!
- Check the position of the flip mirror, especially before taking a long exposure. If you can see through the eyepiece, the flip mirror is not lined up with the CCD.

Feeding Your Observing Notebook

Just as you did for visual observing, you need to take sufficient notes for each image as well as record general information about the conditions.

For each data image record the following: Number in image sequence, time, object, and exposure time

For darks: exposure time is sufficient

Calibration Frames

What for?

Taking calibration images and applying them to your data images reduces the amount of noise in your final product and allows you to see more detail.

How many?

In order to reduce the random noise in your calibration images, it is necessary to take multiple calibration images and average them. In general averaging n images will reduce the random noise in the product by a factor of \sqrt{n} . It is a good idea to get in the habit of taking $n+1$ images so that you have an extra and can afford to throw one out if you find a cosmic ray hit. A cosmic ray completely fills the wells of any pixel it hits as it passes through the detector. If the signal from any contaminated pixels gets into your calibration image then the resulting image artifacts will be passed onto every data image you process with this calibration image.

We recommend that you expose and save at least 5 of each type of calibration frame you need.

What kind?

There are three basic type of calibration frames: darks, zero-biases, and flats. For 12.409 purposes you will only need to take and apply dark frames.

Dark frames:

A dark frame is simply an image taken at the same temperature and for the same duration as the light frame with the source of light to the CCD blocked. This dark frame will contain an image of the noise caused by dark current (thermal noise) and other fixed

pattern noise such as read out noise. When the dark frame is subtracted from the light frame, this pattern noise is removed from the resulting image.

Always take dark frames of equal exposure length to your data images. A set of 3-5 dark frames per exposure time per session (for all data taken at the same chip temperature is recommended.

Zero-biases

A zero-second exposure with the shutter closed that records readout noise. This is included in the dark frames. It is mentioned separately because advanced imagers sometimes use them in combination with a scaled master dark frame to reduce the amount of time spend taking dark frames. This type of calibration is not recommended.

Flat field frames

A flat frame is a regular exposure of uniformly illuminated featureless surface such as a white projection screen or a blank patch of twilight sky through the same optics as your data images. The purpose is to record pixel to pixel variations in the detector sensitivity caused by intrinsic variability in the detector as well as dust or other obstructions or aberrations in the optical path. They are used to get the maximum possible accuracy from photometry (measuring magnitudes). It is time consuming to get good ones and bad ones can actually make your images and photometry worse. This type of calibration will also not be used in 12.409

Packing Up

When you are finished for the evening:

1. Quit CCDOps (if it asks you to deactivate the temperature control, say yes)
2. Unplug USB cable from computer
3. Unplug camera from power (do not remove any cables from the camera just yet)
4. Power off the SCSI converter box
5. Remove the camera from the flip mirror
6. Remove flip mirror and counterweights from telescope
7. Unplug all remaining cables
8. Carefully store all equipment in the case the way you found it

Use the kit checklist to make sure you still have everything you started with (check around the ground nearby, your pockets, and nearby telescope kits if necessary) and that you haven't inherited extra parts from someone else's kit.