CCDOPS

Version 4.0

for Windows 95, Macintosh and DOS

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Section 1 - Installation and Introduction

1. Installation/User Interface

Welcome to Santa Barbara Instrument Group's CCDOPS software. CCDOPS is the camera operating software for all SBIG cameras except the ST-4 (the ST-4 has it's own software package named CCD). This manual is broken down into several sections:

- Section 1 tells you how to install the software on your hard disk and explains the elements of the CCDOPS user interface.
- Section 2 section explains the structure of CCDOPS and gives you the highlights of how to most effectively use CCDOPS for acquiring and processing images. Read this after you have worked through the "First Night Tutorial" in your camera operating manual.
- Section 3 gives detailed information about every command in CCDOPS. Use this as a reference for each of the commands as you explore the system in further detail.
- Section 4 gives hints and tips for experienced users to optimize your imaging experience.

1.1. Different Host Computers

Santa Barbara Instrument Group offers CCDOPS for IBM PCs/Compatibles with DOS and Windows 95 versions and on the Macintosh with native 68K and Power PC versions. The CCDOPS software package supports all SBIG cameras (except the ST-4) and is designed to be operationally identical on all supported platforms. Images captured on the IBM PC can be used on the Macintosh and vice versa. The differences between the PC and Macintosh versions of the software are very minor, mostly owing to minor differences in hardware capabilities between the two platforms. Each of the environments offer a menu based GUI with full support for the mouse.

1.2. Installing the Software

The CCDOPS software is provided on floppy diskette, and should be copied to your system's hard disk prior to use. Install the software into a directory or folder on your hard disk by following the instructions below:

Windows 95 Users

1. Insert diskette number 1 into the floppy disk drive.
2. From the Start menu use the Run command to run A:SETUP.EXE.
3. Follow the directions for the included installer.

Note: *Should you ever want to uninstall the CCDOPS for Windows 95 software run the Add/Remove Programs utility in the Settings->Control Panel item in the Start menu. This way any DLLs that get installed in the Windows directory are handled correctly.*

MS-DOS Users

1. Insert the diskette into the floppy disk drive.
2. At the MS-DOS prompt type "CD \" then hit the Enter key to log into the root directory of your hard disk.
3. Type "MKDIR CCDOPS" then hit the Enter key to create a directory for the software.
4. Type "CD CCDOPS" then hit the Enter key to make that directory active.
5. Type "COPY A:\*.*" or "COPY B:\*.*" depending on which floppy drive you are using then hit Enter to copy all the software to the CCDOPS directory on your hard disk.

When you want to run the software, turn on your computer and type in the following sequence of commands at the MS-DOS prompt:

```
CD \CCDOPS <hit Return>
CCDOPS <hit Return>
```

Note: *CCDOPS for DOS was not designed to run under Microsoft Windows. If you use it under Windows be advised that you may encounter difficulties and/or your ability to communicate with the camera at high speeds may be limited.*

Macintosh Users

1. Insert the diskette into the floppy disk drive.
2. Create a new folder on your hard disk named CCDOPS.
3. Click and drag all the files on the CCDOPS diskette into the folder you've just created.

After you have finished installing the software place the floppy disk in a safe place in case you need to reinstall it later.

Internet Users Note that you can always download the latest version of the CCDOPS software from SBIG's homepage <www.sbig.com>.

1.3. The CCDOPS User Interface

The CCDOPS environment presents the user with a user-friendly menu based interface. Rather than having to remember long command names and do a lot of typing, CCDOPS presents all the commands in a logically organized menu structure. The software has been designed to be simple for inexperienced users while offering advanced capabilities as experience grows. Many man-hours and improvements from user's comments and suggestions have gone into the development of CCDOPS. We encourage you to continue to help us improve the software through your comments.

At the top of the screen is a menu bar with pull-down menus of logically grouped commands. For example the Camera Menu has commands that allow you to take an image (the Grab Command), focus the camera (the Focus Command) or try to initiate communications with the CCD Camera (the Establish COM Link command). The DOS and Macintosh menu bars are shown with one of the pull-down menus in Figure 1.1 below:

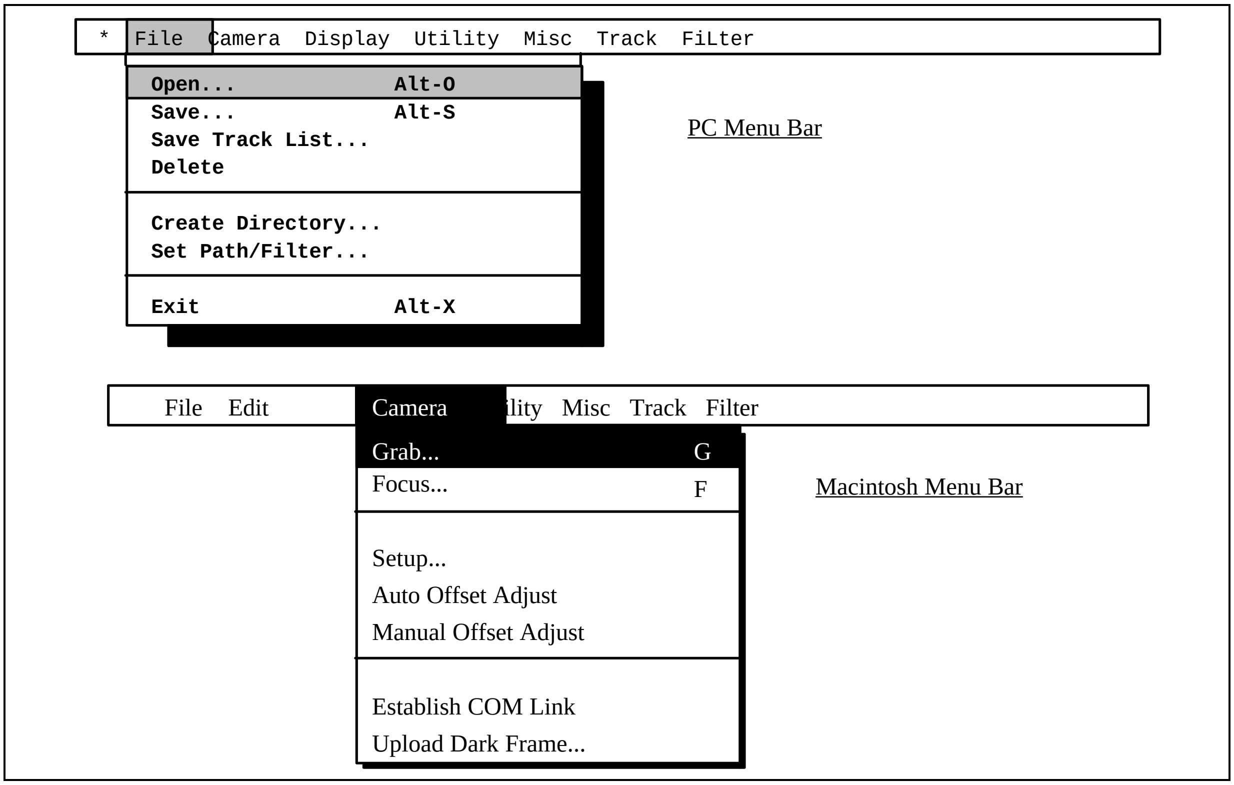
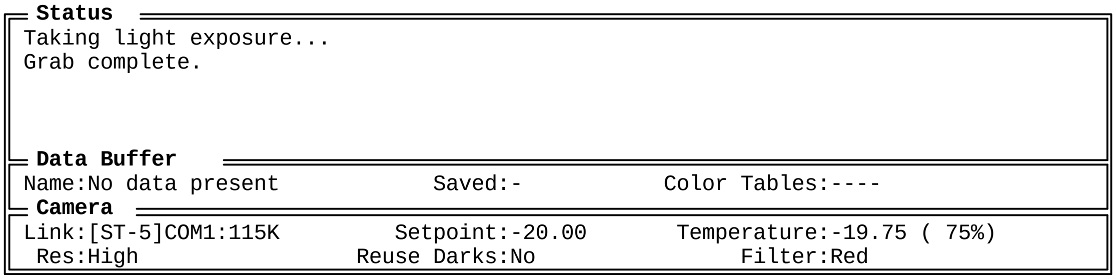

* File Camera Display Utility Misc Track FiLter
Open... Alt-O
Save... Alt-S
Save Track List...
Delete
Create Directory...
Set Path/Filter...
Exit Alt-X
PC Menu Bar
File Edit Camera ility Misc Track Filter
Grab... G
Focus... F
Setup...
Auto Offset Adjust
Manual Offset Adjust
Establish COM Link
Upload Dark Frame...
Macintosh Menu Bar

Figure 1.1 - CCDOPS Menu Bar

Some of the menu commands operate immediately like the Establish COM Link command in the Camera menu. Other commands require further user input such as the Grab command. These "further input required" commands are shown with an ellipsis (...) after the command name. Also, some often used commands have a "hot-key" associated with them which is shown in the menu. Typing the hot-key combination invokes the command. For example holding down the key on the Macintosh , the Ctrl key under Windows 95 or the Alt key under DOS and then hitting the G key invokes the Grab Command.

At the bottom of the screen is the Status Window. The Status Window, shown in Figure 1.2 below, contains two or three sections. The top section called the Status Box is used by the software to provide written feedback to the user about the activities being performed.

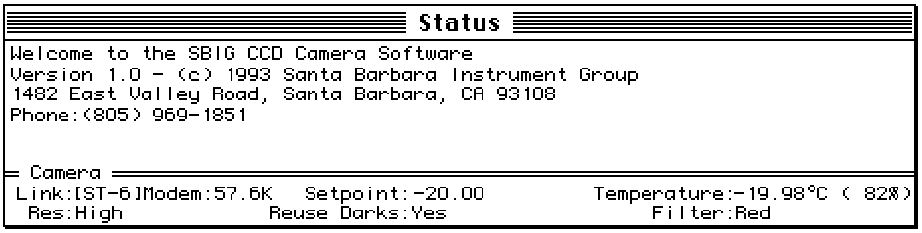
On the DOS version of CCDOPS, there is a double-outlined Data Buffer Box below the Status Box that tells the user about the status of image data held in the software's image buffer. The type of camera used to take the image and the name of the image are shown as well as an indication of whether the image has been saved on the disk drive. Also shown is the status of the Color Tables indicating whether any custom color tables have been loaded. Color Tables are used in conjunction with the Display Command to assign different colors to the display of images rather than the typical gray scale.



```
Status
Taking light exposure...
Grab complete.

Data Buffer
Name:No data present            Saved:-          Color Tables:----
Camera
Link:[ST-5]COM1:115K        Setpoint:-20.00      Temperature:-19.75 ( 75%)
 Res:High                  Reuse Darks:No              Filter:Red
```

DOS Status Window



```
Status
Welcome to the SBIG CCD Camera Software
Version 1.0 - (c) 1993 Santa Barbara Instrument Group
1482 East Valley Road, Santa Barbara, CA 93108
Phone:(805) 969-1851

Camera
Link:[ST-6]Modem:57.6K   Setpoint:-20.00        Temperature:-19.98°C ( 82%)
 Res:High            Reuse Darks:Yes              Filter:Red
```

Win 95 and Mac OS Status Window

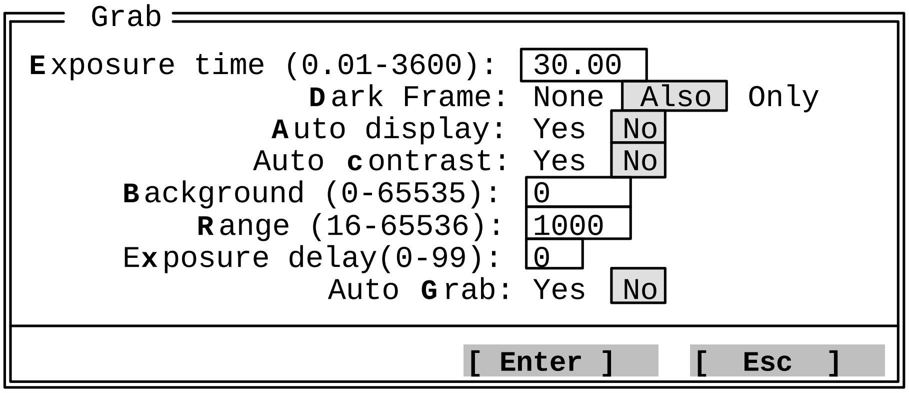
Figure 1.2- Status Window

At the very bottom of the Status Window is the double outlined Camera Box that indicates the status of any CCD camera attached to the host computer through one of its COM ports. The Link status shows the type of camera and the COM port and Baud Rate used to communicate with the camera. Also shown (if a camera is attached) is the status of the camera's cooling. For ST-4X cameras the cooling is either turned on and Enabled or is Off. For the other cameras the user selectable setpoint temperature and the camera's actual temperature are shown as well as the percentage of power being applied to the TE cooler to maintain that setpoint.

The second line of the Camera Box shows the resolution mode the camera is setup for (using the Camera Setup command) and whether dark frames will be reused. In the lower right hand corner the active optical filter from the filter wheel is shown.

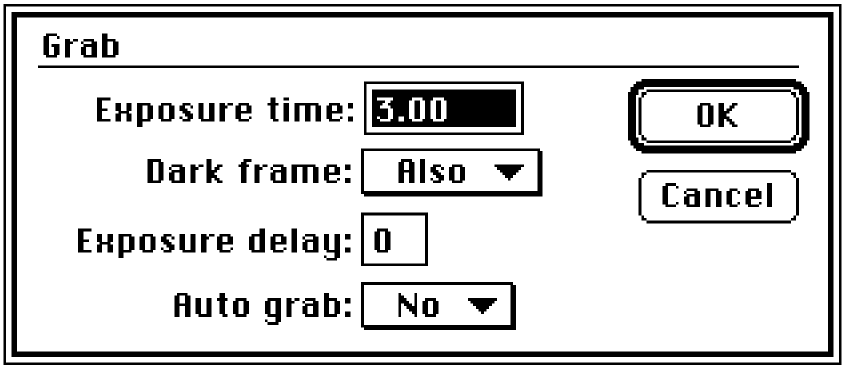
The region between the menu bar and the status window is called the Desktop. The CCDOPS software uses the Desktop area to get further user input for commands like the Grab Command using data entry boxes called Dialogs (or Dialog Boxes). The Desktop area is also to inform the user about the progress of activities that take a long time, such as taking a 1 minute exposure, and to inform the user about important aspects regarding the operation of the camera.

Dialog Boxes pop-up on the Desktop and present the user with a series of data entry items, which as stated previously, fine tune the operation of certain commands. Within these dialogs, data entry items are arranged in a vertical fashion. The user proceeds through each item, setting it as appropriate. Figure 1.3 below shows the DOS and Macintosh versions of the dialog box for the Grab Command:



Exposure time (0.01-3600): 30.00
Dark Frame: None [✓ Also] Only
Auto display: Yes [✓ No]
Auto contrast: Yes [✓ No]
Background (0-65535): 0
Range (16-65536): 1000
Exposure delay(0-99): 0
Auto Grab: Yes [✓ No]

DOS Grab Dialog



Exposure time: 3.00
Dark frame: Also
Exposure delay: 0
Auto grab: No

Macintosh Grab Dialog

Figure 1.3 - Grab Dialog

The Grab Dialog is a good example because it shows the two major types of items commonly found in dialog boxes: list items and data entry items. List items are like the Dark Frame item shown above where the user selects one setting from a list of settings. Data entry items like the Exposure time require the user to type in a value.

1.3.1 CCDOPS for Windows 95

This section is for the Windows 95 user only. DOS or Macintosh users should skip ahead to the appropriate section below.

The Windows 95 version of CCDOPS takes full advantage of the graphical user interface built into the Windows Operating System. This is an ideal environment for imaging applications like CCDOPS since the software has simultaneous access to menus and dialogs for controlling the camera as well as high level graphics for displaying the images.

Any Windows 95 user also has the benefit of Microsoft's investment in the area of user interfaces. Software packages for Windows share a common look and feel that make learning new packages much easier.

While all three versions of CCDOPS provide virtually the same level of capabilities there are minor differences between the three programs owing largely to differences in the operating system. Where as CCDOPS for DOS must switch between Command Mode and Graphics Mode, CCDOPS for Windows 95 offers both capabilities simultaneously. CCDOPS for Windows 95 also takes advantage of the "complete system" approach that the OS offers allowing customization of color tables, printing of images, cutting and pasting.

If you are a new user to the Windows 95 and CCDOPS is your first program we ask you to spend the time with any training material you may have to learn Windows 95 prior to running CCDOPS. It is a small investment in time that will pay off for years.

1.3.2 CCDOPS for DOS

This section is for DOS user only. Macintosh users should skip ahead to section 1.3.2.

The DOS version of CCDOPS runs under DOS but provides a very user friendly environment. Even though it is not Windows software, the user interface is menu based and supports a broad range of hardware configurations. Running under DOS assures the maximum compatibility with the PC systems users currently have and operate.

In the DOS environment the CCDOPS software works in two modes: Command Mode and Graphics Mode. The command mode is used to interact with the user and to control the acquisition and processing of images. The Graphics Mode (discussed further below) is used when image display is required.

Command Mode

Along the top of the Command Mode screen is a menu bar with its pull-down menus (shown in the top of Figure 1.1). Pulling down menus and executing commands can be done using the keyboard or the mouse. Using the mouse is quite easy: you simply click the mouse button on the menu title to pull down the menu and then click the mouse again on the desired menu command. Using the keyboard is almost as intuitive: you simply select the menu by using the left and right arrow keys, and then select the menu command using the up and down arrow keys, executing the command by hitting the Enter key once the appropriate command has been selected.

You also perform data entry in Dialog Boxes using the keyboard and the mouse. Using the keyboard you select the item to change using the up and down arrow keys and then changed the item by typing in the desired value or by using the left and right arrow keys for list items. You can also use the Tab key to tab down through the items in a dialog or you can click the mouse on an item to move to that item or click in one of the options in a list item to select that option.

At the bottom of all dialog boxes are two buttons: Enter and Esc. Clicking the mouse on the Enter button or hitting the Enter key causes the command to read all the data entry back from the dialog and finish executing the command. Clicking the Esc button or hitting the Esc key aborts the command.

Advanced Tips

- Each item in a dialog can be accessed though hot-keys. By holding down the Alt key while hitting the key shown in red or highlighted you can move directly to that item. For example hitting Alt E moves to the Exposure time item in the Grab Dialog shown above.
- In list items options can be selected by hitting the first letter of the option. For example, hitting Y will select the Yes option if you are in the Auto display item of the Grab Dialog.
- In data entry items the first key hit erases the entire contents of the data entry item unless you hit the Backspace key or the left or right arrow keys described below.
- In data entry items the Backspace key erases one character and the left and right arrow keys move the cursor within the data entry allowing correction or insertion.
- In the data entry items hitting the Delete or Del keys erase the entire contents of the data entry item.

Graphics Mode

In the DOS version of CCDOPS the software switches to Graphics Mode when the image needs to be displayed. Graphics mode is used throughout the software when image display is required such as with the Display Command in the Image Menu. These modes all display the image in the upper-right corner of the display with an optional pull-down menu in the upper-left corner of the display.

The size of the image and the "quality" of the image depends largely on the type of graphics adapter you have in your computer. VGA and/or Super VGA[1] are highly recommended in all cases except where you have dual systems: one portable system that you take into the field to acquire images which can have less than VGA capabilities and a second system for display and image processing. With VGA displays the images can be shown using 64 shades of gray. This produces very nice looking images.

EGA based systems are also supported. With an EGA color display the images are "ok" but do not offer much latitude in terms of gray scales or brightness variations. An EGA display adapter with a monochrome monitor works fairly well, again supporting 64 shades of gray but it's not nearly as flexible as VGA based systems.

At the very bottom of the ladder are systems based upon CGA graphics. These systems have very poor spatial and color resolution and produce "blocky" looking images. Our intention in supporting CGA systems was to allow older laptop computers to be used in the field for acquisition of images. Users will not be happy with the quality of displayed images for any serious image processing and are strongly encouraged to upgrade to VGA based systems.

In Graphics Mode data entry is minimal, restricted mainly to selecting items from pull-down menus. As previously mentioned, many of the graphics mode displays have a pull-down menu. The menu is indicated by the presence of a menu name in a rectangular box in the upper-left corner of the display as shown in Figure 1.4 below. Accessing items in the menu is easily achieved using the mouse or the keyboard.

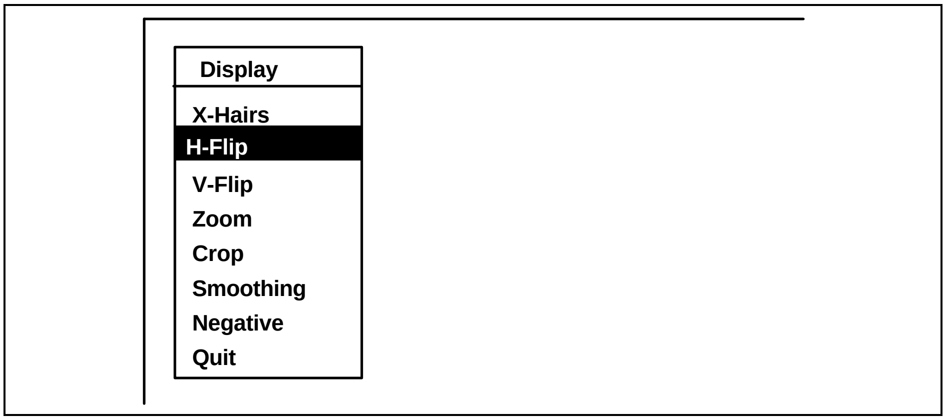


Figure 1.4 - Graphics Mode Menu

Using the mouse is identical to that in the Command Mode: you click on the menu title to reveal the pull-down menu and then click again on the command you wish to execute. Using the keyboard is also similar to Command Mode: you hit the Enter or Down Arrow keys to pull-down the menu, select the appropriate item using the up and down arrow keys, and then hit the Enter key again to execute the command. The items also have "hot-keys" associated with them that will make it quicker as you gain experience with the software. Hitting the first letter of the command name will execute the command without having to pull down the menu. As an example, hitting the "X" key would execute the "X-Hairs" command in the menu shown above.

Note: *You do not have to hold down the Alt key to access the hot-keys in the Graphics Mode.*

When you are through with the command you are using that invoked the Graphics Mode hit the Esc key to return CCDOPS to the Command Mode.

1.3.3 CCDOPS on Macintosh Computers

The Macintosh version of CCDOPS takes full advantage of the graphical user interface built into the Macintosh System Software. This is the ideal environment for imaging applications like CCDOPS since the software has simultaneous access to menus and dialogs for controlling the camera as well as high level graphics for displaying the images.

---

[1] CCDOPS for the PC supports VESA compliant Super VGA cards.

Any Macintosh user also has the benefit of Apple's enormous investment in the area of user interfaces. Software packages for the Macintosh share the common "toolbox" which makes learning to operate the Macintosh a one-time event. All software packages share the same look and feel.

While the Windows 95, DOS and Macintosh versions of CCDOPS provide virtually the same level of capabilities there are minor differences between the two programs owing largely to differences in the operating system. Where as the DOS CCDOPS must switch between Command Mode and Graphics Mode, CCDOPS for Windows 95 or the Macintosh offers both capabilities simultaneously. CCDOPS for the Windows 95 and Macintosh also takes advantage of the "complete system" approach that the these Operating Systems offers allowing customization of color tables, printing of images and cutting and pasting.

If you are a new user to the Macintosh and CCDOPS is your first program we ask you to spend the time with the training disks that Apple has provided you in learning to use the system. It is a small investment in time that will pay off for years.

2. Software Concepts

This section describes the CCDOPS software from a work flow standpoint. Rather than discuss each command in every detail which is done in section 3, this section lets you see the forest through the trees, describing at a high level what each command does and why you would use it. Read this section after your first night with the camera system and it will help chart your course for future use.

2.1. Image Acquisition Routines

Probably the most important part of any CCD camera system is the acquisition of image data. This section describes the various commands that can be used to take images.

2.1.1 Grab

The **Grab** command is the most straight forward way to take images with the camera. It's just like pressing the button on your SLR to take a snapshot. You use the Grab command once the camera system is all set up and focused. In its most simple form it takes a single image.

There are several options associated with the Grab command that expand its use. First off, you can choose to take an **auto Dark-Subtracted image** or a single **Dark Frame** or **Light Frame**. At the start you'll want to take auto Dark-Subtracted images and later, as your experience grows, you may want to take Dark frames separately and store them on disk for later manual subtraction from Light frames.

Another aspect of the Grab command is that you don't have to take full frame images. You can choose to take **Half Frame** or **Quarter Frame** images where only the central half or quarter of the field of view is captured. This has the benefit of reducing storage requirements for images of objects such as Planets that don't fill the field of view. Along this vein, note that you can also use the **Camera Setup** command described below to reduce the camera's resolution through binning which also reduces storage requirements while preserving the field of view.

Finally, the Grab command can be programmed to **automatically display** the image after it has been acquired, or **delay** a number of seconds prior to starting an exposure to allow you time to get back to the telescope and start hand guiding when desired.

2.1.2 Focus

The **Focus** command works like a continuous version of the Grab command. It takes images and displays them on the computer, one after another. In its most simple form it is used to focus the telescope and to find and center objects in the field of view.

As each image is downloaded and displayed on the screen, the Focus command searches through the image and reports the brightness and location of the **brightest pixel** in the image. Critical focus of the telescope/camera system is easily achieved by adjusting the telescope focus until this peak value is maximized.

The Focus command can be programmed to take a partial frame image to help speed up the image display in the **Planet mode**. In Planet mode you select a small region of the full frame with the mouse and on subsequent images only that region of interest is digitized and downloaded. For focusing on stars, this can dramatically increase the frame rate when used with short exposures.

You can also program the Focus command for the **Dim mode** where the camera is switched into low resolution mode. With the use of binning, the image resolution is reduced and pixel size increased. This is handy for finding faint objects, as larger pixels gather more light, or for generally improving the image throughput [2].

2.1.3 Track and Accumulate

Track and Accumulate is a patented process invented by SBIG[3] that allows you to take long duration images through the telescope without having to hand guide. It greatly simplifies digital astrophotography.

First, a little background is required. It's obvious that the clock drive in your telescope counteracts the earth's rotation, but what may not be so obvious is that even the most precise drives, with periodic error correction and an excellent polar alignment eventually drift, causing streaking of your images. What Track and Accumulate does is divide the long exposure into several shorter duration **snapshots** which are automatically co-registered and co-added. The final result is an image that is nearly identical to a single longer image except that there is no tracking induced streaking!

There are a few limitations of this process though. First of all, this couldn't be applied to a bunch of 0.01 second images to remove the effects of atmospheric turbulence, as desirable as it may seem. To get the benefits of co-adding several images to equal a single longer image, the noise in each of the snapshots must be above the camera's read noise floor. What this implies is that you still need to get a relatively good mount and a fairly good polar alignment. The good news is that today's modern mounts can track fairly well over a minute to several minutes. Also faster f/# telescopes and larger pixels help. A second limitation is that over a long exposure, the effects of accumulated telescope drift reduces the size of your final image due to misregistration of shifted frame edges. For example, if over the duration of the acquisition the telescope had drifted 15 pixels in RA and 10 pixels in DEC, the final image would be smaller by that amount.

When using the Track and Accumulate command you choose the **snapshot time** and the **number of snapshots**. You can also program it to take a partial frame, selecting the **Half-Frame** or **Quarter-Frame** mode. The Track and Accumulate command always takes auto Dark-Subtracted images but you can program how often it takes a dark frame by setting the **dark interval**.

2.1.4 Selfguide

Selfguiding is available with the ST-7 and ST-8. This patented[4] SBIG feature allows the 2nd **Tracking CCD** in these cameras to autoguide the main CCD. Nothing could be easier. You enjoy the benefits of a autoguided image with out the hassles of off-axis guiders or deflection caused by secondary refractors.

Before using the Selfguide command you must first Calibrate the telescope drive with the Calibrate command in the Track menu. After that you use the Selfguide command and you select the Imaging CCD's exposure and the Tracking exposure. The command then allows you to select the guide star and starts guiding. Once the autoguiding has settled down you then manually start the imaging exposure.

---

[2] The Auto resoultion mode is handy because it uses the High res mode except in the full frame mode of the Focus command where the Low res mode is used for higher throughput.

[3] Covered by US Patent 5,365,269

[4] Covered by US Patent 5,525,793

2.1.5 Autoguide

The **Autoguide** command allows you to use your CCD camera as an autoguider. This requires that you calibrate the telescope first. When you use the Autoguide command you select the guide star and the software make telescope corrections to keep that guide star stationary on the CCD.

With the **Autoguide Parameters** command you have complete control over the autoguiding. You can even choose to log the guide star images to disk, making a Track Log file that can later be converted to a mosaic image[5] and tracking spreadsheet using the Convert Track Log file command.

2.1.6 Auto Grab

The **Auto Grab** feature allows taking a sequence of images at some periodic interval and saving them to disk. It isn't a command in itself but rather an extension of the **Grab** and **Focus**[6] commands. It's most useful for monitoring type programs or for selecting the best images out of a series of images.

With the Auto Grab feature you must pick a **file name** for the series of images and the software automatically adds an index to the name for you as the images are being logged. In addition to the file name, you also specify whether to save the images in the **SBIG**, **TIFF** or **FITS** formats discussed below. Finally you select the **number of images** to acquire and the **interval** from the start of one image to the start of the next.

When used in conjunction with **Grab** command, the Auto Grab can further be programmed to refresh the dark frames for auto Dark-Subtracted images at a specified **dark interval**. The software then proceeds through the program, taking images at the periodic rate and logging them to disk. Again, this feature is quite handy for variable star monitoring or other related tasks.

When used in conjunction with the **Focus** command, the Auto Grab feature can be used to see the images while they are being acquired or to manually select the best image from a series of images for example. If the Focus command is programmed for the **manual update** mode then after inspecting each image you can choose to skip the image or save it to disk. In the **auto update** mode the Focus command automatically logs each image to disk.

2.1.7 Color Grab

The **Color Grab** feature works in conjunction with the Color Filter Wheel accessory and takes a series of three images through the red, green and blue filters and logs them to disk. Color Grab isn't a command in itself but rather an extension of the **Grab** and **Track and Accumulate** commands.

With the Color Grab feature you must pick a **file name** for the series of images and the software automatically adds an extension (.R, .G or .B) to the name for you as the images are being logged (example M51.R). In addition to the file name you also specify whether to save the images in the **SBIG**, **TIFF** or **FITS** formats discussed below.

For programming the exposure time, you set the **Red exposure** in seconds as part of the **Grab** or **Track and Accumulate** commands and then with the **Color Grab** extension you set the **Green** and **Blue** exposures as a ratio of the Red. We do it as a ratio so you can easily compensate in exposure time for the decreased CCD sensitivity in those color bands[7]. This need only be set once.

2.2. File Operations

Saving and retrieving images on the disk is just as important as acquisition of image data. This section describes the various commands that are used for image storage and retrieval.

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[5] This is a mosaic of tracking images, not big deepsky images.

[6] Under Windows 95 and the Mac OS the Auto Grab feature is only available as part of the Grab command. It's not as necessary with the Focus command because these systems display the Auto Grab images as they're being acquired.

[7] With the CCDs and Color Filters used in the SBIG cameras and Filter Wheels a typical Green ratio of 1.5 and a Blue ratio of 2 is a good starting point. You could increase these ratios if the individual Green and Blue images are noticeably more grainy that the Red image.

2.2.1 Naming Conventions

Although you can choose most any name when saving your images , under DOS you are restricted by MS-DOS's naming convention of an eight character **name** followed by a three character **extension** (example 8INCHM51.ST7). Windows 95 and Macintosh users have no such restriction. Beyond that, we have a few recommendations that may simplify your image naming.

We recommend that you use the eight character name as you wish but try to leave the three character extension up to the CCDOPS software. For everyday images the CCDOPS software will attach an extension to the file name when you save it. For **Auto Grab** images the CCDOPS software will attach a .001, .002, etc. to mark the image sequence. Finally, for **Color Grab** images the CCDOPS software will attach the .R, .G and .B extensions etc.

2.2.2 File Path and Filter

For convenience operating systems allow you to divide your hard disk into different **subdirectories** or **folders**. To get the maximum flexibility out of the CCDOPS software, you should be familiar with how this works. Under Windows 95 and the Macintosh OS this is rather straight forward with different folders representing different subdirectories. Under DOS it is a bit more difficult. Remember that your hard disk is C: and your floppy disk is A:. For example, you might have your CCDOPS software installed in the C:\CCDOPS directory and save your images in the C:\IMAGES\CCD directory.

CCDOPS for DOS always works in one directory at a time and you tell it which directory to use by setting the internal **path** parameter (note this is similar to, but different from the DOS path variable). You can set the path in two ways. If you know the name of the directory, you can use the **Set Path/Filter** command to type in the path. If however you would like to browse through the directories, searching for files in some forgotten spot, the software allows you to navigate through the file structure within the **Open** and **Save** commands. Under Windows 95 and the Macintosh OS you simply choose the appropriate folder when loading or saving images.

When searching through directories looking for images to load, the software also allows you to restrict the files displayed to match a certain pattern. On the Macintosh, this is done automatically with the software only showing image files. Under Windows 95 the File-Open dialog has a ”Files of type” item you can set. Under DOS this is accomplished by setting the **filter** parameter. For example, if you set the path to C:\IMAGES\CCD and the filter to *.ST7, only files with the .ST7 extension show up in the directory. To display all files you would set the filter to *.*. The filter is changed using the Set Path/Filter command.

Sometimes you’ll want to put images for several nights imaging in separate directories, perhaps one directory per night. Under Windows 95 and the Macintosh OS it’s easy to create new directories right from the dialog where you name the images when saving them. Under DOS the simplest way to create a directory is to use the **Create Directory** command in the File menu. This adds that evening's date after DATA. Now any image saved will be in a directory with that date. After midnight, images are still saved in the previous day's directory since you didn't change it. Each night of image taking, you can perform this "dated data directory" shortcut and the next day save images in more appropriate directories that you may wish to create.

2.2.3 Saving Images

Saving images on the disk is accomplished using the **Save** command. You can choose to save the images in one of two **SBIG formats** or in the **TIFF** or **FITS** formats. Which format you choose will depend on what you plan to do with the image in the future.

Images saved in the SBIG 16-bit **compressed** and **uncompressed** formats can later be read back into CCDOPS **which is a very important consideration**. Compressed images take up about one-half the space of the uncompressed format with no loss of information and we recommend you always save your images in this format.

The **TIFF** format is popular with desktop image processing software packages such as Adobe Photoshop. The **FITS** format is a scientific image format that is popular with professional astronomical image processing packages. Be forewarned that *if you only save your images in TIFF or FITS format, you will not be able to read the data back into CCDOPS* .

Also, the TIFF and FITS formats support 8 or 16 bit data. While 16 bit mode is preferable from a standpoint that there is no reduction in image dynamic range (remember the camera is 16 bits), many TIFF programs for example do not know how to handle 16 bit data so you have to use the 8 bit format. When saving the image in the 8 bit format, you should first display the image to get a suitable display and then save the 8 bit data. In that way you have told CCDOPS how to reduce the 16 bit data to 8 bits.

2.2.4 Loading Images

You use the **Open** command to load SBIG **compressed** and **uncompressed** images from the disk into CCDOPS. When the software presents the Open dialog, you can select files or move through the directory structure by opening other directory or disk entries. Under DOS also note that you can point to an image file and click on the **Info** button to view the image parameters without having to load the image.

2.3. Image Display Routines

Image data wouldn't be very valuable if you didn't have some way to look at it. This section describes the various commands and parameters that affect the image display.

2.3.1 Background and Range

The **Background** and **Range** parameters are used throughout the display software and affect the displayed image's brightness and contrast. While the image data has a relatively large dynamic range, computer displays and the human eye only work over a limited range. For example while the CCD may be able to distinguish 65,000 shades of gray, your eye would have a hard time distinguishing more than 100 and the computer displaying more than 64 shades.

Using the background and range parameters you select which portion of the image's intensity values you wish to display. On dim objects you can increase the contrast for example. You can get the CCDOPS software to analyze the image with the **Auto Contrast** setting and have it set the background and range for you or you can set them yourself. Usually Auto Contrast results in the best display.

The background parameter sets the black level in the image or the overall image brightness. Any pixels with intensity below the background are completely black on the display. Lowering the background increases the image brightness by displaying dimmer pixels.

The range parameter is relative to the background level and sets the white level in the image or the overall image contrast. Any pixels with intensity above the level equal to *the background plus the range* are displayed as completely white. Again, decreasing the range parameter increases the image contrast as dimmer pixels begin to saturate on the display.

Finally, pixels with values between the background and the background plus the range are displayed using shades of gray.

2.3.2 Photo vs. Analysis Mode

There are basically two ways to view and image: **Analysis** and **Photo** mode. In either mode you can choose to display the image as a **Negative** or with a soft **Smoothing**. Also if your running under DOS and have a **VESA** extended VGA display adapter, you can use the **arrow keys** to adjust the image brightness and contrast in real time.

In **Analysis mode** the image is displayed and several tools are available to analyze or modify the image. You can use a **Crosshair** to inspect individual pixels and to make **Photometric** and **Astrometric** measurements or verify focus of individual stars (this is explained in detail in Appendix B). You can perform a **Horizontal** or **Vertical Flip** of the image to match other published results or to compensate for varying optical configurations such as refractor, Cassegrain, Newtonian, or diagonal use. Finally, you can **Crop** the image to remove something from the field of view and under Windows 95 and the Mac OS you can enlarge or reduce the image on the screen to reveal more detail or show more of the image on a small screen.

In **Photo mode** the image is displayed in the center of the screen free of any other information. This is handy for taking photographs of the screen and visual presentation.

2.3.3 Image Parameters

The CCDOPS software saves an **image header** with every SBIG format image. The header contains various parameters that were logged when the image was acquired such as the exposure time, the date and time, etc. Several commands utilize this header information.

The **Display Parameters** command shows the image header in a tabular form. The **Modification History** command shows which CCDOPS operations have been performed on the image, such as dark subtraction, etc. The **Edit Parameters** command allows you to change some of the parameters after an image has been acquired (if they had been set incorrectly for example) and the **Telescope Setup** command allows you to tell CCDOPS about the type of telescope you are using. This information also gets saved in the header.

Note: The entries in the image header (such as the Response factor) do not affect the image data itself but only the analysis of the image based upon those parameters.

2.3.4 Slide Shows

The CCDOPS software allows you to create **Slide Shows** of images you have acquired. A slide show is just what it sounds like: a series of images is displayed in **photo mode** at a periodic interval. You'll have to provide the narration though!

You use the **Create Slide Show** command to build the slide show script, selecting the images and the sequence. The script gets saved on disk and is later played back with the **Display Slide Show** command. When playing back the slide show you can program the **interval** between slides, whether the slide show **loops** at the end and whether the images are shown as **negatives** or with a soft **smoothing**.

2.3.5 Printing Images

The **Print** command allows you to make a hard copy print of the image. Under Windows 95 any printer that is supported by the OS will work. On the Macintosh it supports Postscript laser printers and under DOS it supports **Postscript** and **HP compatible** laser printers and the **FotoFun** dye sublimation printer. The image is printed along with the **header**. You can print the image as a **negative** or save it on **disk**[8].

2.4. Image Processing Routines

The third part of any imaging system, after image acquisition and storage, is image processing. This section describes the commands found in the **Utility** menu that are used to process images. Note that the image processing commands that are part of the **Analysis display mode** (Horizontal and Vertical Flip and Crop/Zoom) have already been discussed as part of the Display Commands.

2.4.1 Enlarge/Reduce

The **Enlarge Image** command enlarges the image 2 times and fills in the missing pixels using pixel interpolation. This rounds out square looking star images when taken through short focal lengths and increases the size of the image four fold.

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[8] Saving printed images on disk allows you to take the print file to other laser printers if you don't have one of your own.

It is also handy when sending TIFF images to photo labs for prints to reduce the "blocky" pixel appearance of enlargements and increases the file size to one they are accustomed to handling.

The **Reduce Image** command shrinks the image 2 times, combining each group of 2 x 2 pixels into a single pixel by averaging. It reduces the image's resolution while preserving the field of view.

2.4.2 Filtering

The commands in this section are used to filter the images, typically comparing pixels to their neighbors and enhancing or reducing the differences. This can be used to advantage in removing noise (smoothing) or enhancing detail (sharpening).

Smoothing

The **Smooth** command softens the image by replacing each pixel by a weighted average of itself and its eight neighbors. Three settings of smoothing are available: **soft**, **medium** and **hard**. This can be used to advantage in images that are underexposed and have an objectionable amount of graininess, but it will reduce the sharpness of the image.

Sharpening

The **Sharpen** command enhances image detail and is available in three strengths (**soft**, **medium** and **hard**) and in two forms: **Nebulae** and **Lunar/Planetary**. The Lunar/Planetary option provides the most sharpening but can leave rings around stars that are buried in nebulosity.

Warm/Cool Pixel Removal

The **Remove Cool Pixels** and **Kill Warm Pixels** commands ferret out single pixel blemishes in the image and replace them with a weighted sum of their neighboring pixels. The commands are available in three strengths: **soft**, **medium** and **hard**. Warm pixels are generally caused by hot dark current pixels in the CCD that saturate in the exposure and thus don't subtract out correctly. Cool pixels are often caused by using poor quality dark frame or one taken at a slightly different temperature.

Co-Adding and Averaging

You can reduce the noise in images by co-adding or averaging several images. The **Average Images** command is most useful for dark frames. For light images use the **Co-Add** command which allows registering one image relative to the other after you had used the crosshairs to note the required displacements.

2.4.3 General Purpose/Image Corrections

The commands in this section are generally used to correct the images for one type of artifact or another, whether from the camera or the telescope.

Dark Subtract

The **Dark Subtract** command is used when you are manually taking and storing **light frames** and **dark frames** as opposed to **auto Dark-Subtracted** images. This can be handy in situations where you know you are going to be taking a group of exposures of equal length. You could take a dark frame first, save it on disk, and then take several light frames, using this command to subtract the dark frame before saving the result.

Flat Field

The **Flat Field** command is used to correct an image for the effects of vignetting and/or small pixel-to-pixel variations in response. To correct an image for these effects you first need to make a **flat field image**. That is done by imaging the inside of the dome or a nearby wall or card held in front of the telescope that is uniformly illuminated. The purpose of the flat field image is to record what happens to a uniformly illuminated target, and then apply those intensity variations in reverse to your images.

Build Track/Accum Flat

The **Build Track/Accum Flat** command is used to prepare a special **flat field** image for correcting **Track and Accumulate** images. In the process of capturing a Track and Accumulate image, the CCDOPS software co-adds several images together, shifting them relative to one another to compensate for the telescope drift. To properly correct for the pixel-to-pixel variations and any vignetting, the flat field file must have the same shift and add operations applied to it. This is accomplished with this command in conjunction with a **Track List** file that is created as part of the Track and Accumulate command.

Linear and Log Scaling

The **Scale** command allows both Linear and Log scaling. Linear scaling takes a range of pixel values and scales them to the 0 through 65,535 range, effectively subtracting an offset and multiplying by a scale factor.

Log scaling compresses the image's dynamic range through a non-linear logarithmic scaling function. It essentially highlights the dim portions of the image and attenuates the bright portions, much like a photographic dodging & burning effect. This is useful for compressing the incredible dynamic range of objects like the Orion Nebula where bright stars and nebulosity are surrounded by faint nebular detail. It can also be useful for well exposed galaxies.

Color Combining

The CCDOPS for Windows software has an RGB Combine command in the Utility menu that allows you to take component images (B&W images taken through Red, Green and Blue filters) and combine them into a single 24-bit TIFF image. You can then save and later re-open these images and/or make them part of Slide Show presentations.

2.5. Image Analysis Routines

The commands discussed in this section are general purpose image analysis commands.

2.5.1 Histogram

The **Histogram** command displays the image histogram in a graphical format. The histogram is an analysis of the image on a pixel-by-pixel basis where an accounting of the number of pixels at a given intensity is made. It's sort of like a census count of the pixels. How many pixels have intensities between 1 and 10? How many between 10 and 20? Simply stated it is a graph of the number of pixels having a given intensity (this is also referred to as the frequency) vs. pixel intensity. But what good is it, you ask?

One of the ways the CCDOPS software uses the histogram is in setting the background and range parameters as part of the **Auto Contrast** feature. The software looks for the portion in the histogram where pixels start to have a non-zero frequency and sets the background to that value. It then looks at the top end of the histogram and again looks where the pixel frequencies drop to zero, setting the range accordingly. In that way, the background and range have been adjusted to show the bulk of the image's dynamic range.

2.5.2 Cross Hairs

Using the **Cross Hairs** allows you to examine the image on a pixel-by-pixel basis. As you move the crosshairs around with the mouse or arrow keys, the **coordinates** and brightness **value** of the pixel under the crosshair are shown. The software also shows the **average** pixel value and the deviation (**noise**) of the pixels in a selectable box of pixels surrounding the crosshair.

As explained in detail later, you can also make Photometric (stellar and nebular brightness) measurements and Astrometric (separation) measurements. Finally when positioned over a star, the software will make an estimate of the **seeing** in arcseconds (this counts on you having good focus and tracking).

2.6. Setup Functions

This section describes the various commands that are used to customize the CCDOPS software to your Computer and Telescope.

2.6.1 Camera Setup

The **Camera Setup** command is used to set/enable various options in the camera. You can enable **temperature regulation** and choose a **setpoint**. The camera then regulates the CCD temperature to that setpoint. Choosing a setpoint is usually a fairly simple matter. You want to choose as cold a setpoint as possible without having the power supplied to the TE cooler hold at 100% (as shown in the lower-right hand corner of the status window). If you pick a setpoint roughly 30°C below the ambient temperature, you should be safe[9]. You can monitor the CPU temperature with the **Camera Info** command or the ambient temperature by means of an external thermometer.

Note: You don't have to pick the exact right setpoint, as long as the power to the TE cooler is running between 80 and 95 percent.

You can also program the camera's **resolution** , choosing **Hi**, **Medium** (on some cameras)**, Low** or **Auto** res modes. In Hi res mode the camera is configured for the smallest pixels and highest resolution. In the Low res mode the camera is set for the largest pixels and lowest resolution. This has the advantage of faster image downloads due to the reduced amount of data involved. Finally the Auto mode configures the camera for Hi res mode in all cases *except* the Full Frame Focus mode, where it uses Low res mode. This is handy for speeding up finding objects and focusing the camera.

You can also configure the CCDOPS software to **reuse** dark frames. With that option enabled, the software will remember when you take a dark frame of equal duration to light frame and try to reuse that dark frame for future exposures rather than taking a new one.

2.6.2 Graphics Setup

The **Graphics Setup**[10] command allows you to configure the CCDOPS software for your computer graphics hardware.

Under DOS you can select the type of **graphics adapter** you have, but in general the **Auto** setting should work well. You can configure CCDOPS display for a **Color** monitor, **Monochrome** LCD or for color display of a **NiteVision** mode where every thing turns red. Under the Mac OS you can choose between Gray-Scale displays and bitmapped displays where gray-scale is simulated with dithering.

Finally you can configure the mouse and enable an **annunciator** that beeps at the start and end of an exposure to tell you when you need to be guiding and when the image is fully downloaded.

2.6.3 Communications Setup

You use the **Communications Setup** command to tell CCDOPS which port you are using to communicate with the camera.

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[9] The ST-6, with its 2 stage cooling, can use setpoint roughtly 45° below the ambient temperature.

[10] Under Windows 95 and the Mac OS the Graphics and Communications Setup commands have been merged into one Graphics/Comm Setup command.

2.7. General Purpose Camera Functions

The commands discussed in this section are general purpose camera control commands.

2.7.1 Establish Link

You use the **Establish Link** command to tell the CCDOPS software to look for a camera and to establish a communications link with it. The software does this automatically when you run the software so you will typically only need to use this command after you have changed ports or turned off the camera and then turned it back on again.

2.7.2 Information

The **Camera Information** command interrogates the camera and shows you information about your camera's capabilities including the version of firmware. This information may be useful should you have problems with the camera and are in need of technical support.

2.7.3 Shutdown

The **Shutdown** command should be used when you are ready to put the camera away for the night. It turns off the camera's cooling and otherwise prepares it for being powered down. It's a good idea to wait 30 seconds or so after shutting down the camera before turning off the CPU power because that gives the TE cooler time to warm up.

2.7.4 Autoguiding

The commands in the **Track menu** allow you to use your camera as an autoguider. The **Calibrate** command is used first and it lets the CCDOPS software measure your drive's correction speeds so that it can make calibrated corrections. The **Autoguide** command is then used to do the autoguiding. For a more in depth control of the autoguiding operation, the **Autoguide Parameters** command allows you to fine tune tracking and the **Convert Track Log File** command allows you to diagnose tracking problems.

2.7.5 Filter Wheel

The commands in the **Filter Menu** are used to position the filter wheel in cameras that have filter wheels built in or attached. You also have the capability to calibrate the older model CFW-6 color filter wheel.

3. CCDOPS Menus and Commands

This section has detailed descriptions about the Menus and their respective Commands. For each Menu, a brief description of each Command is given. A separate description is included for commands that require a lot of user input or explanation.

3.1. File Menu (Windows 95 & Mac OS)

Purpose: *The commands in the File menu allow loading and saving images on disk.*

Commands

Open	This command loads SBIG format image files from disk into memory where they can be displayed or processed.
Close	Closes the image in memory by purging it from memory. If the image has changed and has not been saved you are given the opportunity to save it before closing it. Note that you must close one image before you can open another.
Save	Saves the image held in memory on the disk. The same name used to load the file or last save it is used. You also use this command to save Track Lists produced by the Track and Accumulate command by activating the Track List window and invoking this command.
Save As	Saves the image held in memory on the disk, giving you the opportunity to rename the image or save it in the folder of your choice. You can also choose to save the image using the Compressed, Uncompressed, FITS or TIFF formats.
Revert to Saved	Discards any changes made to the image in memory since the last save by reloading the image from disk.
Make Slide Show	Use this command to create a script for slide shows by selecting each image in the script. The script is played back with the Display Slide Show command.
Page Setup	Allows you to select the orientation and other page setup options for printed images. We suggest using the Portrait orientation and turning off the Graphics Smoothing and Faster Bitmap Printing options.
Print	Prints the image as it is displayed in the Picture window. If your printer does not support gray-scale you should first set the Graphics mode item in the Mac Setup command to one of the two color modes.
Quit/Exit	Quits CCDOPS.

Notes

- The Compressed and Uncompressed image formats are SBIG native formats. You can typically use 30% to 50% less disk space by using the Compressed format.
- The TIFF format is supported by third party graphics processing programs and allows you to export CCD images to those other programs.
- The FITS format is supported by third party astronomical image processing programs and allows you to export CCD images to those programs.
- In addition to printing images, you can make a copy of the image displayed in the Picture window by making that window active and then using the Copy command in the Edit menu.
- When printing gray scale images remember to select the Color/Gray scale Print option in the Print dialog.

See Also: Graphics Setup Command, Save FITS Command, Save TIFF Command

3.2. File Menu (DOS)

Purpose: *The commands in the File menu allow loading and saving images on disk.*

Commands

Open	This command loads SBIG format image files from disk into memory where they can be displayed or processed.
Save	This command saves the image in memory onto the disk. You are asked for the name to use in saving the file, and if that name would overwrite an existing image you are warned. You can save the image using the Compressed, Uncompressed, FITS or TIFF formats.
Save Track List	Use this command to save the Track List produced by the Track and Accumulate command if you plan on flat fielding your images.
Delete	This command allows you to delete files on the disk to free up space without having to exit to DOS. The files that match the Filter in the Path from the Set Path/Filter Command are shown.
Print	This command allows you to print images on Postscript and HP Compatible laser printers or the Fargo FotoFun.
Create Directory	This command allows you to create a new directory in which to store images without having to exit to DOS. You enter the path and name of the directory to create and you can also make the newly created directory the current Path.
Set Path/Filter	This command allows you to set the Path where CCDOPS looks for image files to load and save and the Filter which allows only files matching the filter to be shown in the Load Image command.
Make Slide Show	This command allows you to build a script for a Slide Show. You select the images in the order you want them displayed and hit ESC when you are done.
Exit	This command quits CCDOPS back to DOS. If there is unsaved image data or the camera's temperature regulation is active you are given the chance to not exit.

Notes

- The TIFF format is supported by third party graphics processing programs and allows you to export CCD images to those other programs.
- The FITS format is supported by third party astronomical image processing programs.
- Under DOS, with the Open and Delete commands, clicking on the >,QIR"@ button or hitting the Space bar shows the Image Parameters associated with the currently highlighted file.
- The Path is the drive and directory where CCDOPS tries to open and save images.
- The Filter is used to select files to show in the directory listing.
- If more than 40 files are available in the Open and Delete commands then you can use the PgDn and PgUp keys to see 40 files at a time.

See Also: Save FITS Command, Save TIFF Command

Save FITS Command

File Menu, Save Command

Purpose: *The Save FITS Command is used to save the image in memory on disk using the FITS format. You access this command through the Save command by selecting FITS format.*

Dialog Parameters

Bits per pixel	Set this item according to the precision required in the FITS file. For 16 bit FITS files the 16 bit image data is saved unchanged. For 8 bit FITS files the 16 bit image is scaled using the Back and Range parameters.
Back/Range	For 8 bit FITS files these parameters control the scaling of the 16 bit image data to the 8 bit FITS file data. Pixels below the Back value are written as zero. Pixels above Back + Range are written as 255. Pixels between Back and Back + Range are scaled linearly from 0 to 255.
Object	Set this item to any text you want to attach to the FITS file describing the object imaged.
Date of Observation *(Win 95 only)*	Change this item as necessary. It is set to the date the image was taken and is written to the FITS header.
Telescope	Set this item to any text you want to attach to the FITS file describing the telescope that imaged the object.
Observer	Set this item to any text you want to attach to the FITS file describing the observer that imaged the object. This data is initialized from the Telescope Setup command.
Comment	Set this item to any text you want to attach to the FITS file as a comment. This is initialized to the Note attached to the image with the Edit Parameters command, but can be overridden.

Notes

- Only 8 bit FITS files use the Back and Range parameters to scale the image data. 16 bit FITS files are written directly from the image pixel values.
- Prior to saving 8 bit FITS files you may wish to display the image to find the appropriate settings for the Back and Range parameters. As a convenience the settings from the Display Image command are automatically copied to the Back and Range parameters in this command, but they can be overridden, of course.

See Also: Display Image Command, Edit Parameters Command

Save TIFF Command

File Menu, Save Command

Purpose: *The Save TIFF Command is used to save the image in memory on disk using the TIFF format. You access this command through the Save command by selecting TIFF format.*

Dialog Parameters

Byte Order	Set this item to IBM PC or Macintosh based upon the platform you are using to import the images.
Bits per pixel	Set this item according to the precision required in the TIFF file. For 16 bit TIFF files the 16 bit image data is saved unchanged. For 8 bit TIFF files the 16 bit image is scaled using the Back and Range parameters.
Back/Range	For 8 bit TIFF files these parameters control the scaling of the 16 bit image data to the 8 bit TIFF file data. Pixels below the Back value are written as zero. Pixels above Back + Range are written as 255. Pixels between Back and Back + Range are scaled linearly from 0 to 255.
Strips	You will typically want to set this item to *Multiple* as most TIFF readers are capable of reading that format. The *Single* setting can be used if your TIFF reader will not read TIFF files created with the *Multiple* setting.
Observer	Set this item to any text you want to attach to the TIFF file describing the observer that imaged the object. This data is initialized from the Telescope Setup command.
Comment/Note	Set this item to any text you want to attach to the TIFF file as a comment. This is initialized to the Note attached to the image with the Edit Parameters command, but can be overridden.

Notes

- Only 8 bit TIFF files use the Back and Range parameters to scale the image data. 16 bit TIFF files are written directly from the image pixel values.
- Prior to saving 8 bit TIFF files you may wish to display the image to find the appropriate settings for the Back and Range parameters. As a convenience the settings from the Display Image command are automatically copied to the Back and Range parameters in this command.

See Also: Display Image Command, Edit Parameters Command.

DOS Print Command
File Menu, Print Command

Purpose: *The Print Command is used to print a copy of the image and image header on a laser printer or Fargo FotoFun dye sublimation printer.*

Dialog Parameters

Printer type	Set this item based upon the type of printer you have with your PC.
Destination	Set this item to the LPT port that your printer is attached to or set it to *File* in order to save the printed image as a file on disk.
Image	You can choose to print the image as a *Negative* (black print for white areas of the image) or as a *Positive*.

Notes

- Use the Display Image command to adjust the image's background and range parameters before printing the image.
- You can make high quality copies of the images by photographing the monitor directly.
- Many astrophotographs look best when printed as a negative.

See Also: Display Image Command.

3.3. Edit Menu (Win 95 & Mac)

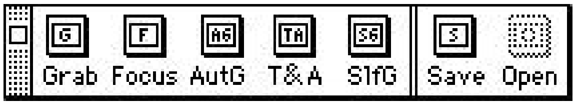
Purpose: *The commands in the Edit menu are the standard edit commands for Windows 95 or the Macintosh plus additional commands for the Icon Bar and Crop Window.*

Commands

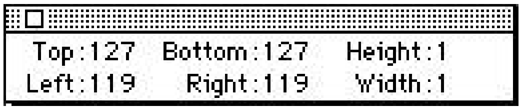
Undo	This command is not used in CCDOPS.
Cut	This command is not used in CCDOPS.
Copy	This command is when the Picture Window is active to make a copy of the image displayed onto the Clipboard where it can be pasted into the Scrapbook or other applications.
Paste	This command is not used in CCDOPS.
Clear	This command is not used in CCDOPS.
Show Icon Bar	This command makes the Icon Bar visible or invisible.
Show Crop Window	This command makes the Crop Window visible or invisible.

Notes

- The Icon Bar is a small window with icons in it for Grab, Focus, Autoguide, Track and Accumulate, Selfguide, Save and Open. Clicking on one of these icons is a shortcut for the pulling down the menu and invoking the respective commands.



- The Crop Window is a small window that shows the coordinates of the crop cursor as you click and drag in the Picture Window.



Top:127 Bottom:127 Height:1
Left:119 Right:119 Width:1

3.4. Camera Menu

Purpose: *The commands in the Camera menu are used to control the camera for taking images, focusing, etc.*

Commands

Grab	This command is used to take a single image or a sequence of images and log them to disk (Auto Grab Command). Typically you would use this command once the object is focused and centered in the field of view and you're ready to take the "keeper" image.
Focus	This command is used to focus the CCD camera or to center objects in the field of view as it repeatedly takes images and displays them.
Eyepiece *(DOS Only)*	This command is used as an electronic eyepiece whereby the entire field of view of the CCD is shown covering most of the screen. It’s like a Photo mode version of the Focus command.
Setup	This command is used to configure the CCD camera hardware for subsequent images. Items include the temperature regulation, resolution, etc.
Information	This command interrogates the camera for its capabilities and reports the capabilities along with the firmware revision, etc.
Auto Offset Adjust *(ST-6 Only)*	For ST-6 cameras this command automatically adjusts the head offset by closing the vane and measuring the video black level, adjusting the offset until the black level is between 2,000 and 10,000 counts.
Manual Offset Adjust	For ST-6 cameras this command allows the user to manually adjust the head offset. For the other cameras the head offset is not adjustable although this command can be used to measure the black level. If you choose to use this command you should adjust the ST-6's offset using the cursor keys until the Video reads between 2,000 and 10,000 counts.
Establish COM Link	This command tries to establish a communications link with an camera. The desired port is set using the Communications Setup command in the Misc menu. Once a communications link is established, the Status Window is updated to show the type of camera found and active port.
Shutdown	This command shuts off the camera's TE cooler and prepares the camera for being powered down.
Upload Dark Frame	This command allows you to select a previously taken and saved dark image and upload it to an ST-4X, ST-5 or ST-6. That dark frame can be reused in subsequent images if the Reuse Dark Frames item in the Camera Setup command is enabled.

Notes

- For a dark frame to be reusable it must match the current imaging mode parameters including the resolution, frame size, exposure duration, temperature, etc.
- Under Win 95 and the Mac OS there isn’t any Eyepiece command because the Focus command and the GUI obviate the need for it. It’s only purpose is to give the DOS users a full-screen, full frame focus mode.

See Also: Grab Command, Auto Grab Command, Focus Command, Camera Setup Commands, Graphics Setup Command, Communications Setup Command

Grab Command

Camera Menu

Purpose: *The Grab Command is used to take a single exposure or a series of exposures and log them to the disk (Auto Grab Command).*

Dialog Parameters

Exposure time	Set this item to the desired exposure duration in increments of a hundredth of a second.
Dark frame	Set this item to *Only* to take and download a single dark frame. Set the item to *Also* to take a dark frame followed by a light frame and download the difference. Set this item to *None* to take and download a single light frame.
Image size	Set this item to *Full* to take an image using the CCD's full field of view. The *Half* and *Quarter* settings take an image using the central $\frac{1}{2}$ x $\frac{1}{2}$ or $\frac{1}{4}$ x $\frac{1}{4}$ field of view, reducing the memory requirements accordingly. On the ST-4X the *Half* setting takes a Half Frame image where the lower half of the CCD, at full width, is used to reduce streaking.
Auto display *(DOS Only)*	The image can be automatically displayed in Analysis or Photo mode after being downloaded. *Note: Under Win 95 and Mac OS the image is always displayed after being downloaded.*
Exposure delay	Setting this item to any value except zero causes the software to delay that number of seconds before taking the light image. This allows the user to start guiding or turn off the lights, for example.
Spec. Processing	Setting this item to Color-Grab allows taking a sequence of 3 images through Red, Green and Blue filters. Setting it to Auto-Grab allows taking a sequence of images and logging them to disk at a regular interval.

Notes

- When taking a dark frame with the ST-4X and ST-5 the user is asked to cover the telescope. Of you have a motorized color filter wheel you can use it as a remote shutter with the Filter Setup command.
- If the Camera Setup has the Reuse Dark Frames item set *Yes* the Grab Command will try to reuse any dark frames stored in the Camera. This can increase throughput significantly if you plan on taking several images with the same exposure time.
- If you get serial "Time Out" errors while the image is being downloaded you should decrease the Baud rate one step using the Communications Setup command.
- Hit the Esc key (Win 95 & DOS) or hit -Period on the Macintosh to abort an image in progress.

See Also: Auto Grab Command, Color Grab Command, Display Image Command, Camera Setup Commands, Graphics Setup Command, Communications Setup Command, Contrast Window

Auto Grab Command

Camera Menu, Grab and Focus Commands

Purpose: *The Auto Grab Command is used to take a sequence of images at a periodic interval and log them to disk.*

Dialog Parameters

File name	Set this item to the name you want the Auto Grab command to use when saving the files. For Windows 95 & Macintosh users you enter the name and select the destination folder using the Standard File Save dialog. For PC users you can enter up to 8 characters for the file name and an optional three character extension, for example ORION.FTS. In both cases the Auto Grab command appends an index to the file name as the images are saved. The index is the image sequence number from 001 to 9999. In the example above the names would be ORION001.FTS, ORION002.FTS, etc.
Type	Set this item to the type of file you want saved for each image. The Uncompressed and Compressed formats are SBIG native formats which can be read back in and processed by CCDOPS. The TIFF and FITS formats are supported by other software packages but you will not be to load images saved in these formats back into CCDOPS.
Exp. interval	Set this item to the interval from start of image to start of image. For example, setting this item to 120 causes the Auto Grab command to start a new image every 2 minutes.
No. of Exp.	Set this item to the number of images you wish to grab and log to disk.
Dark interval	Set this item to the number of images to take before taking a new dark frame. If this item is set to *Series* then a single dark frame is taken at the start for the entire series of images.

Notes

- There is a lower limit to the setting of the Exposure Interval item which is the amount of time required to expose, digitize, download, and save the image. Setting the Exposure Interval below that value will result in the Auto Grab command taking images as fast as it can.
- When higher image throughput is required the amount of time required to digitize, download and save the image can be reduced by lowering the camera resolution in the Camera Setup command or by limiting the field of view with the Image size item in the Grab Command.
- You should set the Image Size item in the Grab Command to the smallest size that will encompass the object to save time and disk space. For example if you're monitoring stellar brightness then you should center the object and reduce the Image size to Half or Quarter.

See Also: Camera Setup Commands, Grab Command

Color Grab Command

Camera Menu, Grab Cmd., Track Menu Track & Accum. Cmd.

Purpose: *The Color Grab Command is used to take a sequence of three images through the color filter wheel. It is accessed through the Grab or Track and Accumulate by selecting Color Grab under Special Processing.*

Dialog Parameters

File name	Set this item to the base name you want the Color Grab command to use when saving the files. You can enter up to 8 characters for the file name but don't specify an extension. The Color Grab command adds a ".R", ".G" and ".B" extension to the red, green and blue image respectively.
File Type	Set this item to the type of file you want saved for each image. The Uncompressed and Compressed formats are SBIG native formats which can be read back in and processed by CCDOPS. The TIFF and FITS formats are supported by other software packages but you will not be able to load images saved in these formats back into CCDOPS.
Red Exposure	This gets set to the exposure time you entered in the Grab or Track and Accumulate dialog and is the total length of the Red exposure.
Green multip.	Set this item to a value that makes the green exposure a multiple of the red exposure.
Blue multip.	Set this item to a value that makes the blue exposure a multiple of the red exposure.

Notes

- Under DOS you use the >3DWK@ button to set the directory where the images will get saved.

See Also: Camera Setup Command, Grab Command, Track and Accumulate Command.

Focus Command
Camera Menu

Purpose: *The Focus Command is used to focus the CCD camera or to center objects in the field of view. It repeatedly acquires and displays images.*

Dialog Parameters

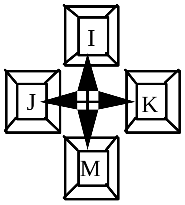
Exposure time	Set this item to the desired exposure duration in increments of a hundredth of a second.
Auto contrast *(DOS Only)*	Setting this item to *Yes* causes the image to be displayed using Auto Contrast where CCDOPS sets the Background and Range parameters based upon the image data. This works well for most images although when focusing on stars you may often find disabling Auto contrast a better option so you can set the Range to show the star's profile. *Note: Under Windows 95 & the Mac OS Auto Contrast is used if the Auto check-box is selected in the Contrast Window.*
Background Range *(DOS Only)*	These items affect the contrast of the displayed image if the Auto Contrast item is set *No*. *Note: Under Windows 95 & the Mac OS the Back and Range parameters from the Contrast Window are used.*
Frame size	With this item set to *Full* you capture images using the CCD's entire field of view. In the *Planet* mode, a full image is captured and then you select a sub-area of the CCD's field of view for subsequent images. In the *Spot* mode the camera digitizes the CCD's entire field of view but only downloads and displays a small region of pixels surrounding the brightest pixel. In *Dim* mode the camera digitizes the CCD's entire field of view and then reduces the image by combining pixels for download and display.
Update mode	Set this item to *Manual* to have the software pause between images to give you time to inspect the image or adjust the telescope before the next exposure is started.
Exposure delay	Set this item to any non-zero value to have the software delay that number of seconds between images. This gives you a chance to adjust the telescope focus after reviewing the image for example.
Auto Grab	Set this item to *Yes* to have the software use the Auto Grab feature where images are automatically logged to disk.
Readout type *(ST-6 Only)*	Set this item to *Rapid Readout* to double the image digitization rate (increasing throughput) at the cost of increased line-to-line noise in the image. This could be used when focusing on bright stars (over 1000 counts) or when centering objects. You should use the *Low Noise* setting when you are taking images you want to save.

Notes

- Planet mode is most useful for fine focusing as the image throughput is increased due to the relatively small number of pixels involved. You would not want to use Dim mode or reduced resolution modes from the Camera Setup command to achieve focus since those options increase the pixel size, making it impossible to get a better focus than the pixel size.
- Dim mode is most useful for centering objects or locating dim objects. It maintains the full field of view with larger pixels (reduced resolution) resulting in increased throughput and increased sensitivity to dim, diffuse objects.
- The Auto setting of the Resolution item in the Camera Setup mode is intended for Focus mode. It automatically switches between Low resolution in Full mode where you gain increased throughput and High resolution in Planet mode for critical focusing. A subsequent Grab command will be in the full resolution mode.
- While in Focus mode, the software displays the location and brightness of the brightest pixel within the image. This is quite handy for achieving critical focus. As you approach the best focus, the Peak will reach its highest level, and will also jump around by 30% to 50%. This is due to the fact that as a good focus is achieved, a large percentage of the light from the star is concentrated within a single pixel. As that tight star image moves around due to slight tracking errors or atmospheric effects and is split between two pixels, the peak drops.
- Under Win 95 & the Mac OS you use the mouse to position the Planet mode region. Clicking and dragging one of the corners or clicking and dragging in the center of the region resizes or relocates the region respectively. Once the region is located, click on the 5HVXPH button in the Focus Window to resume Planet mode.
- Under DOS you use the mouse or keyboard to position the Planet mode region. With the mouse, clicking and dragging one of the corners or clicking and dragging in the center of the region resizes or relocates the region respectively. With the keyboard, the "T" key toggles whether the arrow keys move the center, the lower-right or the

upper-left corner. Once the region is located, hitting the "L" key or using the Located command in the Focus menu resumes Planet mode.

- Under DOS, once in Planet mode with the sub-image being displayed, the Planet region can be moved around without having to re-enter planet mode using the arrow keys or the I, J, K and M keys described below.
- Under DOS, the I, J, K and M keys form a virtual keypad that moves the Planet region around 5 or 10 pixels at a time, depending on whether the shift key is held down.



- When using Planet mode, if you want to resize the Planet region, reselect the Planet mode from the pop-up menu.
- The moral of the story in regards to Focus mode throughput is that less pixels is faster. Partial frame modes (Planet mode) or larger pixel modes (Dim mode or reduced resolution modes) increase the throughput.
- Setting the Update mode to Manual is handy when you are taking short exposures (< 10 seconds) and trying to select a best image through the atmospheric seeing effects. With the Manual mode you let the software capture and display images until you find one you like. At that point you can exit from Focus mode and save the image.
- You can toggle between Auto and Manual update mode by clicking the Focus Window's $ XWR8SGDWH check box (Win 95 & Mac) or by hitting the "U" key (DOS).
- You can pause and restart the Focus mode by hitting the 3DXVH5HVXPH button (Win 95 & Mac) or by hitting the Space key (DOS).
- You can toggle between Auto and Manual contrast by clicking the Contrast Window's $ XWR check box (Win 95 & Mac) or by hitting the "C" key on the (DOS). Under DOS you are then prompted for Auto/Manual contrast. If you choose manual contrast, you then enter the Back and Range parameters. This is much faster than exiting Focus mode and reentering it with Manual Contrast enabled.

See Also: Camera Setup Commands, DOS Focus Mode Menus, Focus Window, Contrast Window, Auto Grab Command

Focus Window (Win 95 & Mac OS)

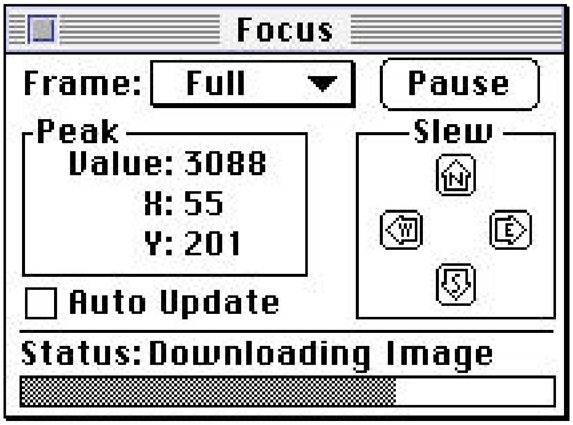
Purpose: *On the Macintosh the Focus Window contains controls that operate in Focus mode.*

Window Items

Frame menu	Change this item to change the desired frame mode from Full, Planet, Spot or Dim as described in the Focus command.
Pause/Resume button	Click this button to momentarily pause the Focus mode and click it again to resume processing.
Peak items	These items show the coordinates and brightness of the brightest object in the image and can be used to achieve critical focus by peaking the brightness.
Slew	Clicking on these buttons allow you to slew the telescope to center objects, etc., assuming you have connected the camera to the telescope through the Relay port.
Auto Update	Unchecking this checkbox causes the Focus mode to pause after displaying each image before starting the next image. This is useful with short exposures for selecting the best image through the atmospheric seeing effects.
Status	This text and bar graph tells the current phase of the focus cycle.

Notes

- Closing the Focus Window exits from Focus mode.
- In the Focus mode with the SCSI based Macintosh cameras, pulling down menus or clicking options in dialog boxes can delay the download and cause image dark current effects. If you find this distracting we suggest you uncheck the "Auto update" checkbox and wait until the image has been displayed before changing the contrasts settings, etc.



Frame: Full

Peak
Value: 3088
X: 55
Y: 201

☐ Auto Update

Status: Downloading Image

See Also: Focus Command

DOS Focus Mode Menus

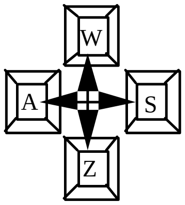
Purpose: *Under DOS the Focus Mode pop-up menus contain commands that change the operation of the Focus mode.*

Menu Commands

Located	This command, which can be invoked with the 'L' key, resumes the Planet mode processing after the Planet region has been positioned.
Full	This command, which can be invoked with the 'F' key, switches the focus mode back to Full frame mode from one of the other modes.
Planet	This command, which can be invoked with the 'P' key, switches the focus mode from Full frame mode to Planet mode.
Dim	This command, which can be invoked with the 'D' key, switches the focus mode from Full frame mode to Dim mode.
B-Spot	This command, which can be invoked with the 'B' key, switches the focus mode from Full frame mode to Spot mode.
Pause	This command, which can be invoked with the Space key, temporarily pauses or resumes Focus mode processing.
Contrast	This command, which can be invoked with the 'C' key, toggles Auto Contrast on and off. If Manual contrast is selected you also set the Back and Range parameters.
Update	This command, which can be invoked with the 'U' key, toggles Auto Update mode on and off. When off, the software pauses after displaying each image before starting the next exposure. This is useful with short exposures for selecting the best image through the atmospheric seeing effects.
Grab	When the Auto Grab option is used and Manual Update is selected, hitting the Grab item after the image has finished displaying logs the image to disk. Hitting the Space bar skips logging the image to disk.
Toggle Hot	This command, which can be invoked with the 'T' key, toggles which part of the Planet region is moved by the arrow keys from the center to the lower-right corner to the upper-left corner.
Exit	This command, which can be invoked with the Esc or 'X' key, exits from the Focus mode back to Command Mode.

Notes

- The W, A, S and Z keys form a virtual keypad that allows slewing the telescope for centering objects, etc., assuming you have connected the camera to the telescope through the Relay port. Each keypress activates the appropriate relay for 0.2 seconds.



See Also: Focus Command, Auto Grab Command

ST-4X Camera Setup Command

Camera Menu

Purpose: *The ST-4X Camera Setup Command is used to configure the ST-4X camera.*

Dialog Parameters

Cooling	Set this item to *Enabled* to turn on the ST-4X's TE cooler, or set this item to *Off* to shut down the TE cooler. You should shut down the ST-4X's TE cooler before you shut down for the night. After turning it off, it doesn't turn off immediately. It gradually reduces the power to avoid thermally shocking the TE cooler. Once the TE drive has gotten to 0% in the Status Window you can exit the software and turn off the ST-4X.
Reuse dark frames	When this item is set to *Yes* the previously captured dark frame stored in the camera can be reused for subsequent exposure of the same duration, resolution, size, etc. This can significantly increase image throughput when you want to take a series of similar exposures.
Antiblooming rate	This item controls how much antiblooming is applied to the CCD while integrating the exposure. The *Low* setting is recommended when there are no bright objects in the field of view that will bloom. The *Medium* and *High* settings are recommended when bright objects cause blooming.
Resolution	The *High* setting utilizes the ST-4X's highest resolution mode of 192 x 164 pixels. The *Low* setting results in 96 x 82 pixels, binning 2 pixels horizontally and vertically which results in a faster digitization and download time. The *Auto* setting uses the High resolution mode for every image acquisition command except for the Full size mode of the Focus command where the Low resolution mode is used.
Response factor	Refer to the Glossary for a description of this item.

Notes

- You ought to give the ST-4X five minutes for the temperature to stabilize before taking "keeper" images after enabling the TE cooling. This doesn't stop you from focusing or centering objects in the field of view.
- If you decide to reuse dark frames with an ST-4X you should take the dark frame in close proximity to the light image since the ST-4X's temperature is not regulated.
- Use the Upload Dark Frame command in the Camera menu to upload a previously taken dark frame to the ST-4X for use with subsequent images.
- The Antiblooming rate item should be set as low as necessary to prevent blooming in the images as increasing the Antiblooming rate slightly increases the dark current.
- The Response factor is attached to all subsequently captured images. To change a captured image's magnitude calibration adjust the Response factor in the Edit Parameters command.
- The pixels sizes for each of the available readout modes are shown in the table below:

Readout Mode	Number Pixels	Pixel Size	Binning
High	192 x 164	13.75 x 16 microns	1:1 x 1:1
Low	96 x 82	27.5 x 32 microns	2 :1 x 2:1

See Also: Display Image Command, Edit Parameters Command

ST-5/PixCel 255 Camera Setup Command

Camera Menu

Purpose: *The ST-5 Camera Setup Command is used to configure the ST-5 and PixCel 255 camera hardware.*

Dialog Parameters

Temperature regulation	Set this item to *Active* to enable ST-5's temperature regulation, or set this item to *Off* to shut it down. You should shut down the ST-5's TE cooler before you shut down for the night. After turning it off, it doesn't turn off immediately. It gradually reduces the power to avoid thermally shocking the TE cooler. Once the TE drive has gotten to 0% in the Status Window you can exit the software and turn off the ST-5.
Setpoint	When the temperature regulation is enabled, this is the temperature the camera tries to maintain. The camera's actual temperature and percent TE cooler power are shown in the lower right corner of the Status Window.
Reuse dark frames	When this item is set to *Yes* the previously captured dark frame stored in the camera can be reused for subsequent exposure of the same duration, setpoint temperature, resolution, size, etc. This can significantly increase image throughput when you want to take a series of similar exposures.
Antiblooming rate	This item controls how much antiblooming is applied to the CCD while integrating the exposure. The *Low* setting is recommended when there are no bright objects in the field of view that will bloom. The *Medium* and *High* settings are recommended when bright objects cause blooming.
Resolution	The *High* setting utilizes the ST-5's highest resolution mode of 320 x 240 pixels. The *Low* setting results in 160 x 120 pixels, binning 2 pixels horizontally and vertically which results in a faster digitization and download time. The *Auto* setting uses the High resolution mode for every image acquisition command except for the Full size mode of the Focus command where the Low resolution mode is used.
Response factor	Refer to the Glossary for a description of this item.

Notes

- You can watch the camera's temperature to see when the temperature regulation has stabilized after changing setpoints. If the percent power applied to the TE cooler reaches 100% after stabilization you have chosen a setpoint temperature that is too low.
- Use the Upload Dark Frame command in the Camera menu to upload a previously taken dark frame to the ST-5 for use with subsequent images.
- The Antiblooming rate item should be set as low as necessary to prevent blooming in the images as increasing the Antiblooming rate slightly increases the dark current.
- The Response factor is attached to all subsequently captured images. To change a captured image's magnitude calibration adjust the Response factor in the Edit Parameters command.
- The pixels sizes for each of the available readout modes are shown in the table below:

Readout Mode	Number Pixels	Pixel Size	Binning
High	320 x 240	10 x 10 microns	1:1 x 1:1
Low	160 x 120	20 x 20 microns	2 :1 x 2:1

See Also: Display Image Command, Edit Parameters Command

ST-237/PixCel 237 Camera Setup Command
Camera Menu

Purpose: *The ST-237 Camera Setup Command is used to configure the ST-237 and PixCel 237 camera hardware.*

Dialog Parameters

Temperature regulation	Set this item to *Active* to enable ST-237's temperature regulation, or set this item to *Off* to shut it down. You should shut down the ST-237's TE cooler before you shut down for the night. After turning it off, it doesn't turn off immediately. It gradually reduces the power to avoid thermally shocking the TE cooler. Once the TE drive has gotten to 0% in the Status Window you can exit the software and turn off the ST-237.
Setpoint	When the temperature regulation is enabled, this is the temperature the camera tries to maintain. The camera's actual temperature and percent TE cooler power are shown in the lower right corner of the Status Window.
Reuse dark frames	When this item is set to *Yes* the previously captured dark frame stored in the camera can be reused for subsequent exposure of the same duration, setpoint temperature, resolution, size, etc. This can significantly increase image throughput when you want to take a series of similar exposures.
Resolution	The *High* setting utilizes the ST-237's highest resolution mode of 640 x 480 pixels. The *Med* setting results in 320 x 240 pixels and the *Low* results in 213 x 160 pixels, binning 2 or 3 pixels horizontally and vertically respectively. This results in a faster digitization and download time. The *Auto* setting uses the High resolution mode for every image acquisition command except for the Full size mode of the Focus command where the Low resolution mode is used.
Response factor	Refer to the Glossary for a description of this item.
Cooling fan	Use this item to enable or disable the ST-237’s cooling fan. For example in planetary work where cooling isn’t the utmost concern and you’re worried about the possibility of vibration you would turn off the fan.

Notes

- You can watch the camera's temperature to see when the temperature regulation has stabilized after changing setpoints. If the percent power applied to the TE cooler reaches 100% after stabilization you have chosen a setpoint temperature that is too low.
- The Response factor is attached to all subsequently captured images. To change a captured image's magnitude calibration adjust the Response factor in the Edit Parameters command.
- The pixels sizes for each of the available readout modes are shown in the table below:

Readout Mode	Number Pixels	Pixel Size	Binning
High	640 x 480	7.4 x 7.4 microns	1:1 x 1:1
Med	320 x 240	14.8 x 14.8 microns	2:1 x 2:1
Low	213 x 160	22.2 x 22.2 microns	3 :1 x 3:1

See Also: Display Image Command, Edit Parameters Command

ST-6 Camera Setup Command

Camera Menu

Purpose: *The ST-6 Camera Setup Command is used to configure the ST-6 camera hardware .*

Dialog Parameters

Temperature regulation	Set this item to *Active* to enable ST-6's temperature regulation, or set this item to *Off* to shut it down. You should shut down the ST-6's TE cooler before you shut down for the night. After turning it off, it doesn't turn off immediately. It gradually reduces the power to avoid thermally shocking the TE cooler. Once the TE drive has gotten to 0% in the Status Window you can exit the software and turn off the ST-6.
Setpoint	When the temperature regulation is enabled, this is the temperature the camera tries to maintain. The camera's actual temperature and percent TE cooler power are shown in the Status Window.
Reuse dark frames	When this item is set to *Yes* the previously captured dark frame stored in the camera can be reused for subsequent exposure of the same duration, setpoint temperature, resolution, size, etc. This can significantly increase image throughput when you want to take a series of similar exposures.
Antiblooming rate	This item controls how much antiblooming is applied to the CCD while integrating the exposure. The *Low* setting is recommended when there are no bright objects in the field of view that will bloom. The *Medium* and *High* settings are recommended when bright objects cause blooming.
Resolution	The *High* setting utilizes the ST-6's highest resolution mode of 375 x 242 pixels. The *Medium* setting results in 250 x 242 pixels, and the *Low* setting results in 250 x 121 pixels through combinations of binning which increases image throughput. The *Auto* setting uses the High resolution mode for every image acquisition command except for the Full size mode of the Focus command where the Low resolution mode is used.
Response factor	Refer to the Glossary for a description of this item.

Notes

- You can watch the camera's temperature to see when the temperature regulation has stabilized after changing setpoints. If the percentage power applied to the TE cooler reaches 100% after stabilization you have chosen a setpoint temperature that is too low.
- Use the Upload Dark Frame command in the Camera menu to upload a previously taken dark frame to the ST-6 for use with subsequent images.
- The Antiblooming rate item should be set as low as necessary to prevent blooming in the images as increasing the Antiblooming rate slightly increases the dark current.
- The Response factor is attached to all subsequently captured images. To change a captured image's magnitude calibration adjust the Response factor in the Edit Parameters command.
- The pixels sizes for each of the available readout modes are shown in the table below:

Readout Mode	Number Pixels	Pixel Size	Binning
High	375 x 242	23 x 27 microns	2:1 x 1:1
Medium	250 x 242	34.5 x 27 microns	3:1 x 1:1
Low	250 x 121	34.5 x 54 microns	3:1 x 2:1

See Also: Display Image Command, Edit Parameters Command

ST-7/8 Camera Setup Command

Camera Menu

Purpose: *The ST-7 and ST-8 Camera Setup Command is used to configure the camera hardware.*

Dialog Parameters

Temperature regulation	Set this item to *Active* to enable camera's temperature regulation, or set this item to *Off* to shut it down. You should shut down the camera's TE cooler before you shut down for the night. After turning it off, it doesn't turn off immediately. It gradually reduces the power to avoid thermally shocking the TE cooler. Once the TE drive has gotten to 0% in the Status Window you can exit the software and turn off the camera
Setpoint	When the temperature regulation is enabled, this is the temperature the camera tries to maintain. The camera's actual temperature and percent TE cooler power are shown in the lower right corner of the Status Window. You will typically be able to regulate to temperatures 30 degrees C below ambient. We recommend picking readily achievable temperatures so you can build a library of dark frames.
Reuse dark frames	When this item is set to *Yes* the previously captured dark frame stored in the camera can be reused for subsequent exposure of the same duration, setpoint temperature, resolution, size, etc. This can significantly increase image throughput when you want to take a series of similar exposures.
Resolution	The *High* setting utilizes the camera's highest resolution mode of 9µ square pixels. The *Medium* setting results in 18 micron square pixels, binning 2 pixels horizontally and vertically which results in a faster digitization and download time. The *Low* setting is a 3 by 3 bin. The *Auto* setting uses the High resolution mode for every image acquisition command except for the Full size mode of the Focus command where the Low resolution mode is used. The tracking CCD, if selected, can also be binned. *Medium* and *Low* settings produce a 2x2 bin. When capturing a self guided image the tracking CCD is always in *High* resolution mode, and the imaging CCD at whatever is set here.
Response factor	Refer to the Glossary for a description of this item.
Active CCD	This item sets the CCD that is read out by the Grab and Focus Commands when acquiring images. You will typically collect images using the *imaging* CCD, but may wish to view the *tracking* CCD image to center a guide star.
Non-ABG Streak Removal	Setting this item to *Yes* utilizes a special readout mode of the non-ABG versions of the ST-7/8 that removes the horizontal streaking component of blooming from stars that bloom in the image. Users of ABG versions of the ST-7/8 should leave this set to *No*.

Notes

- You can watch the camera's temperature to see when the temperature regulation has stabilized after changing setpoints. If the percent power applied to the TE cooler reaches 100% after stabilization you have chosen a setpoint temperature that is too cold.
- The response factor, multiplied by 6700, is the number of electrons generated by a 0th magnitude star per second per square inch of clear aperture.
- The Response factor is attached to all subsequently captured images. To change a captured image's magnitude calibration adjust the Response factor in the Edit Parameters command.
- The pixels sizes for each of the available readout modes are shown in the table below:

Readout Mode	Number Pixels	Pixel Size	Binning
ST-7 High	765 x 510	9 x 9 microns	1 :1 x 1 :1
ST-7 Medium	382 x 255	18 x 18 microns	2 :1 x 2 :1
ST-7 Low	255 x 170	27 x 27 microns	3 :1 x 3 :1
ST-8 High	1530 x 1020	9 x 9 microns	1 :1 x 1 :1
ST-8 Medium	765 x 510	18 x 18 microns	2 :1 x 2 :1
ST-8 Low	510 x 340	27 x 27 microns	3 :1 x 3 :1

See Also: Display Image Command, Edit Parameters Command

3.5. Display Menu (Win 95 & Mac OS)

Purpose: *The commands in the Display menu under Windows 95 & the Mac OS allow displaying extra information about the image in memory.*

Commands

Show Crosshair	This command reveals the Crosshair Window where pixel information is displayed as a crosshair is moved around in the image.
Show Histogram	This command reveals the Histogram Window which shows a histogram of the image's pixel values. The histogram is a plot of the number of pixels (vertical axis) having a given pixel value or number vs. value (horizontal axis).
Parameters	This command brings up a dialog showing the image parameters including the exposure time, temperature, pixel size, etc.
Modifications	This command brings up a dialog showing a history of the modifications made to the image since it was captured. This is handy for remembering whether you "Removed Hot Pixels" etc., to images you had previously captured and processed.
Color Table	This command reveals the Color Table Editor where you can select and create false-color tables for displaying the images. This is only available on Macintosh computers that support color or gray-scale.
Slide Show	This command is used to show a previously scripted slide show.
Photo Mode	This command blacks out the entire screen and displays the image in the center which can be handy for taking photographs, etc. To exit from photo mode click the mouse or hit any key.

Notes

- Under Windows 95 & the Mac OS the image is always displayed in the Picture Window. The brightness and contrast of the image is controlled by the items in the Contrast Window.
- The color tables available in the Color Table Editor are saved with the CCDOPS application, not with the image.
- Use the Make Slide Show command in the File menu to create the slide show script.

See Also: Contrast Window, Crosshair Window, Color Table Editor.

3.6. Display Menu (DOS)

Purpose: *The commands in the Display menu under DOS allow displaying the image and displaying additional information about the image.*

Commands

Image	This command switches to Graphics Mode and displays the image.
Histogram	This command allows displaying the image's histogram in either text or graphics format. The histogram shows the number of pixels having a given pixel value or number Vs value. In the text format the histogram is shown in a table with a count of the number of pixels for every 256 wide range of pixel values (0-255, 256-511, etc.). In the graphics format the histogram is plotted with the vertical axis representing the number of pixels and the horizontal axis representing the pixel value.
Parameter	This command brings up a dialog showing the image parameters including the exposure time, temperature, pixel size, etc.
Modifications	This command brings up a dialog showing a history of the modifications made to the image since it was captured. This is handy for remembering whether you "Removed Hot Pixels" etc., to images you had previously captured and processed.
Slide Show	This command is used to show a previously scripted slide show.
Load User Color Table	This command allows you to load false-color tables for displaying images in the photo display mode.

Notes

- Color tables are available for the EGA, MCGA, VGA and Super VGA displays.
- If you want to create your own false-color tables refer to Appendix B.
- On the right in the Data Buffer box of the Status Window the software shows which color tables are loaded. An E, M, V or X indicate the presence of the EGA, MCGA, VGA and XVGA (Super VGA) color tables.
- Use the Make Slide Show command in the File menu to create the slide show script.

See Also: Display Image Command

Display Image Command (DOS)

Display Menu

Purpose: *The Display Image Command is used under DOS to switch from Command Mode to Graphics Mode where the image is displayed.*

Dialog Parameters

Display mode	The *Analysis* mode allows you to use crosshairs to measure the image and apply other image processing functions to the image. The *Photo* mode clears the screen and displays the image in the center of the screen, void of any text or menus. This is handy for taking photographs of the image.
Auto contrast	Set this item to *Yes* to have the software pick settings for the Background and Range parameters below. This works well for most images except for images containing only stars. Set this item to *No* if you want to manually set the Background and Range parameters.
Background **Range**	When Auto contrast is not enabled, pixels with values below the Background level are displayed as black. Pixels above the Background + Range level are displayed as bright white. Pixels values between the Background level and the Background + Range level are assigned shades of gray.
Smoothing	When this item is set *Yes* the image is smoothed for display purposes. This reduces the graininess of images at the expense of blurring.
Negative image	Set this item to *Yes* to display the image as a negative. This can be handy for dim nebulosity as the contrast of negative images is better for dim objects.
Top/Left	In the photo display mode some display adapters do not have enough resolution to display the entire image. These items indicate how many pixels off the top and off the left to skip and not display.
Color select	In the photo display mode you have the choice of displaying the image using the software's built in gray-scale color table (*Standard* setting) or by using a false-color table (*User* setting).

Notes

- The settings in the Display Image command do not modify the image data itself. They only affect the display of the image.
- In the analysis display mode the software combines pixels as necessary to be able to display the full image independent of display adapter setting.
- The gray-scale rendering of images may be better in the photo mode compared to the analysis mode on any given display adapter. The software takes advantage of the increased screen area and may try to dither the image to increase the gray-scale.
- Lowering the Background parameter makes the image brighter, revealing dimmer objects. Lowering the Range parameter increases the image's contrast.
- Auto contrast sets the Background and Range such that 10% of the pixels have intensities below the Background and 1% of the pixels have values above Background + Range.
- If you change either the Background or Range parameters the software will automatically switch Auto contrast off for you.
- If you want to create your own false-color tables refer to the Appendix.

See Also: Graphics Setup Command, DOS Display Mode Menus

DOS Display Mode Menus

Display Command, Graphics Mode

Purpose: *Under DOS, the analysis mode of the Display Mode contains pop-up menus which control the operation of the Display mode.*

Display Menu Commands

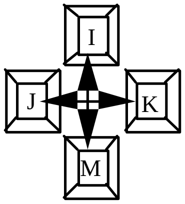
X-Hairs	This command, which can be invoked with the 'X' key, switches the Display mode to Crosshair mode, revealing the X-Hairs menu described below.
H-flip	This command, which can be invoked with the 'H' key, flips the image horizontally.
V-flip	This command, which can be invoked with the 'V' key, flips the image vertically.
Zoom	This command, which can be invoked with the 'Z' key, allows you to Zoom the image 4:1. A zoom region is shown on the image which can be positioned with the mouse or the keyboard. Once positioned, hitting the 'Z' key zooms the image, interpolating between pixels, and hitting the 'R' key zooms the image by replicating each pixel 4x4 times.
Crop	This command, which can be invoked with the 'C' key, allows you to Crop the image. A crop region is shown on the image which can be positioned and sized with the mouse or the keyboard. Once positioned, hitting the 'C' crops and redisplays the image.
Smoothing	This command, which can be invoked with the 'S' key, toggles Smoothing on and off, redisplaying the image.
Negative	This command, which can be invoked with the 'N' key, toggles Negative image on and off, redisplaying the image.
Quit	This command, which can be invoked with the Esc or 'Q' key, exits from the Display mode back to Command Mode.

X-Hairs Menu Commands

Set Position	This command, which can be invoked with the 'S' key, zeros the separation measurement by setting the home or zero location of the separation to the crosshair's pixel coordinates when the key is pressed.
Centroid	This command, which can be invoked with the 'C' key, sets the home or zero location of the separation to the coordinates of the centroid of the data at the crosshair's position.
Position	This command, which can be invoked with the 'P' key, measures the centroid of the data at the crosshair's position and updates the Separation measurement to that location.
Background	This command, which can be invoked with the 'B' key, uses the data at the crosshair's position as a measurement of the sky background for magnitude and centroid calculations.
Toggle Box	This command, which can be invoked with the 'T' key, toggles the size of the box used in measuring the background, average pixel value, and magnitudes from 3x3 pixels to 11x11 pixels.
+/- Magnitude	These commands, which can be invoked with the '+' and '-' keys, adjust the image's response factor (from the Edit Parameters Command) in order to adjust the calculated magnitudes by ±0.1 or ±0.01 magnitudes depending on whether the shift key is held down.
Quit	This command, which can be invoked with the Esc or 'Q' key, exits from the Crosshair mode back to Display mode.

Notes

- The I, J, K and M keys form a virtual keypad that moves the Crosshair, Zoom and Clip regions around 5 or 10 pixels at a time, depending on whether the shift key is held down.



- For accurate stellar magnitude and centroid determinations you should always set a background region in an area of the image representing the background conditions around the star. If the star is buried in nebulosity then pick a background region with a similar nebular intensity.

- If you find it necessary to adjust the magnitude measurements you may wish to copy the resulting Response factor from the Edit Parameters command to the Camera Setup command so that subsequent images will be correct.
- Stellar magnitude calculations depend on the settings of the Response factor and Aperture area parameters in the Edit Parameters Command. The Diffuse Magnitude calculations additionally depend on the Focal length parameter.
- Separation calculations depend on the settings of the Focal length parameter in the Edit Parameters Command.
- Separations are shown in arcseconds. Orientations are with 0° up, working clockwise towards 360°.

See Also:	Edit Parameters Command, Camera Setup Commands.

Contrast Window (Win 95 & Mac OS)

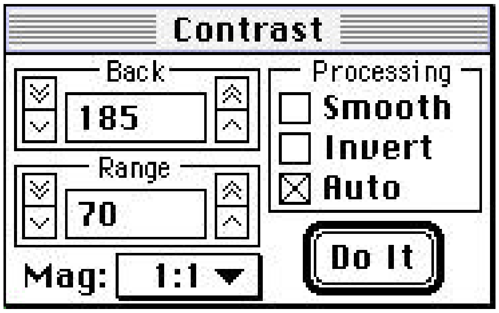
Purpose: *The Contrast Window contains controls that affect the display of the image in the Picture window.*

Window Items

Back/Range	When Auto contrast is not enabled, pixels with values below the Back level are displayed as black. Pixels above the Back + Range level are displayed as bright white. Pixels values between the Back level and the Back + Range level are assigned shades of gray.
Smooth	When this item is checked the image is smoothed for display purposes. This reduces the graininess of images at the expense of blurring.
Invert	When this item is checked the image is displayed as a negative. This can be handy for dim nebulosity as the contrast of negative images is better for dim objects.
Auto	When this item is checked the software sets the Back and Range parameters based upon the image data. This works well for most images except for images containing only stars. Uncheck this item if you wish to manually set the Back and Range parameters.
Do It/Apply	Hitting this button redisplays the image based upon the settings of the other items in this window.
Mag	This pop-up menu selects the magnification (zoom-level) of the image displayed in the Picture window.

Notes

- The settings in the Contrast Window do not modify the image data itself. They only affect the display of the image.
- Lowering the Back parameter makes the image brighter, revealing dimmer objects. Lowering the Range parameter increases the image's contrast.
- Auto contrast sets the Background and Range such that 10% of the pixels have intensities below the Background and that 1% of the pixels have values above Background + Range.
- If you change either the Background or Range parameters the software will automatically switch Auto contrast off for you.
- The Color Table Editor can be used to create your own false-color tables.
- You have to click the ' R,W button to redisplay the image after changing the settings in the Contrast Window (except the $ XWR checkbox which is automatic).
- Holding the Option key down and clicking in the image zooms in and centers the clicked on pixel in the Picture window.
- Holding the Command key down and clicking in the image zooms out and centers the clicked on pixel in the Picture window.



Back: 185
Range: 70
☐ Smooth
☐ Invert
☒ Auto
Mag: 1:1

See Also: Color Table Editor

Color Table Editor (Win 95 & Mac OS)

Purpose: *The Color Table Editor allows you to create your own false-color tables for displaying the images.*

Window Items

Table menu	Use this pop-up menu item to select the table to select or edit.
New	Clicking on this button creates a new color table for you to edit.
Delete	Clicking on this button deletes the active color table. **Be careful because you can not undo this!**
Rename	Clicking on this button allows you to rename the active color table.
Dup	Clicking on this button makes a copy of the active color table for you to edit.
Ramp	Clicking and dragging in the Color Table and then clicking this button blends the colors in the selected region from the starting color to the ending color.
Done	Click on this button when you are all through with the Color Table Editor.

Notes

- As you move the mouse around in the Color Table the active cell is shown below the Color Table.
- You can change the color of any individual cell in the Color Table by double-clicking on that cell. This brings up the standard Color Picker.
- The Color Table Editor is only available on Macintosh models that support color or gray-scale.
- The color tables available in the Color Table Editor are saved with the CCDOPS application, not the individual image files.

Crosshairs Window

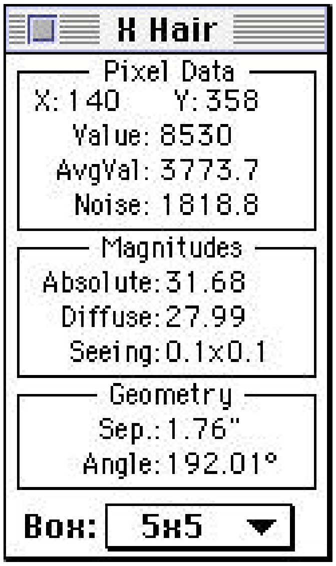
Purpose: *The Crosshairs window allows inspecting the image on a pixel-by-pixel basis. Under DOS it is available through the Analysis display mode. Under Win 95 and the Mac OS it is shown with the Show Crosshairs command in the Display menu.*

Window Items

Pix X, Y	These show the horizontal and vertical positions of the crosshair relative to the upper-left pixel which is pixel 1,1.
Value	This shows the brightness (in ADU) of the pixel directly under the crosshair.
AvgVal	This shows the average pixel value (in ADU) of the pixels in a "box" centered under the crosshair.
Noise	This shows the RMS variation (in ADU) of the pixels in the "box" under the crosshair.
Mag/Absolute	This shows the calculated magnitude of the star in the "box" under the crosshair.
DifMag/Diffuse	This shows the calculated magnitude per square-arcsecond of the nebulosity in the "box" under the crosshair.
See/Seeing	This shows the "full-width at half maximum" in arcseconds for the star in the "box" under the crosshair.
Sep.	This shows the separation in degrees/minutes/seconds of arc between the reference position and the crosshair.
Angle	This shows the angle clockwise from vertical between the reference position and the crosshair.
Boxsize/Box	This sets the size of the "box" used in the average, magnitude and seeing calculations.

Notes

- Hitting the 'B' key (or clicking in the image under Win 95 & Mac OS) places the background cursor.
- Hitting the 'S' key sets the reference position to the whole-pixel value of the crosshair position.
- Hitting the 'T' key (or selecting from the pop-up menu under Win 95 & Mac) sets the size of the "box" used in the average, magnitude and seeing calculations.
- Hitting the 'C' key sets the reference position to the centroid of the data under the crosshair.
- Hitting the 'P' key measures the separation between the reference position and the centroid of the data under the cursor.
- Hitting the '+'/'-' keys adjusts the image's Response Factor such that the calculated magnitude increases/decreases by 0.1 or 0.01 magnitudes based on whether the shifty key is down.
- Refer to Appendix B for a detailed description of the Astrometric and Photometric capabilities of CCDOPS.



X: 140 Y: 358
Value: 8530
AvgVal: 3773.7
Noise: 1818.8
Absolute: 31.68
Diffuse: 27.99
Seeing: 0.1x0.1
Sep.: 1.76"
Angle: 192.01°
Box: 5x5

3.7. Utility Menu

Purpose: *The commands in the Utility menu are image processing commands that modify the image data.*

Commands

Dark Subtract	Use this command to manually subtract a dark frame on the disk from the image in memory. You would only do this if you did not have the Grab command automatically subtract a dark frame. You can use the Standard dark subtraction or a special "Adaptive" routine that tries to adjust the dark image to more closely match the light image. We suggest you always save the image first and stick with the Standard routine. If your images have many residual hot or cold pixels after the dark subtraction reload the image and try the adaptive routine.
Co-Add	Use this command to co-add an image on disk to the one in memory. You can offset the images relative to one another in X and Y. These offsets allow you to co-register the images. You can also specify a count offset to be subtracted from the sum of the two images which may be essential to prevent the sum of the two images from saturating at 65535 counts.
Smooth	This command smoothes the image by combining each pixel with a weighted sum of itself and its eight neighboring pixels, reducing the graininess of the image at the expense of increasing blur. You can select from three filter strengths which apply increasing amounts of smoothing to the image.
Sharpen	This command sharpens the image by performing an unsharp masking operation with three strengths. The *Nebulae* setting is not as strong as the *Lunar/Planetary* but it won't leave rings around stars with surrounding nebulosity.
Flat Field	This command allows you to select a Flat Field image on disk to use in flat field correcting the image in memory.
Scale	This command allows you to scale the pixel values in an image either linearly or logarithmically. You specify Background and Range parameters which are used in scaling the image. Pixels with values below Background become 100 and pixels with values above Background + Range become 65535. Pixels with values between Background and Background + Range are scaled appropriately.
Remove Cool Pixels	This command removes dark pixels from images by replacing them with a weighted sum of the pixel's eight neighbors. You select from three strengths which affect varying degrees of dark pixels.
Kill Warm Pixels	This removes bright pixels from images by replacing them with a weighted sum of the pixel's eight neighbors. You select from three strengths which affect varying degrees of bright pixels.
Invert Pixels	This command makes the image into a negative image by inverting the pixel values around the midpoint in intensity. It can be used to make negative images for co-adding with pixel offsets.
Resample Pixels	This command resamples the image to effectively change the pixel sizes to square pixels. It is handy for achieving the correct aspect ratio in displayed or exported images although it reduces the resolution slightly and adds a smoothed appearance to images.
Pixel Math	This command allows you to do simple arithmetic operations on the image such as adding or subtracting a constant or multiplying or dividing by a constant. This can be handy to make two images match each other in terms of brightness or contrast.
Enlarge Image 2x	Images will often be acquired in Medium or Low resolution modes, where the stars can be blocky looking and the image may not fill the screen. This command enlarges the image 2x in each direction, interpolating between pixels. The result is a larger format image with less "blockiness".
Reduce Image 2x	This command bins the image 2x2 to produce a smaller image. This may help in detecting faint nebulosity.

Column/Row Repair	The ST-8 CCDs sometimes have bad columns at the edge of the field of view. Using this command, and entering the column number (X-coordinate) of the bad column determined in analysis crosshairs mode, will eliminate the column. The column data is replaced by the average of its neighbors.
Pseudo 3D	This command makes a pseudo 3-D relief of the image.
Add by Track List	This command is used to create a Track and Accumulate Flat Field image from a standard Flat Field image and a Track List. This command combines the standard flat field image with itself using the offsets specified in the track list. You specify an offset level to subtract from each co-addition of the flat field file and you select the flat field and the track list files.
Average Images	This command allows you to average several images together which can be useful for reducing noise. You select each of the images from the disk and the software averages them together and leaves the result in memory where it can be saved. Note that all images must be from the same model camera and have the same dimensions.
Edit Parameters	This command is used to edit the parameters attached to images such as the focal length, etc.
Flip Horizontal **Flip Vertical** *(Win 95 & Mac Only)*	These commands flip the image horizontally or vertically. This is handy for making the orientation of your images match published images for comparison purposes. *Note: Under DOS these commands are available in the Display Mode menu.*
Crop *(Win 95 & Mac Only)*	Click and drag in the Picture window to select a crop region then use this command to crop the image. To cancel the Crop simply click in the Picture window. *Note: Under DOS this command is available in the Display Mode menu.*

Notes

- Since these commands modify the image data itself you may wish to use them on a copy of the image, or when saving the image give it a new name.
- CCDOPS adds a bias of 100 counts to images to stop them from underflowing. A truly black image will show 100 counts with the Crosshair.
- Each modification made to the image through the commands in the Utility menu are recorded with the image and can be displayed using the Image Modifications command.

See Also: Edit Parameters Command, Image Modifications Command

Edit Parameters Command

Utility Menu

Purpose: *The Edit Parameters Command is used to change image parameters associated with captured images such as the focal length, etc.*

Dialog Parameters

Date of obs. **Time of obs.**	You may change these items to reflect the date and time the image was acquired. These values are initialized from the system clock when the image is captured.
Exposure time	There should be no reason to change this. It is set by the software to be the total integration period for the image, including all snapshots in the case of Track and Accumulate images.
Focal length	Change this item to reflect the focal length (in inches) of the telescope used to capture the image. This value is copied from the Telescope Setup Command when the image is captured.
Aperture	Change this item to reflect the clear aperture (in square-inches) of the telescope used to capture the image. This value is copied from the Telescope Setup Command when the image is captured.
Optical Filter	Change this character string to reflect any optical filter you may have used to capture the image.
Response factor	Change this item to calibrate the magnitude measurements for the given image. The magnitude adjustment functions of the Display Image command adjust this value accordingly.
Observer	Change this item to reflect the name of the observer that captured the image. This value is copied from the Telescope Setup Command when the image is captured.
Note	Set this item to any descriptive information you wish attached to the image, such as the object name, etc.

Notes

- Adjust the Focal length parameter to calibrate the separation measurements. If the separations are coming out too small by some percentage, raise the focal length by the same percentage.
- Adjust the Response factor or Aperture area to calibrate the magnitude measurements. If the magnitudes are coming out too high (the calculated star brightness is too dim) then you would lower the Response factor or Aperture area accordingly. Remember an increase in of 1.0 magnitude corresponds to a decrease in brightness of 2.5 times (5 magnitudes = 100X, 0.01 magnitude = 6%).
- If you find you have to make adjustments to the Focal length, Aperture area or Response factor then you should make the same changes to the values in the Camera Setup or Telescope Setup commands so that subsequent images will be correct.

See Also: Telescope Setup Command, Display Image Command

3.8. Misc Menu

Purpose: *The commands in the Misc menu allow you to setup the CCDOPS software for your computer and telescope.*

Commands

Graphics/Comm Setup *(Win 95 & Mac Only)*	This command allows you to configure CCDOPS for your model computer.
Graphics Setup *(DOS Only)*	This command allows you to configure CCDOPS for the graphics capabilities of your PC or PC Compatible computer.
Communications Setup *(DOS Only)*	This command allows you to configure CCDOPS for the communications capabilities of your PC or PC Compatible computer.
Telescope Setup	This command allows you to configure CCDOPS for the telescope you are using to acquire images.
Default Note	Use this item to set the comment attached to each subsequently acquired image.
Loopback COM Test *(DOS Only)*	This command allows you to test whether the serial ports on your PC are compatible with the CCDOPS software.

Notes

- The settings from the setup commands are retained in a CCDOPS.CFG configuration file so that they are preserved the next time you run CCDOPS. This is true of many of the settings throughout CCDOPS.

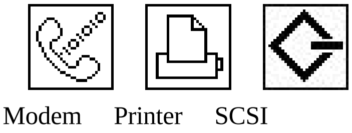
See Also: Graphics/Comm Setup Commands, Graphics Setup Command, Communications Setup Command, Telescope Setup Command

Graphics/Comm Setup Command (Macintosh)

Misc Menu

Purpose: *The Mac Graphics/Comm Setup Command is used to configure CCDOPS to your model of Macintosh computer.*

Dialog Parameters



COM Port	Select the port that is connected to the camera. With an ST-4X, ST-5 or ST-6 typically you will use the Modem port and leave the Printer port for printing. If you have an ST-7, ST-8 or PixCel select the SCSI port and make sure the SCSI adapter does not conflict with any other SCSI device IDs.
Baud rate	Set this item to *Auto* to have CCDOPS determine the fastest Baud rate that the software and camera can use or manually select a fixed Baud rate if you have troubles with *Auto*.
Graphics mode	On black and white (no gray-scale) Macintosh models, like the Classic and some of the portables, you can choose *2 Color Precision* or *2 Color Fast* modes. The precision setting uses a slower but visually more pleasing algorithm to simulate gray-scale on these two color systems. On models with color or gray scale you should select the *256 Color* mode.
Annunciator	When this item is set to *On* the software plays a little tune when an image has finished downloading (Beethoven's 5th). It also emits two tones when the software starts (low note followed by a high note) or finishes (high note followed by a low note) taking a light frame to let you know when to guide if you are manually guiding exposures. If you find this annoying then you can turn it off.

Notes

- If you decide to use the Printer port then you will have to turn off AppleTalk and any background printing options you have installed.
- The COM port and Baud rate used in talking to the camera are displayed in the lower-left corner of the Status Window.
- If you find that the image display on the Macintosh, with its square aspect-ratio pixels, is distracting you could use the Resample Pixels command in the Utility menu to produce an image that will display with the correct aspect-ratio. You should do this on a copy of the image as it modifies the image data.

Graphics/Comm Setup Command (Windows 95)

Misc Menu

Purpose: *The Windows 95 Graphics/Comm Setup Command is used to configure CCDOPS to your model of PC computer.*

Dialog Parameters

Interface	Select the type of communications port that is used for communicating with your camera. You can select *None*, *Serial* or *Parallel*. If you select the *None* setting the software will not try to communicate with the camera and can be used for image processing.
LPT Port	Set this item to the LPT port your camera is connected to.
COM Port	Set this item to the serial port you are using for communicating with the camera.
Baud rate	Set this item to *Auto* to have CCDOPS determine the fastest Baud rate that the software and camera can use or manually select a fixed Baud rate if you have troubles with *Auto*.
Annunciator	When this item is set to *On* the software plays a little tune when an image has finished downloading (Beethoven's 5th). It also emits two tones when the software starts (low note followed by a high note) or finishes (high note followed by a low note) taking a light frame to let you know when to guide if you are manually guiding exposures. If you find this annoying then you can turn it off.

Notes

- The COM port and Baud rate used in talking to the camera are displayed in the lower-left corner of the Status Window.
- If you find that the geometrical distortion of the image display Under Windows 95 distracting, with its square aspect-ratio pixels, you could use the Resample Pixels command in the Utility menu to produce an image that will display with the correct aspect-ratio. You should do this on a copy of the image as it modifies the image data.

Graphics Setup Command (DOS)

Misc Menu

Purpose: *The DOS Graphics Setup Command is used to configure CCDOPS to your PC's graphics capabilities.*

Dialog Parameters

Graphics card	Set this item to *Auto* to have CCDOPS detect the graphics capabilities of your computer or set it to the type of graphics adapter resident in your system. If you have a VESA compliant Super VGA card the *Auto* setting will detect the card and use the extended resolution capabilities in the Photo display mode. If you want to use the VESA display in analysis mode you must select the VESA option.
VESA Photo Mode	Set this item to *Auto* to have the software choose the best VESA resolution mode for image display. Otherwise set it to a fixed display resolution to force the software to use a particular mode.
Color display	Set this item to *Color* if you have a color monitor or *Monochrome* if you have a monochrome monitor. If you have a color monitor you may want to try the *NiteVision* mode which uses red colors for the Command Mode and Graphics Mode displays, making night vision adaptation easier.
Aspect	In the Photo display mode, this item stretches or shrinks the image's widths to correct for the difference in aspect ratio between the CCD and the display. Setting the Aspect greater than 1.0 widens the displayed image, assuming there are enough display pixels. Setting the Aspect less than 1.0 narrows the displayed image.
Mouse button	Set this item to the button you like to use on your mouse.
Annunciator	When this item is set to *On* the software plays a little tune when an image has finished downloading (Beethoven's 5th)[11]. It also emits two tones when the software starts (low note followed by a high note) or finishes (high note followed by a low note) taking a light frame to let you know when to guide if you are manually guiding exposures. If you find this annoying then you can turn it off.

Notes

- VGA users, and ST-4X users in particular, may wish to select the MCGA graphics card as it offers lower resolution but better gray-scale rendering of images.
- The high resolution modes of the Super VGA boards are used in the Photo display mode of the Display Image command.
- In the Photo display mode on the MCGA and Super VGA displays you can use the arrow keys to adjust the brightness and contrast of the displayed images within a limited range without having to redisplay the image. The left and right arrow keys adjust the brightness and the up and down arrow keys adjust the contrast.
- CCDOPS software tries to use the VESA modes 100 or 101 in the Photo display mode which are the 640x400 or 640x480 pixel, 256 color modes.

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[11] Some users have noted that a Souza march might be more inspiring.

Communications Setup Command (DOS)

Misc Menu

Purpose: *The DOS Communications Setup Command is used to configure CCDOPS for communications with your camera.*

Dialog Parameters

Interface	If you have an ST-4X, ST-5 or ST-6 choose the *Serial* setting. If you have an ST-7, ST-8 or PixCel choose the *Parallel* setting.
COM port	For serial based cameras, choose the serial port that is connected to the camera. Make sure there are no conflicts with a mouse or other peripheral.
Baud rate	Set this item to *Auto* to have CCDOPS determine the fastest Baud rate that the software and camera can use or manually select a fixed Baud rate if you have troubles with *Auto*.
Parallel port	For parallel based cameras, choose the parallel port that is connected to the camera.

Notes

- For serial based cameras, the serial throughput can be degraded a notch or two by the unnecessary EMM386.SYS driver. If you have problems communicating at the highest baud rates try removing this driver from your CONFIG.SYS file.

Telescope Setup Command

Misc Menu

Purpose: *The Telescope Setup Command is used to configure CCDOPS to the type of telescope you are using to acquire images.*

Dialog Parameters

Focal length	Set this item to the focal length of your telescope in inches. For example if you are using an f/10 C8, the approximate focal length would be 80 inches (f/10 times 8 inches). Don't forget to include the effects of any focal reducers or barlow lenses you may be using.
Aperture	Set this item to the clear aperture area of your telescope in square inches. For a round telescope with a central obstruction the aperture area is (100 - % of Obstruction)/100 * 3.14 * (Diameter/2)^2. For example a C8 with a 15% obstruction has a clear aperture of (100 - 15)/100 * 3.14 * (8/2)^2 = 42.7 square inches.
Observer	Enter your name or the name of your observatory in this item.

Notes

- The settings of these items are copied to each new image when it is captured.
- If you find you have to make adjustments to an image's Focal length or Aperture area then you should make the same changes to these values so that subsequent images will be correct.
- Although the settings of these items will not effect the quality of captured images in any way, the value of Focal length parameter copied to the image's parameters is used in the calculation of Separations and Diffuse Magnitudes. In addition, the copy of the Aperture parameter is used in the calculations of Stellar and Diffuse Magnitude.

See Also: Edit Parameters Command, Camera Setup Commands

3.9. Track Menu

Purpose: *The commands in the Track menu allow using the CCD camera as an autoguider or taking Track and Accumulate images.*

Commands

Track and Accumulate	This command allows you take several short duration images and automatically co-register and co-add them to get the benefits of a longer exposure without having to guide.
Autoguide	This command allows you to use your ST-4X, ST-5 or ST-6 as an autoguider. You enter the exposure time and the software takes a full field of view image where you select a guide star. The software then enters Track mode where it makes telescope corrections to keep the guide star at a fixed position in the field of view.
Self Guide	This commands allows you to use your ST-7 or ST-8 as a self guided camera where the Tracking CCD is used for Tracking and the Imaging CCD is used for imaging.
Calibrate	This command is used to calibrate the telescope drive for tracking purposes.
Autoguide Parameters	This command offers several parameters that allow you to fine tune the tracking performance of the system.
Move Telescope	With this command you select one of the four relays in the CPU and a duration and that relay is then activated for that period of time, moving the telescope. Two speeds are available if you use the Alarm Relay as discussed in the notes below. This is handy for seeing if you have correctly interfaced the CPU's Relay port to the telescope's hand controller.
Convert Track Log	This command takes a previously captured track log file and creates a mosaic image and track log spreadsheet. Track logging is enabled with a setting in the Autoguide Parameters dialog.

Notes

- You need to use the Calibrate command to calibrate your telescope's drive corrector before using the Autoguide Command, The Self Guide command, or having the Track and Accumulate command make corrections between images.
- In the Track and Self Guide modes the software displays the X and Y guiding error in pixels while tracking the star.
- If you wire the Alarm Relay in the CPU to your hand controller in a way such that it controls the correction speed you can use the Move Telescope command's Speed parameter to access the different speeds. With the Speed set to *Set rate* the alarm relay is activated simultaneously with the selected relay. With the Speed set to *Track rate* the alarm relay is not activated.

See Also: Track and Accumulate Command, Self Guide Command, Calibrate Track Command, Autoguide Parameters Command.

Track and Accumulate Command

Track Menu

Purpose: *The Track and Accumulate Command is used to take several short duration images and automatically co-register and co-add them to get the benefits of a longer exposure without having to guide.*

Dialog Parameters

Snapshot time	Set this to the longest exposure you can take without showing noticeable streaking due to drive drift. If you have to set this under 30 seconds then you probably need to tune up your drive or get a better polar alignment.
Number of snapshots	Set this item to the number of images to co-register and co-add for the final image. For example if you desire a 10 minute exposure and have the Snapshot time set to 120 then you would set this item to 5.
Frame size	You will typically set this item to *Full* to use the CCD's full field of view, but could reduce the field of view if image throughput is a concern or if you're imaging a small object.
Dark interval	Set this item to the number of images to co-add before taking a fresh dark frame. Setting this item to *Series* takes a single dark frame at the start for the entire series of snapshots.
Track mode	When this item is set to *Align* the software co-registers the snapshots without making telescope corrections between images. The *Relays* setting causes the software to only rely on telescope corrections, and the *Both* setting causes the software to co-register the snapshots as well as make telescope corrections.
Declination	When using the Relays or Both track modes, set this to the North or South declination of the object so the software can adjust the tracking speeds for decreasing effectiveness towards the poles.
Spec. Processing	When this is set to *Color-Grab* the software takes three images in sequence through the Red, Green and Blue filters. You select the Red exposure and then the relative lengths of the Green and Blue exposures.

Notes

- A 60 second to 120 second Snapshot time is desirable as it allows the resulting images to be as good as a single longer image from a Signal/Noise standpoint.
- On the ST-4X and ST-5, without an automatic vane for taking dark frames, you may find taking a single dark frame preferable by setting the Dark interval to *Series*.
- On telescopes with small to medium amounts of drift, using the *Align* Track mode is preferable as you don't have to connect the CPU's Relay port to the telescope's hand controller and you don't have to worry about the Calibrate Track command. If you find that the width of your Track and Accumulate images is being reduced substantially from the full width then you might consider the *Both* Track mode. The *Relays* mode should only be used on extremely stable mounts with very little backlash as the interval between corrections can be quite long.
- Under DOS, after you select the desired guide star, the software switches the display to a blown up image of the guide star with tracking performance information.
- Under Windows 95 and the Mac OS, the Track and Accumulate Window shows tracking performance. You can escape from Track and Accumulate by closing this window.
- Two graphs show the X and Y guiding error Vs time. The error is either the residual error (Residue = partial pixel error after co-registration) in the *Align* or *Both* modes, or is the total error in the *Relays* mode.
- An on-screen table shows the guide star's position, instantaneous error, and average error in pixels.

Autoguide Command
Track Menu

Purpose: *The Autoguide Command is used with the camera to autoguide the telescope ,*

Dialog Parameters

Exposure time	Set this to the exposure time desired for the tracking. The CCD will take an initial exposure, allow you to select the guide star, and then track on the selected star. The pixel error in subsequent images is displayed so you can see that the process is working properly. Pressing ESC aborts the tracking.
Declination	Set this to the North or South declination of the object so the software can adjust the tracking speeds for decreasing effectiveness towards the poles.

Notes

- You must use the Calibrate Track Command before using the Autoguide Command.

Self Guide Command

Track Menu

Purpose: *The Self Guide Command is used with an ST-7 or ST-8 to take a self guided CCD image.*

Dialog Parameters

Exposure time	Set this to the exposure time desired for the imaging CCD.
Track time	Set this to the exposure time desired for the tracking CCD.
Declination	Set this to the North or South declination of the object so the software can adjust the tracking speeds for decreasing effectiveness towards the poles.
Image size	You will typically set this item to *Full* to use the CCD's full field of view, but could reduce the field of view if image throughput is a concern or if you're imaging a small object.

Notes

- You must use the Calibrate Track Command before using the Self Guide Command.
- After you select the desired guide star, the software starts tracking with the Tracking CCD. Once the system has stabilized hit the Space bar to start the imaging CCD exposure.

PS - Please remember: it's very easy to forget to hit the space bar to start the exposure!

Calibrate Track Command

Track Menu

Purpose: *The Calibrate Track Command is used to calibrate the telescope drive for tracking purposes.*

Dialog Parameters

Exposure time	Set this item to the exposure required to show the calibration star with at least a few hundred counts without saturating.
X time **Y time**	Set these items to the number of seconds the Calibrate Track command should activate the drive controller in the respective directions to achieve 10 to 50 pixels of movement of the calibration star.
Steps	At the start, or if you want the Calibrate Track command to take a single move for the four calibrations set this item to 1. If you suspect your drive corrector has substantially different correction speeds for short corrections Vs long corrections then you may want to increase this item to break the X and Y times above into several shorter steps.
Declination	Set this item to the approximate declination of the calibration star if you plan on using a single calibration for a broad range of guide star declinations or set it to 0 if you plan on calibrating at different declinations.
Active CCD	For ST-7/8 users, set this item based upon which CCD is to be used for the calibration. Note that you can calibrate with either CCD and use either CCD for guiding and the CCDOPS software will sort it all out.

Notes

- You must use the Calibrate Track Command before using the Autoguide or Self Guide Commands or using the Track and Accumulate Command with the Track mode set to *Relays* or *Both*.
- For a calibration star you need to pick and roughly center a relatively bright star (5th through 7th magnitude), that does not have any similarly bright stars around it. If you plan on using a single calibration for many guiding episodes at varying declinations you should additionally pick a calibration star that is within ±20° of the celestial equator.
- You should make sure the head is oriented in the telescope with the CCD X axis parallel to RA and the CCD Y axis parallel to DEC.
- If you want the Calibrate Track command to skip one of the axes set the calibration time of that axis to zero. For example, if your telescope does not have a DEC motor you would set the Y time to zero.
- If the Calibrate Track Command detects any problem in calibrating the telescope you will be warned. Otherwise the software updates the settings of the X and Y relay speeds and the Active directions in the Tracking Parameters command.

See Also: Autoguide Command, Track and Accumulate Command, Tracking Parameters Command

Tracking Parameters Command

Track Menu

Purpose: *The Tracking Parameters Command is used to fine tune the tracking performance of the CCD camera system.*

Dialog Parameters

Active dirs.	Set this item to the directions in which the software will correct while tracking. If your telescope has both DEC and RA corrections select the *All* option. If you don't have DEC then select *X Only*. If you just wish to use the tracking commands to monitor your telescope's uncorrected guiding performance then you would set this to *None*. Note: These *directions are not tied to the relays; they are tied to the CCD orientation. X Only means your telescope will move the star in the CCD's X direction, not that the X Relays are active. Also note that the Calibrate Track command will change the setting of this item based upon its findings.*
X Direction	Users with German Equatorial mounts can reverse the settings of this item every time you flip the mount. Other users should leave this set to *Forward*.
Aggressiveness	This items controls how aggressive the guider is. Setting it to 5 causes the guider to apply half the corrections it would if it were set to 10 and can be used to control overcorrecting on some mounts.
Log Tracking Results	Set this item to *Yes* to have the software log the tracking images from the Autoguide and Selfguide commands for diagnostics. You can then use the Convert Track Log File command to make a mosaic image and tracking spreadsheet showing the position and error over time.
X/Y Backlash	If your mount has backlash you can try to improve the guiding by setting these items to the number of seconds of backlash. Note that this can make the guiding unstable if over applied and that it does not apply to the Calibrate command, only the tracking commands.
Relay speeds	These items should be set by the Calibrate Track command but may be manually adjusted. Let the Calibrate Track command set these values initially because, in addition to setting the correction speed, the Calibrate Track command learns which direction each relay moves the star image. This is essential for applying the correct polarity correction for a given guiding error. One way to fine tune these parameters is to do a Calibrate and then enter the Track mode on the same star. While the system is guiding, bump the telescope in one direction and watch the tracker correct. If it continually under corrects then you should lower the appropriate correction speed and vice versa.
Minimum move	This item sets the minimum move (in thousandths of a second) the software will make in response to a guiding error. A good setting for this is 50. Much shorter than that and the relays don't have time to respond. Much longer than that and drives with high correction speeds can have relatively large pixel errors before the software corrects.
Maximum move	This items sets the maximum move (in thousandths of a second) the software will make in response to a guiding error. A good setting is 1000, although you may want to increase it. While using the Autoguide command think of this as "What's the longest time I ever have to punch the button to move the star back when I'm guiding by hand"? Typically you would make short corrections, hardly ever approaching a one second correction. In Track and Accumulate the story is different since the time between corrections can be many seconds to a few minutes.

Notes

- The autoguiding capabilities of the software almost assure that you will probably never have to adjust these parameters (except the Declination). They really are for fine tuning.
- The speed parameters are tied to the Relay, not the CCD direction. For example, the Relay +X speed is the speed the star moves across the CCD (in pixels per second) in response to activating the +X relay.
- **Important!** The speed parameters have to be accurate for your drive to within a factor of 2 or else, if the software overcorrects, it will eventually drive the star out of the guide box as it oscillates back and forth.

See Also: Calibrate Track Command, Track and Accumulate Command, Autoguide Command

3.10. Filter Menu

Purpose: *The commands in the Filter menu are used in conjunction with filter wheels or to select filters or to calibrate the filter wheel.*

Commands

1 through 6	These commands position motorized filter wheels or tell the software which filter position has been selected with the manually operated CFW-6.
Filter Setup	This command allows you to select the type of filter wheel and assign names to the six filter positions.
Calibrate	This command is used to calibrate the motorized CFW-6 filter wheel. In a six step procedure you fine adjust the positions of the rotary wheel to center the filter cells. The calibration results are recorded in the FILTER.CFG file for future use.

Notes

- If you have a motorized CFW-6A or CFW-8 the commands in the Filter menu automatically position the filter wheel.
- If you have a manually operated filter wheel, use the commands in the Filter menu to inform the CCDOPS software about the filter you have selected for use.
- The name of the currently selected filter is shown in the lower right hand corner of the Camera Box in the Status Window. This information is also retained with images when they are captured.

See Also: Filter Setup Command

Filter Setup Command
Filter Menu

Purpose: *The Filter Setup Command is used to configure the CCDOPS software to your type of filter wheel.*

Dialog Parameters

Filter wheel	Select the type of filter wheel you are using or *None* if you are using individual filters.
Dark Position	If you have a CFW-6A or CFW-8 and are using it in conjunction with the shutterless ST-4X or ST-5 cameras you can get the CCDOPS software to use the filter wheel as a remote shutter by covering one of the positions and setting that position here.
Filter 1 through 6	Enter a descriptive name for each of the filters in the six positions of the filter wheel or enter the name of the six most common filters you use.

Notes

- The names you enter in the Filter Setup command are used in the Filter menu and are saved with new images as they are captured.
- The motorized CFW-6A and CFW-8 attach to the CPU's AUX port and can be positioned with the commands in the Filter menu.
- Manually positioned filter wheels like the CFW-6 need to be positioned by the user and then you need to let the CCDOPS software know which filter has been selected with the commands in the Filter menu.
- If you select the Motorized filter wheel CCDOPS will reposition the filter wheel when you start up and establish the COM link with the camera.
- If you select a Manual filter wheel CCDOPS remembers the position you have selected next time you start the software. You might check to insure the software and the filter wheel agree if you have been away for a few days.
- If you are temporarily not using the filter wheel or any individual filters select the None option in the filter wheel item. You can still use the commands in the filter menu to select filters if you happen to be using them and the software will start up with "No filter" selected.

3.11. AO Menu

Purpose: *The commands in the AO menu are used in conjunction with the AO-7 Adaptive Optics accessory.*

Commands

Self Guide	This command allows you to use the AO-7 as a high-speed drive corrector. This is just like the Self Guide command in the Track menu except that the AO-7 is used to correct for drive errors.
Calibrate	This command calibrates the AO-7's displacement response and must be run before you can use the AO-7 for guiding. Note you can calibrate with either CCD.
Setup	This command is enable and disable the AO-7 and control the slew rate.
Exercise	This command allows you exercise the AO-7, flipping it back and forth in one or both axes.

Notes

- When the AO-7 is enabled all the corrections that would normally apply to the relays are redirected to the AO-7. This means the Track and Accumulate, Self Guide and Autoguide commands will correct the AO-7 in response to a drive error, not the telescope through the relays. If after you've installed and enabled the AO-7 you want to go back to ordinary relay-based telescope control you should disable the AO-7 with the AO Setup command.
- Unlike the normal relay response and the Calibrate command in the Track menu, you do not have to recalibrate the AO at varying Declinations. One calibration should work for all orientations since the AO-7 is attached to the camera, not the telescope.
- Use the Exercise command to make sure the AO-7 is properly connected to the camera and communicating with the camera and software.

See Also: AO Self Guide Command

AO Self Guide Command

AO Menu

Purpose: *The AO Self Guide Command is used with an ST-7 or ST-8 and an AO-7 to take a self guided CCD image where the AO-7 acts as the drive corrector.*

Dialog Parameters

Exposure time	Set this to the exposure time desired for the imaging CCD.
Track time	Set this to the exposure time desired for the tracking CCD.
Track box	Set this to *Small, Medium* or *Large* to use a 16x16, 8x8 or 4x4 box of pixels for guiding. With short tracking exposures (under 0.05 seconds) you'll achieve higher rates with the Medium and Small settings.
Dither Exposure	When this item is set to *Yes* the software periodically displaces the guide-star up and to the right and disables guiding. It does this with a "5-seconds on", "5-seconds off" interval, giving a "double" exposure showing the self guided results to the lower-left and the unguided results to the upper right.

Notes

- You are shown a full FOV image from the tracking CCD where you select the guide star.
- The software starts guiding on the tracking CCD but you must hit the Space Bar (DOS) or click the "Start" button (Win 95 and Mac OS) the start the Imaging CCD exposure. This give you a chance to watch the performance and let the system "bed-down" before taking the big image.
- The software shows the following diagnostics while tracking:

Guide rate:	This shows the effective rate the AO-7 is running at. Both the rate (Hz) and Period (ms) are shown. Shorter tracking times and smaller Track boxes result in higher rates.
AO Position:	This shoes the deflection of the AO in percent. 50% x 50% is in the center. As the telescope drifts this could approach the limits of compliance in the AO-7, shown as 0% or 100%.
RMS Wander:	This is the high frequency (baseline removed) RMS error in the position of the guide star.
Total Counts:	This shows the integrated brightness in the guide star (first number) versus the brightness when you started guiding.

- You can enable and disable the Fan by hitting the 'F' key (DOS) or clicking the "Enable fan" checkbox (Win 95 and Mac OS).
- You can enable and disable the AO corrections by hitting the 'A' key (DOS) or clicking the "Enable AO" checkbox (Win 95 & Mac OS).
- You can increase or decrease the Aggressiveness with the Up and Down arrow keys (DOS) or with the Aggressiveness control (Win 95 & Mac OS). The normal value for the aggressiveness is 10 meaning the AO-7 makes ten-tenths of the correction it should. If the guide star is jumping around more when the AO is enable than when it's not then you can reduce the aggressiveness to 5 for example to make the AO only make 50% of the normal correction.
- While you might think that higher rates are desirable, you never want to go so fast that the guide star image becomes so noisy that the performance is degraded by low Signal/Noise in the guide star.
- 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.
- The AO Self Guide command will activate the relays and try to bring the telescope back in line when the AO gets beyond 25% or 75% in either axis. You have 2 options in this regard:
  A: Don't connect the guiding cable to the telescope and just watch to make sure the AO doesn't get all the way to the limit (0% or 100%). This is the easy option.
  B: Connect the telescope cable and use the Calibrate command in the Track menu to Calibrate the Relays/Telescope. This is more difficult.
- Use the dither option to take 30 second or 1 minute images and then use the Crosshairs to measure the stellar half-width of the guided and unguided star images. Ideally the AO guided image will have 30% lower half-width and 50% to 100% better peak brightness.
- You can enable Track Logging in the Track Parameters command to make a mosaic image of the guiding performance.

PS - Please remember: it's very easy to forget to hit the space bar to start the exposure!

4. Hints and Tips

This section contains hints and tips to get the most use out of your camera and software. There is a section of Question and Answers to the most common questions followed by several sections of tips.

4.1 Question and Answer

This section contains answers to some of the more common questions we hear in the Technical Support department.

Q. *Is there a short cut to focusing the camera?* A. We find the best method is using the peak brightness as described in the manual but there are almost as many opinions here as there are people.

Q. *How often do I need to refocus?* A. When there has been a big temperature change (3 °F) or when you have moved to a vastly different position of the sky with an SCT, you should consider refocusing.

Q. *Can I use a camera lens with the camera?* A. Yes, SBIG sells an adapter for the camera that allows you to use C-mount or other lenses with the camera.

Q. *Who should I call when I have questions or problems with the software?* Call or e-mail SBIG <sbig@sbig.com> and ask for Technical Support.

Q. *How long of a cable can I use between the PC and the CPU?* A. You should be able to use cables up to 100 feet in length but it will vary from PC to PC.

Q. *Where can I get a longer cable?* A. Go to your nearest computer store and ask for a male to female extension cable.

Q. *Why does the software say there isn't enough memory?* A. You need to make sure you have at least 1 Megabyte Extended memory and that the HIMEM.SYS driver is loaded into your CONFIG.SYS file. Also check that other entries in the CONFIG.SYS or AUTOEXEC.BAT files are not consuming too much memory.

Q. *I see dark spots in my images, what causes them?* A. If the dark spots are a single pixel they are typically caused by hot pixels in the CCD saturating and can be removed with the Remove Cool Pixels command. If they're several pixels wide you should suspect dust on the window and that effect can be removed with flat fielding your images or clean the window with an "air duster".

Q. *My images have dark tendrils in the corners. What can I do?* A. These are caused by the CCD frosting and you need to replace the desiccant as described in the camera operating manual.

Q. *Can I write my own software for the camera?* A. Appendix A describes the file format used to save images. You can also request an Application Note from SBIG telling how to interface and program to the camera.

Q. *Is there other software available for the camera?* A. You can upgrade your camera with the Color Filter Wheel and CCDCOLOR software. Also there are several third party software packages for image processing, camera control and various printer output.

Q. *Can I run the software under Windows,?* A. While we don't recommend running the CCDOPS software under Windows you should be able to do it. Also Software Bisque's SkyPro software supports the camera under Windows and is fully integrated with their excellent The Sky software. Contact Software Bisque at (303) 278-4478.

Q. *What do I do if my images have elongated stars?* A. If using Track and Accumulate you are probably using a snapshot time that is too long. If the snapshot time is longer than the amount of time your drive can track unguided with acceptable guiding errors, you will see elongated stars in your final images. If your snapshot times are getting down to 30 seconds or less you should improve your drive.

If you are using your camera as an autoguider for film photography and are noticing unacceptable guiding errors, please check the following:

1. Can you move the telescope using the Move command? This is an indicator as to whether or not you are properly connected to your drive system via the relay cable from the CPU.
2. Be sure that your calibration time gives at least 10 to 50 pixels of movement for each step of the Calibrate command.
3. Check for flexure between the CCD camera head and your system. Check for flexure between the guide scope or off-axis guider and your telescope system. This is a very common source of guiding

errors. A very small movement of the CCD head with respect to the guide scope during an exposure can cause unacceptable streaking.

4. If your mount is stable, try longer exposure times while tracking to average out the atmospheric effects.

Q. *What do I do if my CCD frosts?* A. If your camera starts to frost after a year of use it's time to replace the desiccant as described in the camera operating manual.

Q. *The moon is too bright, what do I do?* A. Try a full aperture solar filter. Try a variable rotating neutral density filter. Don't use off-axis apertures smaller than 4" or you give up resolution.

Q. *What exposure is best for planets?* A. Use the crosshairs mode to measure the disk's intensity. Make sure that the pixels are about 75% saturated. This should give a good range of brightness. Sometimes moons can also be imaged at the long end of the exposure range.

Q. *Which laptop is best for CCD use?* A. Nearly any laptop will work, however you should take a copy of CCDOPS with images and run it from any units you are considering. Color LCD isn't necessary unless it is your only computer.

Q. *Why are my images grainy looking and not smooth?* A. The grainy look is from low signal to noise. A longer integration time will increase signal and reduce graininess. Try doubling exposure times. This works up to a point where you begin picking up sky background (light pollution) which limits maximum practical integration times. Also make sure your cooler is running at 75% capacity or more.

Q. *What are the advantages of shorter focal lengths and faster F# telescopes?* A. Shorter focal lengths increase the field of view, allowing you to image larger objects. Faster F# telescopes increase the field of view *and* shorten the exposure times. Do not underestimate the benefits of focal reducing your f/10 SCT systems!

4.2. CCDOPS Use Tips

- If you display an image and nothing shows, check that the Auto Contrast was enabled.
- When selecting a Track and Accumulate guide star, it is not necessary to exactly set the cursor on the center of the selected star. It automatically snaps to the brightest pixel, not necessarily the geometric visual center.
- Co-adding images together, whether guided or accumulated, averages out noise and results in a smoother image than one single long exposure. Keep in mind, the longer the individual exposure, the higher the signal to noise until you reach background sky limits. You will find that at f/10, a single 60 second exposure will be grainy for low contrast objects and 5 minutes may be the minimum tolerable, requiring off-axis guiding or a guide scope. At f/6.3, this snapshot time may be 1 minute and at f/2 it may be 10 seconds. Don't be afraid to experiment with poorly guided images of varying exposure times to learn what works best. Co-adding many underexposed images still results in inferior results. This is especially true for tricolor.
- If you are fortunate enough to have access to a full aperture solar filter or C-Mount camera and camera lens adapter, daytime use with the CCD camera is possible at f/6.3 to f/10. Distant power poles and power lines silhouetted against the sky work well as a target. Use binning since turbulence will limit resolution. This will allow you to learn the software flow in daylight.
- Dark frames aren't necessary for short exposures of bright objects (Jupiter at f/20 with 2x Barlow projection or the moon).

4.3. Hints and Tips for Laptop Users

- If you mainly use your laptop for field use with CCDOPS, it is possible to modify your AUTOEXEC.BAT file to boot directly into CCDOPS, saving time.
- If your laptop is monochrome, obtain a small piece of red litho stripping film (rubylith) to slip in front of the LCD display. Most print shops have the red plastic. Use it matte side out.

- Cursor movement through CCDOPS is much faster using the mouse, especially if your laptop has one of the small keyboard based pen-point mice.
- Some LCD displays dim when it is very cold outside. A small heat pad behind the display can help.
- Don't be afraid to adjust display brightness on your computer in the course of viewing an image. Negative views require opposite settings.
- Try to use a laptop with 64 shades of gray. Some laptops have a display setup mode in their resident software to optimize. VESA compliant is also useful for real time cursor contrast changes.
- LAPLINK software and cables allow easy next day image file transfer to your main computer. This is very handy.
- Images will always look better when displayed on a video monitor, however, an active matrix LCD display is pretty close except in brightness.
- You may wish to change your display and hard drive sleep cycles (battery conservation) to longer "keep awake" times so as not to interfere with image acquisition (long Track and Accumulate).
- LED flashlights help to see the keyboard when the display is dimmed red.

4.4. Telescope Tips

- Always verify best collimation prior to installing the CCD camera. Because sub-arc second imaging (better than that you can see visually) is possible.
- Always secure the camera head cable to the optical tube assembly. Never let the cable dangle free from the focuser/ocular holder.
- Off-axis guiding is worth it, even on a bunch of 3 minute co-adds of a deep sky object.
- Don't guess on focus. If you're not sure, it is time to refocus.
- Take time to frame your object. Rotate the camera 90 degrees to take advantage of the CCD chip's aspect ratio and don't forget to refocus again.
- Focal reduce as much as possible for deep sky objects. Exposure times are then shorter and signal to noise gets better. 2-3 arc-seconds per pixel (30" focal length) is plenty of resolution for deep sky objects, especially nebulae. Good tracking is still critical down to 12" focal lengths in hi-res mode. Always polar align to minimize Dec drift.
- Focusing micrometers really help, especially on SCTs where you want to always enter the best focus position on a counterclockwise knob rotation. This advances the primary mirror forward against gravity and preloads bearings, screw threads and any mirror/baffle rocking. A light knuckle rap prior to exposure or guiding is advisable to settle moving components. It is always possible to ascertain exact focus only after you have passed a peak intensity and then come back to the peak's setting. You may not see the exact high value, but will see the trend at best focus position. Again, don't guess at focus.
- Focusing on planets is difficult since seeing can uniquely blur each frame. If a planet's moon is present, use the slow motion hand control to move over to it. Readjust exposure time accordingly and refocus on it, then bring the planet back into view and capture it.
- If track problems exist, first check balance in declination and then RA since they interact. Verify the 1 1/4" camera head coupler doesn't rock in the telescope bushing and that it is flush at it's coupler flange with bushing. Check drive clutches or clamps. Check drive rate setting. With guiding ocular visually check PEC setting or reprogram. Trails on only the brightest stars along short axis of the CCD is blooming, not tracking.

Section 4 - Hints and Tips

- Real dark skies are not necessary for beautiful CCD images of deep sky objects. CCDs are far superior to film with or without filters in this respect. Tricolor CCD will benefit from dark skies, but still works great compared to color film.
- Simple 2 element refractors can show bloated stars due to chromatic aberration since CCDs have a wide spectral response and a very wide dynamic range of signal. Red filters can help or quality multi-element color corrected refractors.
- Always keep an eye on ambient temperature changes. A 3 degree Fahrenheit change can affect SCT focus enough to merit refocusing. Temperature drop = clockwise movement of SCT focus knob (yes, the way you didn't want to move it).
- Closely re-align your finder as needed to the CCD image on the screen to speed up object finding. Don't use a 90 degree diagonal to visually acquire objects and expect them to be in the CCD camera view. The CCDs are generally small in size and 90 degree diagonals are never rotationally collimated to optical axis close enough to use for CCD work. Special laser collimated diagonals are available for this purpose as well as CCD framing oculars with exact reticle patterns to match the CCD chip.
- Digital setting circles with hi-res encoders (1/12 degree or better) can get you close to faint objects if you are polar aligned and they are "dialed in" as well.
- Integrating Software Bisque's "The Sky" software into your imaging system is another help in object acquisition, but adds new complexity to the operations until after you are comfortable with CCDOPS and CCD imaging. It is then a very interactive tool.
- Don't bother with deep sky imaging on an Alt/Az configured mount even if it tracks. Image rotation results and precludes co-adding, etc. in most instances. Use a wedge and polar align such systems for best and simplest results.
- Wait for both telescope and CCD camera to thermally settle in before trying for optimal results. Typically wait 1/2 to 1 hour after setting up and running. This is a good time to set up software, balance scope, and polar align, etc.
- Use a dew shield on SCTs to prevent dewing and minimize stray light. Re-balance as necessary. CCDs have a tremendous dynamic range. Bright stars at edge of field can spray light across nebula, especially Veil, Horsehead, California nebulae. Anti-blooming can't help scattered light. Reposition field slightly and try again.
- Fast telescopes with high resolution optics offer remarkable imaging characteristics with CCD cameras, especially tricolor. Exposure times are short, excellent tracking is easier, signal is awesome, therefore contrast of colors in deep sky objects is spectacular enough to warrant color dye sublimation prints that rival photographic color prints done with film through much larger telescopes at a much higher difficulty level. Takahashi Epsilon, Flat Field cameras and specialized SCTs are hard to match in performance.

5. Glossary

ABL - Auto bias level. ST-7/8 and PixCel 255 images that show this in the image parameters dialog have had an auto bias level done on them to bring the dark signal down to 100 counts.

ADU - Analog/Digital Unit. This is the number of counts in a pixel in terms of counts out of the analog/digital converter. To convert to electrons multiply by the e^-/ADU shown in the Image Parameters command.

Antiblooming Gate - When a CCD pixel has reached its full well capacity, electrons can effectively spill over into an adjoining pixel. This is referred to as blooming. The Antiblooming gate can be used to help stop or at least reduce blooming when the brighter parts of the image saturate.

Astrometry - Astrometry is the study of stellar positions with respect to a given coordinate system.

Autoguider - All SBIG CCD cameras have auto guiding or "Star Tracker" functions. This is accomplished by using the telescope drive motors to force a guide star to stay precisely centered on a single pixel of the CCD array. The camera has four relays to control the drive corrector system of the telescope. The CCD camera head is installed at the guide scope or off axis guider in place of a guiding eyepiece.

CCD - The CCD (Charged Coupled Device) is a flat, two dimensional array of very small light detectors referred to as pixels. Each pixel acts like a bucket for electrons. The electrons are created by photons (light) absorbed in the pixel. During an exposure, each pixel fills up with electrons in proportion to the amount of light entering the pixel. After the exposure is complete, the electron charge buildup in each pixel is measured. When a pixel is displayed at the computer screen, its displayed brightness is proportional to the number of electrons that had accumulated in the pixel during the exposure.

Dark Frame - The user will need to routinely create image files called Dark Frames. A Dark Frame is an image taken completely in the dark. The telescope aperture must be covered or in the case of the ST-6, a shutter vane covers the CCD. Dark Frames are subtracted from normal exposures (light frames) to eliminate fixed pattern and dark current noise from the image. Dark Frames must be of the same integration time and temperature as the light frame being processed.

Dark Noise - Dark Noise or Dark Current is the result of thermally generated electrons building up in the CCD pixels during an exposure. The number of electrons due to Dark Noise is related to just two parameters; integration time and temperature of the CCD. The longer the integration time, the greater the dark current buildup. Conversely, the lower the operating temperature, the lower the dark current. This is why the CCD is cooled for long integration times. Dark noise is a mostly repeatable noise source, therefore it can be subtracted from the image by taking a "Dark Frame" exposure and subtracting it from the light image. This can usually be done with very little loss of dynamic range.

DCR - DC Restore (DCR) only applies to the ST-6. It is used as a faster readout alternative to Double Correlated Sampling during focus mode. It works by setting the black level to the offset in a particular ST-6 by reading the average value of dark pixels. This usually results in a usable image for focusing while giving a much faster digitization and download cycle during focusing.

Double Correlated Sampling - Double Correlated Sampling (DCS) is employed to lower the digitization errors due to residual charge in the readout capacitors. This results in lower readout noise but can increase the digitization time by a factor of two in the ST-6. This feature can be switched off when faster digitization rates are desired. This is often done during find and focus modes.

e^-/ADU - This is the gain of the camera in converting the CCD output into counts. It is shown in the Image Parameters dialog for each image and is used by programs like Hidden Image.

False Color - False Color images are images that have had colors assigned to different intensities instead of gray levels.

FITS Image File Format - The FITS image file format (which stands for Flexible Image Transport System) is a common format supported by professional astronomical image processing programs such as IRAF and PC Vista. CCDOPS can save image files in this format but can not read them.

Flat Field - A Flat Field is a image with a uniform distribution of light entering the telescope. An image taken this way is called a flat field image and is used with CCDOPS to correct images for vignetting.

Focal Reducer - A Focal Reducer reduces the effective focal length of an optical system. It consists of a lens mounted in a cell and is usually placed in front of an eyepiece or camera. With the relatively small size of CCDs compared to film, focal reducers are often used in CCD imaging.

Frame Transfer CCDs - Frame Transfer CCDs are CCDs that have a metal mask over some portion (usually half) of the pixel array. The unmasked portion is used to collect the image. After the exposure is complete, the CCD can very quickly shift the image from the unmasked portion of the CCD to the masked portion, thus protecting the image from light which may still be impinging on the CCD. This acts as an electronic shutter.

Full Well Capacity - Full Well Capacity refers to the maximum number of electrons a CCD pixel can hold. This number is usually directly proportional to the area of the pixel.

Half Frame Mode - Half Frame Mode is used with the ST-4X to help eliminate streaking from bright objects during readout. Place the bright object (planets, moon, etc.) in the lower half of the frame. After the exposure is complete, the ST-4X will shift the image very quickly into the upper half of the frame. This allows the ST-4X time to digitize the half frame image without the bright object in the field of view corrupting the data.

Histogram - The Histogram is a table of the number of pixels having a given intensity for each of the possible pixel locations of the image file. Remember that, in the end, the image file is nothing more than a list of pixel values, one for each CCD pixel. These value numbers can be displayed in two formats; as a table or plotted as a graph.

Light Frame - The Light Frame is the image of an object before a Dark Frame has been subtracted.

Path/Filter - For DOS users the Path setting tells CCDOPS which directory and disk drive to find and store the image files. In essence, it defines the current directory. The filter controls which image files are shown in the Open directory. Only files that match the filter are shown. For example, a filter setting of "*.ST6" will only show files that have an "ST6" extension.

Photometry - Photometry is the study of stellar magnitudes at a given wavelength or bandpass.

Pixel Size - The smallest resolution element of a CCD camera is the CCD pixel. The pixel sizes for each of the SBIG cameras are as follows:

Camera	Pixel Size (microns)
ST-4X	13.75 x 16
ST-5/PixCel 255	10 x 10
ST-237/PixCel 237	7.4 x 7.4
ST-6	23 x 27[12]
ST-7/8	9 x 9

Planet Mode - Planet Mode is the most useful way to achieve focus. When you select Planet mode, a full frame is exposed, downloaded, and displayed on the computer monitor. A small window can be placed anywhere in the image area and the size of the window can be changed. Subsequent downloads will be of the area inside the box resulting in a much faster update rate.

Quantum Efficiency - Quantum Efficiency refers to the fractional number of electrons formed in the CCD pixel for a given number of photons. Quantum Efficiency is usually plotted as a function of wavelength.

Readout Noise - Readout noise is associated with errors generated by the actual interrogation and readout of each of the CCD pixels at the end of an exposure. This is the result of fixed pattern noise in the CCD, residual charge in the readout capacitors and to a small extent the noise from the A/D converter and preamplifier.

Readout Streaking - When a bright object is imaged using a short exposure time, readout streaking can occur. Readout streaking can look similar to blooming except it extends across the entire image passing through the bright object. This is a result of image shift at the beginning and again at the end of an exposure due to frame transfer in the case of the ST-5 and ST-6 and due to digitization in the ST-4X. The readout streaking is usually very faint with respect to the overall image and can sometimes be eliminated from the display image by slightly raising the background level.

Resolution Mode - The resolution of a CCD camera is determined by pixel size. Pixel size can be increased by combining or binning more than one pixel and displaying it as one pixel. Doing so decreases the effective resolution but speeds up the download time of the image. Maximum resolution is determined by the size of the individual CCD pixel.

Response Factor - Response Factor is a multiplier used by CCDOPS to calibrate CCDOPS to a given telescope for photometric calculations. The Response Factor multiplied by 1000 is the number of photoelectrons generated in the CCD for a 0th magnitude star per second per square inch of aperture. The standard value for the Response Factor is 2000 but will vary from camera to camera, night to night (as the atmospheric transparency changes), telescope to telescope (again transparency).

The best way to determine the proper setting is to take an image of a known star and then use the Crosshairs to measure the brightness. Adjust the displayed magnitude by pressing the "+" and "-" keys (or "shift +"/"shift -") which will adjust the image's Response Factor accordingly. Finally, copy the result from the Image Parameters dialog to the Telescope Setup for subsequent images.

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[12] The TC241 CCD used in the ST-6 actually has 11.5 x 27 micron pixels. The CPU combines two 11.5 micron pixels to make the 23 micron pixel . This give pixel with a more square aspect ratio.

Saturation - Saturation refers to the full well capacity of a CCD pixel as well as the maximum counts available in the A/D converter. The pixel is saturated when the number of electrons accumulated in the pixel reaches its full well capacity. The A/D is saturated when the input voltage exceeds the maximum. The saturation values for the various cameras are shown in the table below.

Camera	Full Well Capacity	Maximum A/D Counts	e$^-$/ADU[13]
ST-4X	150,000e$^-$	16,383	7.2
ST-5	50,000e$^-$	16,383	3.0
ST-6	400,000e$^-$	65,535	6.7
ST-7/8 *w ABG*	40,000e-	65,535[13]	2.3
ST-7/8 *wo ABG*	80,000e-	65,535[14]	2.3
PixCel 255	50,000e-	65,535[15]	2.0
PixCel 237	30,000e-	4095	4.2

Sky Background - The sky background illumination or brightness is the number of counts in the image in areas free of stars or nebulosity and is due to city lights and sky glow. High levels of sky background can increase the noise in images just like dark current. For some objects deep sky filters can be used to reduce the sky background level.

Seeing - Seeing refers to the steadiness and the clarity of the atmosphere during an observing session.

TE Cooler - The TE Cooler is a Thermal Electric cooling device used to cool the CCD down to operating temperature. The CCD is mounted to the TE Cooler which is mounted to a heat sink, usually the camera head housing.

TIFF Image File Format - The TIFF image file format (which stands for Tagged Interchange File Format) was developed jointly by Microsoft and Aldus Corporations to allow easy interchange of graphics images between programs in areas such as presentation and desktop publishing. CCDOPS can save image files in this format but it can not read them.

Track and Accumulate - The Track and Accumulate function is an patent pending feature of CCDOPS that allows the user to automatically co-register and co-add (including dark frame subtraction) a series of images of an object. These exposures can be taken unguided as long as the "Snapshot time" does not exceed the length of time before tracking errors of your clock drive become apparent. This allows you to image and track without guiding or the need to connect the CCD Relay port to your drive motors.

Track List - The Track List is an ASCII file generated by CCDOPS during a Track and Accumulate session. The Track List logs all the corrections made by CCDOPS for each of the images. Track lists are required when flat fielding Track and Accumulate images.

Tri-Color - Tri-Color refers to color images created using three different colors mixed into a balanced color image using red, green and blue filters. An object is imaged three times, once with each color filter. The three images are then co-added and color balanced with the appropriate software.

Vignetting - Vignetting is obstruction of the light paths by parts of the instrument. It results in an uneven illumination of the image plane. The effects of vignetting can be corrected using flat field images.

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[13] The e$^-$/ADU shown are for the High Resolution readout mode. These numbers can be different for other readout modes. Use the Camera Information command in the Camera menu to see the actual value for the other readout modes.

[14] While the A/D in the ST-7/8 saturates at 65,535 counts, the CCD saturates below that in the high resolution mode so don't expect to see pixel values all the way to the top in the high res mode.

[15] The PixCel 255 saturates at 32,767 counts in the high res mode (where the CCD saturates) and at 65,535 in the Low res mode.

A. Appendix A - SBIG File Formats

This section describes the file formats used to save SBIG images on both the IBM PC and compatible computers and the Macintosh computers. The files contain the image data as well as header information describing the image in terms of exposure time, telescope, etc. The files come in two varieties: Compressed and Uncompressed. In addition the file format has evolved throughout the development of these CCD cameras and has finally settled down to the "Type 3" format described herein.

Type 3 Format

The Type 3 format starts with a 2048 byte header of ASCII information followed by the image data in one of two varieties: Compressed or Uncompressed. The ASCII information for Type 3 files consists of a line showing the type of camera used to acquire the image and the variety of image data (Compressed or Uncompressed) as shown in the example below:

PixCel255 Compressed Image<lf><cr>
or
PixCel255 Image<lf><cr>

where <lf> and <cr> represent the linefeed (hex 0A) and carriage return (hex 0D) characters. Other camera images replace the "PixCel255" with the camera name ("ST-4X", ST-5", "ST-6", "ST-7" "ST-8", “PixCel237”) in the lines above respectively. After the 1st line are several lines of parameters in the format:

Parameter = Value<lf><cr>

where "Parameter = " is a string describing the parameter and "Value" is a string containing the value of the parameter. At the end of all the parameters is the line:

End<lf><cr><ctrl-z>

used to signify the end of the of the image information. The <ctrl-z> is used to tell DOS commands like type to stop and not display any further data. The remainder of the 2048 bytes in the header are unused. The parameters for a Type 3 file are shown below:

Appendix A - SBIG File Formats

Table 1

Type 3 Parameters

PixCel255 Compressed Image
File_version = 1
Data_version = 1
Exposure = xxx
Focal_length = xx.xxx
Aperture = xx.xxx
Response_factor = xx.xxx
Note = xxxxxxxx
Background = xxx
Range = xxx
Height = xxx
Width = xxx
Date = xx/xx/xx
Time = xx:xx:xx
Exposure_state = xx
Temperature = xx.xx
Number_exposures = xx
Each_exposure = xx
History = xxxxxx
Observer = xxxxxxxx
X_pixel_size = xx.xx
Y_pixel_size = xx.xx
Pedestal = xx
E_gain = x.xx

The following parameters are optional and may be present

User_1 = xxxxxxxx
User_2 = xxxxxxxx
User_3 = xxxxxxxx
User_4 = xxxxxxxx
Filter = xxxxxxxx
Readout_mode = xx
Track_time = xxx
Sat_level = xxx
End

Table 2

Parameter Descriptions

??? Compressed Image - This indicates the type of camera used to take the image and the fact that the data is compressed as described below. The ??? will be PixCel255, PixCel237, ST-4X, ST-5, ST-6, ST-7 or ST-8.

??? Image - This indicates the type of camera used to take the image and that the image data is not compressed and is saved as N rows of M pixels where N and M are specified by the Height and Width entries in the header. The pixels are two byte unsigned integers each with the least significant byte before the most significant byte. The pixels are written with pixel (1,1) first, proceeding in left-to-right order to pixel (1,M), followed by the subsequent N-1 rows of pixel data.

File_version - This field should be 3 to indicate the file is Type 3.

Data_version - This field describes the version of the image data and will be 1.

Exposure - This field indicates the exposure time in 1/100ths of a second.

Focal_length - This field indicates the focal length in inches of the telescope used to capture the image.

Aperture - This field indicates the aperture area in square-inches of the telescope used to capture the image.

Response_factor - This field specifies the CCD's response calibration factor.

Note - This field is the annotation attached to the image.

Background - This is the value of the Background parameter used to display the image when it was last saved.

Range - This is the value of the Range parameter used to display the image when it was last saved.

Height - This is the height of the image in pixels.

Width - This is the width of the image in pixels.

Date - This field shows the date the image was captured.

Time - This field shows the time the image was captured.

Exposure_state - This field contains sets of bits indicating whether ABG was active during the exposure, whether Double Correlated Sampling was used and whether DC Restore was used.

Temperature - This field indicates the temperature of the CCD in °C at the end of the exposure.

Number_exposures - This field indicates how many images were co-added to produce a composite image.

Each_exposure - For composite images this field indicates the exposure time of the individual exposures in 1/100ths of a second.

History - This is a string of characters indicating which image processing functions have peen performed on the image. The following is the mapping between individual characters in the string and the operation performed:

@ - Modifications made before history established.
A - Co-addition of image.
B - Image linearly scaled.
D - Image dark subtracted.
E - Cool pixels removed.
F - Flat field corrected.
G - Image smoothed.
H - Image sharpened.
I - Image pseudo flat field corrected.
J - Image quantized or posterized to less than 16 bits precision.
K - Warm pixels removed.
L - Image flipped horizontally.
M - Image flipped vertically.
N - Image zoomed with pixel interpolation.
O - More than 40 operations performed.
P - Image log scaled.
Q - Pixels combined.
R - Image auto dark subtracted.
S - Image zoomed with pixel replication.
T - Image clipped and filled (ST6COLOR)
U - Image converted to 8 bit log format (ST6COLOR).
V - Image merged to color using 2 color merge (ST6COLOR).
W - Image merged to color using 3 color merge (ST6COLOR).
X - Image translated and back filled (ST6COLOR)
Y - Image pixels inverted.
Z - Image sharpened with unipolar algorithm.
[- Image sharpened with one-sided sharpening.
\ - Image modernized by replacing ST6COLOR history characters[16]
] - Image resampled to make square pixels.
^ - Image averaged.
_ - Constant added to or subtracted from image.
` - Constant multiplied by or divided into image.
0 - (Zero) The history string is set to '0' for new images. This is not a C null string, it is actually the '0' character.
a - Image enlarged 2X by pixel interpolation.
b - Image reduced 2X by pixel combining.
c - Column or Row repair.
d - Adaptive dark subtraction.
e - Pseudo 3D
f - Auto pixel repair dark subtract.
g - HPR Subtract
h - Deconvolve

Please note the SBIG reserves the use of the characters '@' through '~' (decimal 64 through 126) for their use, and that any other characters added to the history string by other users should not use those characters.

Observer - This string contains the name of the observer who captured the image.

X_pixel_size - This field indicates the width in millimeters of the pixels in the image.

Y_pixel_size - This field indicates the height in millimeters of the pixels in the image.

Pedestal - This field indicates any pedestal (constant value) that has been subtracted from each pixel in the image.[17]

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[16] The ST6COLOR software used history codes 'S', 'T' and 'V' differently than described in this table. Modernizing replaces 'S' with 'T' (clip operation), 'T' with 'U' (compress operation) and 'U' with 'X' (translate operation).

[17] All image pixels have a bias of 100 counts added to them to stop underflow due to noise. If you need to flat field correct an image the pixel value that is due to light is:

E_gain - This field gives the conversion factor between pixel values and electrons of charge in the CCD. The units are e^-/count.

The following fields are optional. They may or may not be present. in the header As the CCDOPS software has evolved these fields have been added to the header. a few at a time If present they will be in the order shown.

User_1 through User_4 - These fields are for the use of non-SBIG software packages and can be up to 64 characters in length each, terminated with the <lf><cr> characters. SBIG software will ignore and preserve the settings of these 4 user parameters when reading and writing files. Either all 4 should be present or none of them should be present. If present and any one of them is blank then a single dash character ("-") should be written before the <lf><cr> characters. Finally, SBIG uses the User_1 filed to indicate the version of CCDOPS software used to capture the image.

Filter - This field is a 10 character text string indicating the name of the optical filter used when taking the image.

Readout_mode - This field indicates the readout mode the CCD camera's internal firmware utilized in capturing the image.

Track_time - This field, when non-zero, indicates the exposure used for the Tracking CCD in Self-Guided images.

Sat_level - This field indicates the maximum level you should expect in the pixel data. The ST-4X and ST-5 are 14 bit cameras for example and this setting will be 16383. Note that this level can increase as images are co-added or with Track and Accumulate images.

Image Compression

Type 3 images can be saved using a simple form of image compression. The image compression consists of saving the differences between adjacent pixels and using single bytes for small differences rather than double bytes.

Each line of compressed image data starts with a two-byte integer (least significant byte first) indicating the compressed length of the line in bytes followed by the compressed image data. The 1st pixel of the actual image data is written using two-bytes and is the actual pixel value. Subsequent pixels are written as follows depending on the difference between that pixel and the previous pixel (= pixel (m,n) - pixel (m, n-1)):

> If -127 127 then write as a single byte in 2's complement format, otherwise write hex 80 (-128) followed by the actual pixel value using two-bytes (least significant byte first).

The last caveat to the compressed image data is that if any line after being compressed has as many or more bytes than if it were stored uncompressed then that line is stored uncompressed with the 2 bytes of length followed by the actual pixel values written using 2-bytes per pixel (least significant byte first).

Note also that the compression algorithm described above used in saving images is similar though different than the compression algorithm used in downloading images from the CPU. You can not simply read a compressed image from the CPU and write it to file, adding a header. You must the CPU data and then compress the file data. This unfortunate consequence stems from the desire to have the CPU compression occur on the fly to keep the image throughput up.

Actual Counts = Image Counts - 100 + Pedestal

where Image Counts is what is read from the file and Actual Counts is the light response. For flat field correcting images you would multiply the Actual Counts by the flat field correction, not the Image Counts.

A.2. PC Color Table Formats

The PC version of CCDOPS software supports the use of user generated color tables with EGA, VGA, MCGA, and Super VGA video graphics adapters. These color tables are loaded with a command in the Display menu and apply in the Photo display mode.

The Data Buffer box of the Status Window contains a Color Table field to the right which has space for loading one color table for each of the supported graphics display adapters. For example, if VGA and Super VGA color tables were loaded, the Color Table field would say "--VX". The dashes indicate no EGA or MCGA tables are currently loaded, where as VGA and Super VGA (XVGA) are loaded.

The Color Table files share a common format, and are ordinary text files to facilitate easy creation and modification by the user. Color Table files are stored in the same directory as the CCDOPS software and have a .TBL extension. The first line of a Color Table file indicates the file is a color table and is as follows:

"CCDOPS Color Table"

The second line indicates the intended graphics display adapter and will be either "EGA", "MCGA", "VGA" or "XVGA". The third line is a number indicating the number of color entries contained in the Color Table file. Table B1 below shows the maximum allowed number of color table entries for a given display mode.

Display Mode	Maximum Colors
EGA	16
MCGA	256
VGA	16
XVGA	256

Table B1 - Display Mode Colors

After the third line are N lines of color table entries where N is the number contained on the third line. The format of the color table entries is different for the various display adapters and is described individually below:

EGA - Each color table entry is a single number from 0 through 63. 0 is black, 63 is bright white. A maximum of 63 represents 6 bits of color (bits b0 through b5). The representation of color in this format is as follows: The 6 bits are broken down into two 3-bit fields occupying bits b0-b2 and b3-b5. Bits b0, b1 and b2 represent high intensity (bright) shades of Blue, Green and Red respectively. Bits b3, b4 and b5 represent low intensity (dim) shades of Blue, Green and Red respectively.

Others - Each color table entry is a series of three numbers, from 0 to 63 each, separated by a space. The three numbers in order from left to right on the line represent the Red, Green and Blue intensities. "0 0 0" represents black and "63 63 63" represents white.

Finally, the last line of the Color Table file is "End" to signify the end of the file.

A.3. TIFF Format

The TIFF format (which stands for Tagged Interchange File Format) was developed jointly by Microsoft and Aldus Corporations to allow easy interchange of graphics images between programs in areas such as presentation and desktop publishing. The TIFF format is described in "Tag Image File Format, Revision 5.0, FINAL" by Aldus Corporation, Seattle, Washington.

A.4. FITS Format

The FITS format (which stands for Flexible Image Transport System) is a common format supported by professional astronomical image processing programs such as IRAF and PC Vista. The format of FITS images is described in "Implementation of the Flexible Image Transport System (FITS)" published by NOST, NASA/OSSA Office of Standards and Technology, NASA Goddard Space Flight Center, Greenbelt, MD.

B. Appendix B - Astrometry and Photometry

Using the crosshair mode[18] enables examination of images on a pixel by pixel basis for such measurements as Stellar and Diffuse Magnitude, and measurement of stellar positions. The 14 to 16 bit accuracy of SBIG cameras produces beautiful low-noise images and allows very accurate brightness measurements to be made. With appropriate filters stellar temperature can be measured.

B.1. Astrometric Measurements.

The CCDOPS software allows measuring separations between objects in the field of view of an image. Essentially, these measurements involve the user specifying telescope focal length and two points in the image and the software calculating the separation in arcseconds (1 arcsecond = $\frac{1}{3600}$ of a degree). The details of this process follow.

You can specify each of the two points using two methods or algorithms: 1) A point can be selected to be a pixel coordinate in the image; or 2) A point can be calculated by the software to be the centroid or "center of light" of the area near a pixel in the image. The latter works well when measuring separations involving stellar objects, the former should be used in all other cases.

The crosshairs mode of the operating software is used to make the astrometric measurements. Setting the positions of the two points is a five step process: 1) A determination of the background level is made, 2) The cursor is moved to the first point, 3) The position of the first point is recorded and the separation measurement zeroed, 4) The cursor is moved to the second point, 5) The separation is calculated and displayed. These steps are discussed in detail below:

1) If neither of the two points is stellar and measurements from pixel to pixel in the image are desired then you can skip ahead to step 2. If however you want the software to more accurately measure distances based upon stellar objects, then you must let the software know what the background level is. Move the cursor to an area of sky free of stars and nebulosity and hit the 'B' key (for background).

2) Move the cursor to the desired location of the first point using the arrow keys or mouse. If the first location is a star, then position the cursor near the center of the star.

3) If the first point is not a star and you desire to zero the separation on a pixel, then hit the 'S' key (for set position) to set the position of the first point to the pixel coordinate of the crosshair. If however the first object is a star and you wish to zero the separation on the optical center of the star, then hit the 'C' key (for centroid) and the computer will calculate the centroid of the star under the crosshair and zero the separation measurement at that centroid position. The advantage of using the centroid is that the zero position can be set between pixels resulting in a more accurate measurement.

4) Move the cursor to the desired location of the second point. Each time the cursor is moved, the separation between the 1st point and the current pixel coordinate of the cursor is calculated and displayed.

5) If the second point is not a star then you're done. The separation shown is the separation between the 1st point and the current pixel coordinate of the cursor in seconds of arc. If however the second point is a star and you wish to set the 2nd point to the centroid of the star, then position the cursor near the center of the star and hit the 'P' key (for position). The computer will calculate the centroid of the area under the cursor and use that centroid location for calculating and displaying the separation. You will have to hit the 'P' key each time you move the cursor to a new location because as soon as you move the cursor, the 2nd point is set to the pixel coordinate of the cursor and no new centroid is calculated. Finally note that in both cases, you can make several separation measurements between the 1st point and the different 2nd points without having to re-set the position of the 1st point.

How does the computer calculate the separation, you ask? The separation calculations are discussed in detail at the end of this section but in general, the software does this by measuring the physical separation of the two points in the image and dividing by the focal length of the telescope. For this reason, accurate astrometric measurements depend on the correct setting of the focal length parameter in the Edit Parameters command. This parameter, which is copied from the Telescope Setup command, should be set to the focal length of the telescope in inches.

---

[18] The Crosshairs mode is accessed through the Display Image command in the Analysis mode.

An object with a known separation, such as a wide double star, can be used to accurately determine the focal length as follows:

1) Set your focal length parameter in the Telescope Setup command approximately correct. For example if you have an 8-inch f/10 telescope, the approximate focal length is 80 inches.
2) Take an image of the known object and measure the separation.
3) Finally adjust the focal length parameter in both the Edit Parameters command and the Telescope Setup command accordingly. For example if the measured separation is 10% lower than the actual value, then you should lower the focal length parameter by 10%.

B.2. Photometric Measurements.

The CCDOPS software also lets you make photometric measurements of objects in the field of view. These measurements include stellar magnitude and surface brightness (Diffuse Magnitude). Stellar magnitude measures the total energy in an object . Surface brightness calculates the total energy per unit of area.

These measurements are made in the crosshairs mode and involve three steps: 1) A determination of the sky background is made to zero the calculations, 2) The crosshair is positioned on the star or portion of nebulosity, and 3) An appropriate box-size is determined for accurately measuring the magnitude. These three steps are detailed below:

1) Move the cursor to an area that is representative of the background surrounding the object you wish to measure. For example, if you're trying to determine the magnitude of a star buried in nebulosity, you would select a background area with roughly the same brightness as the nebulosity surrounding the star. If you are trying to measure the surface brightness of a galaxy, then pick a location out in the sky background free of stars and nebulosity. Once the cursor is positioned, hit the 'B' key (for background) to calibrate the magnitude measurements based upon the background level.
2) Position the crosshair over the object of interest. For stellar objects get the crosshair close to the center of the star. For nebular objects place the crosshair over the region of interest.
3) The size of the box used to measure the magnitude is toggled through using the 'T' key (for toggle box size). For stellar objects the box size should be big enough to include all the light from the star but small enough to exclude other objects from the calculations. As you increase the size of the box from 3x3, you will see the calculated magnitude decrease (stellar brightness increase) and plateau out as the box size includes all the star's light. For nebular objects, set the size of the box large enough to get the desired smoothing effects of larger numbers of pixels but small enough to be able to measure any desired spatial variations in the surface brightness.

Accurate measurements of photometric quantities requires attention to several items. First, the CCD's spectral response means it measures light from 4000Å through 9000Å with varying efficiencies. In general the CCD's response peaks near 6750Å and is roughly 50% (relative to the peak) at 4500Å and 7500Å. Using the CCD without any optical bandwidth filters is roughly equivalent to measuring photographic magnitudes. Second, the software needs to know the aperture area of the telescope. Larger apertures capture more light. This is set in the Telescope Setup command for images to be taken in the future and in the Edit Parameters command for existing images. This aperture area should be the clear aperture area with any obstruction subtracted. The software also depends on a response or calibration factor to convert pixel counts to magnitudes. This parameter is in both the Camera Setup and Edit Parameters commands. The approximate value for SBIG cameras is 2000. The reason we say "approximate" is that the calibration parameter is adjusted to calibrate the magnitude to that of a known star or object. Reasons for the variation include transparencies of optical elements in the telescope, transmission of the atmosphere and manufacturing variations from camera to camera. All this aside, the method you use to determine the correct setting of the CCD response factor is as follows:

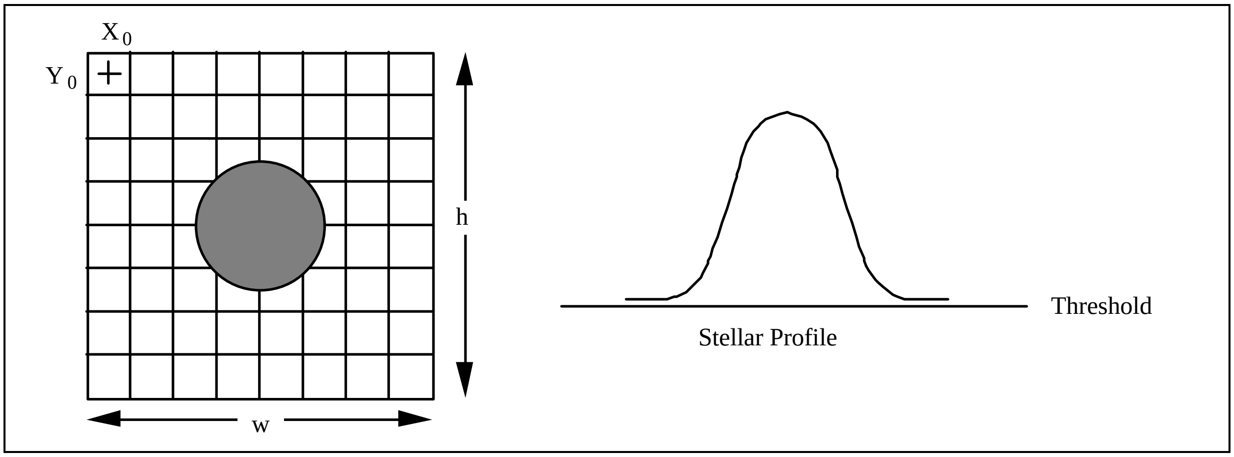
1) Select an object in the field of view for which you know the magnitude or take an image of a known object. The former is preferable because it takes into account any variations in atmospheric transmission as a function of altitude in the sky which can be quite substantial. Objects at the zenith go through less air than objects near the horizon.
2) Make a background setting as described in the steps above.

3) Position the cursor over the known object and select the box size as described above. If the magnitude shown is incorrect, use the '+' and '-' keys to adjust the calculated magnitude. Each press of the '+' and '-' keys adjusts the magnitude by 0.1 or 0.01 depending on whether the Shift key is held down.
4) When the calculated magnitude is correct, note the settings of the response factor parameter in the Edit Parameters command and copy it to the settings in the Camera Setup command so it will be used in future images[19].

If you're interested in the nuts and bolts of the photometric calculations, read on. They're described in full detail below.

B.3. Calculation of Centroids

The centroid calculation is directly analogous to a center-of-mass calculation for an object if you represent the local mass density with the pixel intensity values and allow a discrimination level at the average background level. This is shown in the following figures and formulas:



$$Threshold = \frac{\sum_{i=0}^{w-1}\sum_{j=0}^{h-1} P(i,j)}{h \times w}$$

where in the formula above *P(i,j)* represents the intensity value of the pixel at x=X_0+i, y=Y_0+j. Also the *Threshold* value which will be used as a discrimination level in the centroid calculation is taken over the background area and represents the average pixel level in the background area.

$$Xcentroid = X_0 + \frac{\sum_{i=0}^{w-1}\sum_{j=0}^{h-1} i \times (P(i,j) - Threshold)}{\sum_{i=0}^{w-1}\sum_{j=0}^{h-1} P(i,j) - Threshold}$$

$$Ycentroid = Y_0 + \frac{\sum_{i=0}^{w-1}\sum_{j=0}^{h-1} j \times (P(i,j) - Threshold)}{\sum_{i=0}^{w-1}\sum_{j=0}^{h-1} P(i,j) - Threshold}$$

---

[19] The star's spectral class can produce ±0.5 magnitude errors in this determination. For the greatest accuracy calibrate the response factor on a star with a similar spectral class.

where in the formulas above should the quantity *P(i,j) - Threshold* be less than zero, zero is substituted on a pixel-by-pixel basis.

B.4. Calculation of Separation

The angular separation between two points on the image is determined by calculating the corresponding physical separation between the points on the CCD and dividing by the focal length, keeping track of the units[20]:

$$Separation = \frac{3600 \times 180}{p} \times \frac{\sqrt{(\Delta x \times 0.01)^2 + (\Delta y \times 0.01)^2}}{25.4 \times fl}$$

where *Separation* is in seconds of arc, x and y are the x and y separations between the two points in pixels and fl is the focal length of the telescope in inches.

B.5. Calculation of Magnitude

The magnitude calculation involves calculating the total energy in a star, subtracting the background, correcting for the exposure time, aperture area and CCD response factor and taking a scaled logarithm. The calculation is broken down into several steps below:

$$L = \sum_i \sum_j P(i, j)$$

$$B = \sum_i \sum_j P(i, j)$$

where *L* and *B* are the sum of all pixel values in the box centered on the star and background areas respectively.

$$Magnitude = -2.5 \times \log_{10}\left(\frac{L - B}{A \times C \times T}\right)$$

where *A* is the aperture area in square inches, *C* is the magnitude calibration factor and *T* is the exposure duration in seconds. Note that the units of *C* are counts per second per square inch of aperture for a 0th magnitude star. C is proportional to the CCD's response factor from the Camera Setup command. You can calculate C from the CCD's Response factor (R) using the formula below:

$$C = \frac{1000 \times R}{e^- \,/\, AD \;\; Count}$$

B.6. Calculation of Diffuse Magnitude

Diffuse Magnitude is the magnitude per square arcsecond of subtended area. The calculation uses the Magnitude calculated above and the area of the box as shown below[21]:

$$BoxArea = \left(\frac{3600 \times 180}{p}\right)^2 \times \left(\frac{BoxSize^2 \times 0.01 \times 0.01}{(fl \times 25.4)^2}\right)$$

---

[20] The pixel sizes shown are for an ST-5 in the High Resolution readout mode (0.01 x 0.01 millimeters). For the other cameras or readout modes substitute the appropriate X and Y pixel sizes. This information is shown in the Image Parameters command.

[21] Refer to the previous footnote.

where *BoxArea* is the area of the box over which the Diffuse Magnitude is calculated in square arcseconds, *BoxSize* is the size of the box in pixels and *fl* is the focal length of the telescope in inches. Finally:

$$DiffuseMagnitude = \frac{Magnitude}{BoxArea}$$

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