CFW-9
Color Filter Wheel
Manual

SBIG - Santa Barbara Instrument Group

CFW-9 Manual
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The CFW-9 Color Filter Wheel

INTRODUCTION

This manual describes Santa Barbara Instrument Group's CFW-9 Color Filter Wheel. This product can be used with CCDOPS, CCDSoftV5, and other software to facilitate taking and processing of color images with USB versions of the ST-7/8/9/10/2000 cameras. This list may be expanded as we add new models. Many third party software packages also support SBIG products.

The Color Filter Wheel is an accessory that mounts on the front of the camera. The filter wheel has five filter positions, typically for Red, Green, Blue, and Clear Filters, plus 1 Clear Aperture position for additional filters of your choice. "Primary" color images are taken through the Red, Green and Blue Filters and the Clear Filter allows ordinary observing without having to refocus.

Overview of Taking and Processing RGB Color Images

This section provides an overview of the steps necessary, both at the telescope and in front of the computer, to take and process tri-color images.

Telescope Work

At the telescope you use camera control software such as CCDOPS to take sets of three images for each object. The images represent the Red, Green and Blue primary colors (For LRGB imaging an additional grayscale image is captured. This technique is discussed elsewhere). Take these images as you would for monochromatic images except use the filter wheel to select each of the three primary spectral bands.

You can take equal duration exposures in the Red, Green, or Blue or match the exposure duration of each primary image to the brightness of the object. Typical ratios of Red : Green : Blue are 1 : 1 : 1.6 to match the exposure to the CCD's sensitivity using SBIG Filters, although accurate color balance should be done for your system with neutral gray objects or "white" G5 type stars.

Each of these images should be dark subtracted[1] and should be saved with a name that indicates the color of the filter (e.g., M51R, M51G, M51B). Note, however, that different software programs may handle tri-color files differently and the naming convention you use is dictated by your software. If you are using a fast system (low F

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[1]   You may also want to use the other image enhancement features of CCDOPS such as removing cool pixels. In general the three image set should be made to look their best prior to merging the RGB image.

number) and your images show signs of vignetting (such as a variation in the sky background level) then you should also take flat field images and flat field correct your primary images using CCDOPS. Whether you need to take different flat field images for each primary color or not will depend on how different the vignetting pattern is for the different primary images. Typically a single flat field image will suffice.

Color Image Processing

A complete description of color processing is beyond the scope of this manual. A complete description and step-by-step instructions may be found in the CCDSoftV5 manual. Different software packages may handle the combining differently, but in general, you register or co-align the primary color images. You select the Red image from the set of three primary images you want to register and the software then loads and displays it. In that image you select a reference star (or pixel) and this reference star (or pixel) is used to register the Red, Green and Blue images to one another. Once the images have been registered, they are merged together to form a tri-color image and minor adjustments are made to achieve color balance.

Third party software packages such as Maxim DL and Adobe Photoshop are popular programs for combining the three primary images. While these packages tend to be expensive, often times you can find last year's versions at a sharp discount and they really are powerful image processing packages producing the most professional results.

Hardware Reference

This section describes the *CFW-9* Color Filter Wheel accessory for the ST-7/8/9/10/2000 USB cameras. It includes instructions on how to install and operate the filter wheel.

## *Attaching to the CCD Camera*

The *CFW-9* is installed onto the camera and sits between the Camera Head and the Telescope.
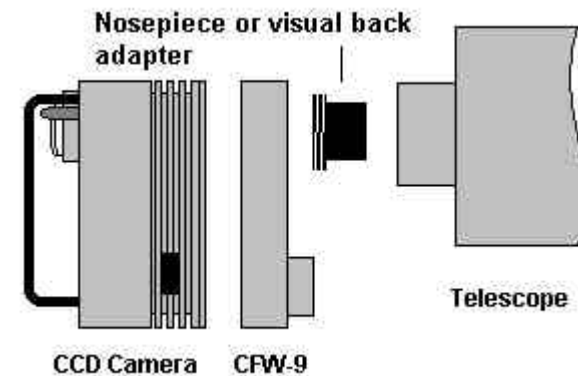

The filter wheel contains a magazine with five filter positions capable of holding standard threaded 1.25 inch eyepiece filters. SBIG provides optional filters for use with the *CFW-9*. The filter wheel attaches to other accessories through the universal T-Thread. The front and back of the *CFW-9* have apertures with female T-threads. Using T-Thread makes the *CFW-9* adaptable to a variety of telescopes. You can attach a 1.25 inch or 2 inch nosepiece into the front or you can attach an adapter that mates directly to the back of SCTs, replacing the standard Visual Back.

A permanent mounting of the *CFW-9* to the ST-7/8/9/10/2000 cameras is accomplished by attaching the CFW-9 directly to the face plate of the camera by the following procedure:

1. Remove the ST-7/8/9/10/2000's T-Thread mount held in place with 4 phillips head screws and set the screws aside. [The T-Thread mount is where the nose piece screws into the camera head. It is a block approximately ¼" thick and shaped like the letter "D" attached to the face plate of the camera. It has three set screws holding an internal ring that has female T-Threads].
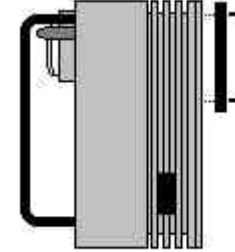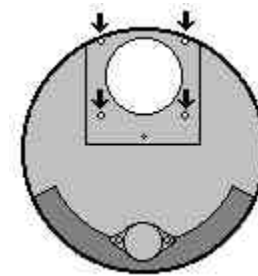

2. Remove the cover of the *CFW-9* and pull the filter magazine out of the housing.
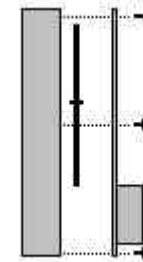
3. Remove the four rubber hole plugs from the rear of the *CFW-9* by pushing them through the housing with a small allen tool. Save

these in case you decide to later use the *CFW-9* with the T-Thread coupler or with a different camera.

4. Using the four 4-40 by 3/16 socket screws provided, attach the *CFW-9* cover to the front of the ST-7/8/9/10/2000. Make sure you use the provided screws whose length of 3/16 is required to thread into the ST-7/8/9/10/2000 front plate without breaking through the blind taps. Then re-assemble the carousel and housing.
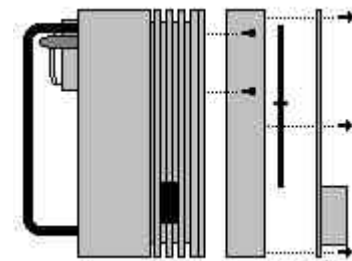
Making the Electrical Connection

The *CFW-9* has a cable that comes out the side that needs to connect to your camera electronics. The *CFW-9* gets it power and positioning information from the camera thru this connector. This cable plugs into the I2C-AUX port on the ST-7/8/9/10/2000 USB camera. **Note: This is different from the earlier CFW8A which used the AO/CFW/SCOPE port on both parallel port cameras and USB cameras. You cannot use the CFW9 with our earlier parallel port cameras.**
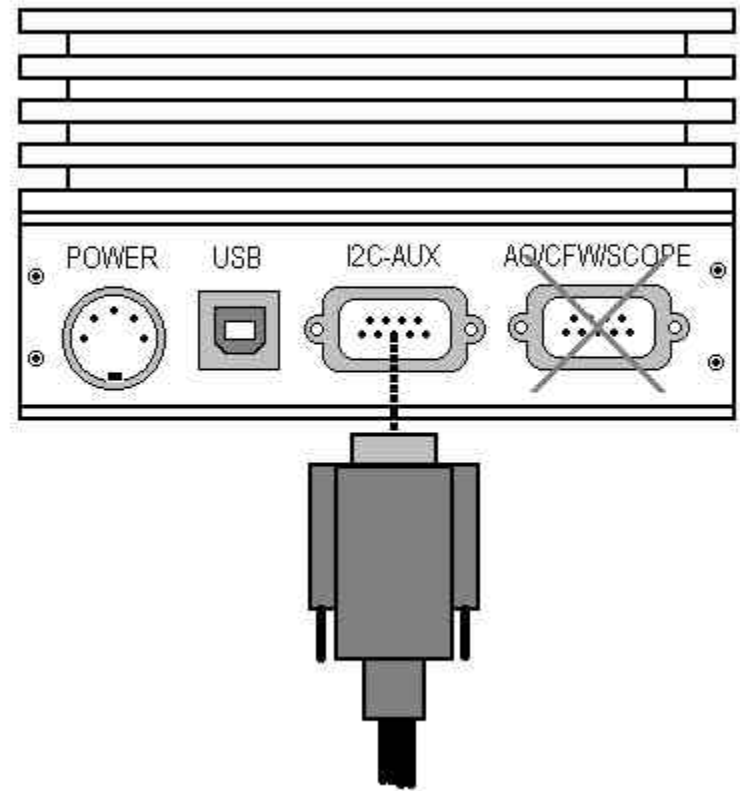
Attaching to the Telescope

At the front of the *CFW-9* you can attach any T-Thread based adapter that will connect to your telescope, including the nosepiece from your camera. When using a nosepiece to slip the camera and filter wheel assembly into an eyepiece holder, you need to pay careful attention to insure the weight of the filter wheel with the camera attached is held in place with the eyepiece holder's retaining screws.

SBIG also sells an optional T-Thread Visual Back Adapter which screws directly onto the back end of the popular Schmidt-Cassegrain telescopes. This makes for a very rigid mounting.

After attaching the camera/filter wheel combination to the telescope, you should then drape the Camera's head cable over the fork of the telescope and clip it in place so that the cable doesn't drag on the ground as the telescope rotates. Also avoid hanging the camera head and filter wheel by the cables as this could overly strain the cables.

Positioning the Filter Wheel

The motorized *CFW-9* filter wheel is positioned using commands in the CCDOPS software's Filter menu. The unit does not require calibration like older models and is auto-homing at power-up.

You need to tell the CCDOPS software that you are using the *CFW-9* and this is accomplished by selecting the *CFW-9* as the filter wheel type in the Setup command of the Filter menu. If you have an older version of CCDOPS that does not show the *CFW-9* you should update your software and drivers by downloading the latest version of CCDOPS and Driver Checker Utility from the SBIG web site.

There are individual commands in the Filter menu with hot keys for positioning the filter wheel. Also the Camera Status window shows which filter is currently in position, and this information is recorded with images when they are captured. You can rename the filters using the Filter Setup command.

If you have removed the filter wheel from your camera or removed the filter from the magazine you can select the None command in the Filter menu. The None command doesn't position the filter wheel, it just tells the software that you aren't using a filter at the moment. If you run without filters for a period of time you should use the Filter Setup command to select the "None" type of filter wheel.

Use the Setup command in the Filter menu to tell the CCDOPS software which filter position contains which filter. You do not have to follow the default RGB positions.

Vignetting

The increased length of the filter wheel assembly will cause vignetting for fast systems (those with low F numbers such as F/3.3). The vignetting will be worse for the larger ST-8, ST-9, ST-10 with their relatively large CCDs versus the ST-7. Vignetting will show up as a fall off in the sky background at the edges of the field of view. Flat fielding greatly reduces the troublesome effects of vignetting.

If a nosepiece is used to attach the camera and filter wheel combination to the telescope, the 2" nosepiece should be used if possible. SCT users should use the optional T-thread Visual Back to make a more secure attachment.

Selection of Color Filters

SBIG color filters include an infrared blocking coating so that a separate IR blocking filter is not needed.   The filters used in the SBIG filter wheel have been chosen to optimize the accuracy of the colors produced by the tri-color software. The passbands of each filter are summarized in the table below:

Color Filter Passbands

Filter	Passband (nm)
Red	612-670
Green	488-574
Blue	392-508

The filters are custom filters designed specifically for SBIG cameras.   Dichroic filters were chosen over absorption filters for three reasons.   First of all, they have high transmission in the passband region. Second, a sharp transition can be obtained in the region around 496 nm. And last, they are all deposited on a sheet of glass of the same thickness, eliminating focus shifts due to varying filter thickness.   An infrared blocking coating is applied to these filters to eliminate spectral leaks in the infrared where the CCD has high sensitivity.   These bands would be severely contaminated if these leaks were not blocked. Colored plastic filters also have severe red leaks beyond the visible spectral range, so one should particularly avoid those.

The sharp transition between the blue and green region is necessary for proper color rendition of emission sources. The 500 nm oxygen line is blue-green in color, and so must pass through both blue and green filters. The hydrogen-beta line at 486 nm is very blue, and must be rejected by the green filter. The green filter will pass less than 10% of this line.

Hints for the User

Be aware that color imaging is substantially more difficult than using the CCD unfiltered. Whereas before, you only needed to take one image you now need to take three, and each one needs to be about 4 times as long since only a portion of the total spectral range is passed by each filter. This aggravates tracking problems, which are also more pronounced due to the requirement of registering three images. Hot pixels and cosmic ray hits are more objectionable since they become strongly colored in the final image (the hot pixel remove utility in CCDOPS should be used). In spite of all this, you will find that even subtle colors present in galactic scenes enhance the image noticeably, and emission nebulas take on beautiful hues of blue, blue-green and red. Star colors are dramatically enhanced, and impart a three dimensional aspect to the image.

We have endeavored to create a product that enables true color pictures of deep sky objects to be produced. We have made certain philosophical decisions with which some may disagree.   For example, if we traveled in space to where we were quite close to the Dumbbell Nebula it would appear to be a large gray mass devoid of color, buried in mostly white stars. If we traveled to other galaxies they would be no brighter, in general, than our Milky Way. Many extended objects, such as the Horsehead Nebula, have very low contrast relative to the sky background, often less than 10%, and would never stand out sharply. The images you see on the computer screen are not true, in the general sense, being considerably enhanced in brightness and contrast over the actual object. We have carried this philosophy to the way our program displays star images; stars saturate to the proper color, not white. Your eye would see them differently but less accurately! We find the result very pleasing, but please give us your impression.

Maintenance of the Color Filter Wheel

The surface of the filters may be safely cleaned with Isopropyl or Methyl alcohol and cotton swabs. Use a gentle circular motion, using several swabs until the surface is clean. The machined parts may be cleaned by rubbing with a soft cloth. A small amount of lubricant can be applied to the magazine axle should the unit start to chatter but please do so sparingly. It really is a light duty interface. If some part of the *CFW-8A* assembly is damaged, replacement parts may be obtained from Santa Barbara Instrument Group.

Disassembly of the *CFW-9* is rather straight-forward. You can remove the front cover by removing the six screws that hold it in place. Once removed, the front cover comes completely free of the *CFW-9* allowing access to the filter magazine.

The filter magazine can be removed by lifting the magazine straight-up out of the back housing by one-quarter inch then tilting away from the motor and removed completely from the housing. Upon inspection you will notice that the filter magazine has a top and a bottom. The filters screw in from the bottom and the top has the optical alignment pins.
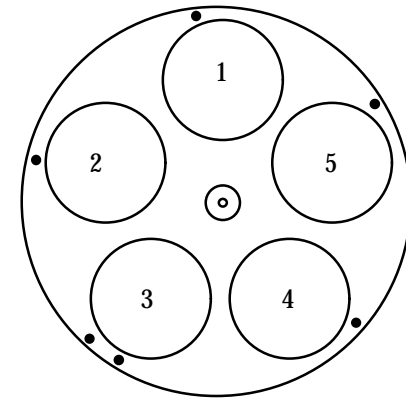
As viewed from the top the filter positions are shown in the figure above, noting the position of the double-pinned position adjacent to position 3.

The filter wheel is reassembled in the reverse process. Rotate the filter magazine so that the alignment pins straddle to either side of the motor then tilt the magazine into place and drop it into the back of the housing. Be careful to not bend the axle in the process and also make sure the magazine is inserted with the filters down towards the camera) and the alignment pins up.

The filter wheel will be held in place against the motor and can be leveled to make installing the front cover easier. Though it should not be necessary to do so you may loosen the two screws that hold the motor in place. If you do so you'll need to remove the motor cover from the font cover so that you can readjust the tension of the motor against the magazine. Adjust the tension till the magazine does not rotate freely but not so tight as to put strain on the motor that would be accompanied by irregular movement of the magazine or soft "clicking" sounds. You do not need to worry about the angular orientation of the magazine as the unit will auto home itself upon power-up.