



Operating Manual  
Supplement  
for  
Model ST-4000XCM

Santa Barbara Instrument Group  
147A Castilian Drive  
Santa Barbara, CA 93117 USA  
Phone (805) 571-7244 Fax (805) 571-1147  
Web: [www.sbig.com](http://www.sbig.com) E-mail: [sbig@sbig.com](mailto:sbig@sbig.com)

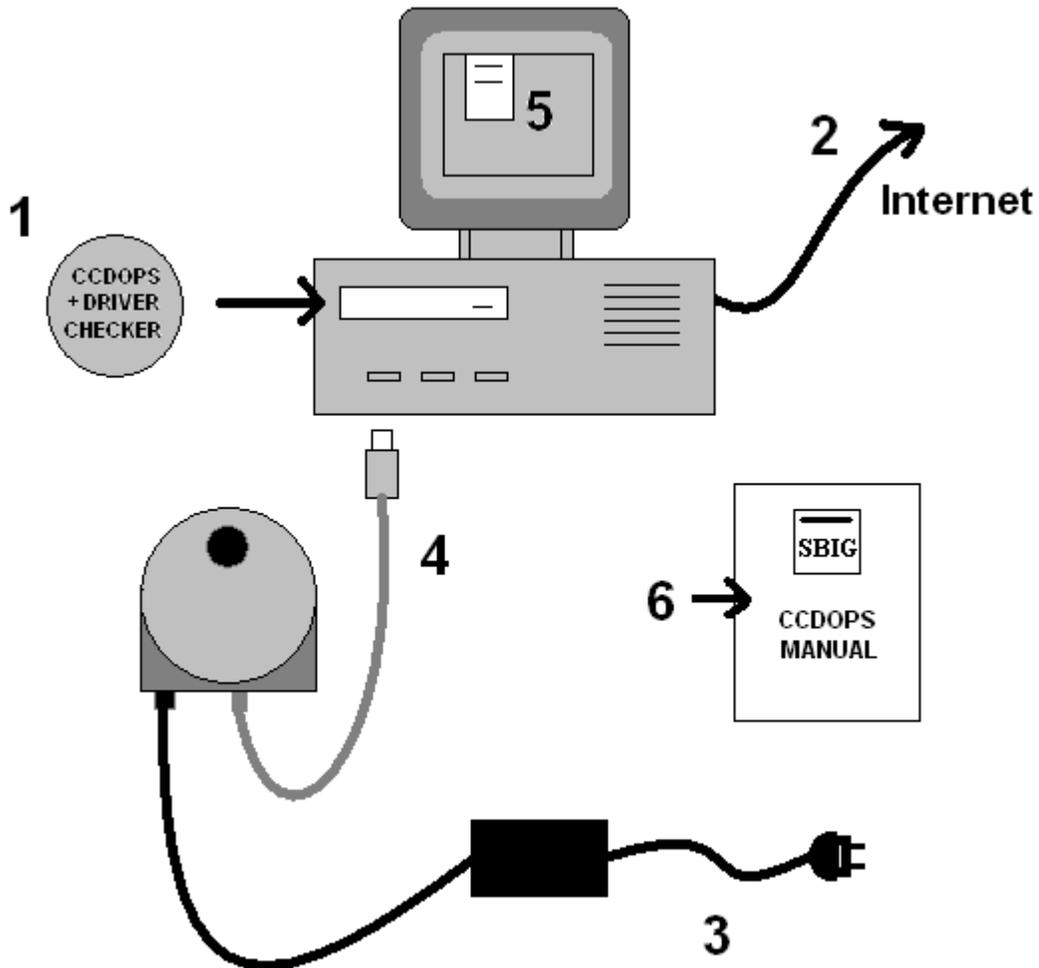
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## Quick Setup Guide

**Note: You must install the software and drivers BEFORE connecting the camera to your computer**

1. Install CCDOPS and Driver Checker on your computer
2. Connect to the Internet and Run Driver Checker
3. Connect power cable to the camera and 110 - 220VAC (Green LED = On)
4. Connect the USB cable between your camera and computer
5. In the CCDOPS Camera Menu go to Camera-> Setup -> Temperature Regulation -> Active and set the temperature - there will be a pause while the software establishes a COMM link to the camera
6. Refer to the CCDOPS manual and this Supplement for taking and processing Single-Shot Color images.



## **Limited Edition ST-4000XCM**

The ST-4000XCM camera is essentially the same as the ST-2000XCM camera with the exception of the size of the imaging CCD and a few items explained in this supplement below. However, insofar as instructions for use, please follow the instructions for the ST-2000XCM in the Camera Operating Manual and CCDOPS Software Manual.

### **Software**

CCDOPS version 5.47 or later supports the ST-4000XCM camera. This version is supplied on the CDROM packed with the camera. You can also download the latest version of the drivers from our web site -> Software Downloads -> 32 bit Windows. If you are using CCDSoftV5, Maxim or other software that normally supports SBIG cameras, please confirm with the vendor that your version supports the new ST-4000XCM camera with our latest universal drivers.

### **CCD Chamber Window**

Please note that this camera has a larger CCD chamber window than the ST-2000XCM to allow for the larger CCD and tracking CCD. This window is custom made for the ST-4000XCM camera with optical glass that is AR coated and UV/IR blocked to optimum color balance. No external blocking filter is required when taking single shot color images with the ST-4000XCM.

### **Dark Frames**

The shutter on all ST cameras is intended to make taking dark frames at night at the scope automatic. However the shutters can pass some light in a bright ambient environment. Therefore, if you take dark frames with the camera off the telescope in room light or in daylight you should cover the nosepiece with the supplied rubber cap

### **Filter Wheel**

Normally this size CCD is found in the STL camera body with 2" filters. However, because it is a special edition of the ST series, our standard 1.25" filter wheels are too small for this camera and we do not recommend 1.25" filters for this sized CCD. In general, however, there is no need to add a filter wheel to a single-shot color camera.

### **AO-8 and Remote Guide Head**

The AO-8 Adaptive Optics and Remote Guide Head accessories are compatible with the ST-4000XCM camera.

### **Individual Filters**

In the event that you wish to use an individual filter, such as an H-alpha filter, you should use one that is in a cell with 48mm threads that will screw into the internal threads in the camera's supplied 2" nosepiece.

## **Camera Lens**

To use a 35mm camera lens with the ST-4000XCM camera, an optional CLA-7 camera lens adapter is available from SBIG for Nikon and Canon FD lenses. Please note the Canon adapter is for manual focus FD lenses only.

## **Image Rotation**

The KAI-4020CM CCD is unique among the Kodak CCDs in that pixel 1,1 is in a different corner relative to the rows of pins than other CCDs we use in ST cameras. This means that (normally) the image is rotated 90 degrees relative to the tracking CCD compared to other SBIG cameras. To avoid confusion, with the release of the ST-4000XCM camera, CCDOPS has been revised to automatically rotate raw images from the ST-4000XCM so that they are oriented the same way as all other SBIG cameras. This feature is software specific, however, and you should be aware that not all software packages may treat the image the same way as CCDOPS. Maxim is known to have a feature that will rotate the image. Please check with your other software vendors to see if they have a similar feature. You can still use any software that supports the ST-4000XCM, but just be aware that they may provide a different orientation of the image.

Because the image is rotated to present the tracking CCD at the top center of the image as it is with other SBIG self-guiding cameras, you will notice in dark frames that the image appears to be read out from right to left instead of top to bottom. This can be seen in a slight gradient from side to side in dark frames. This is normal and disappears when the dark frame is subtracted from the light frame in normal processing. Also, any hot pixels that would otherwise leave a vertical line in a dark frame will instead appear horizontal. Again, these are normal occurrences.

## **Lines in Dark Frames**

Finally, while not specific to the ST-4000XCM camera, it is worth mentioning in this Supplement, especially for first time users of CCD cameras, that it is normal to see lines and bright points in dark frames. Lines are usually caused by hot pixels that cause a streak in the dark frame during the readout process. These lines are not column defects and they do not indicate anything wrong with your camera. These disappear when a dark frame is subtracted from a light frame.

Please see the Application Note Dated May 25, 2005 at the end of this Supplement for more information.

## Easy Processing of Single-Shot Color Images with CCDOPS

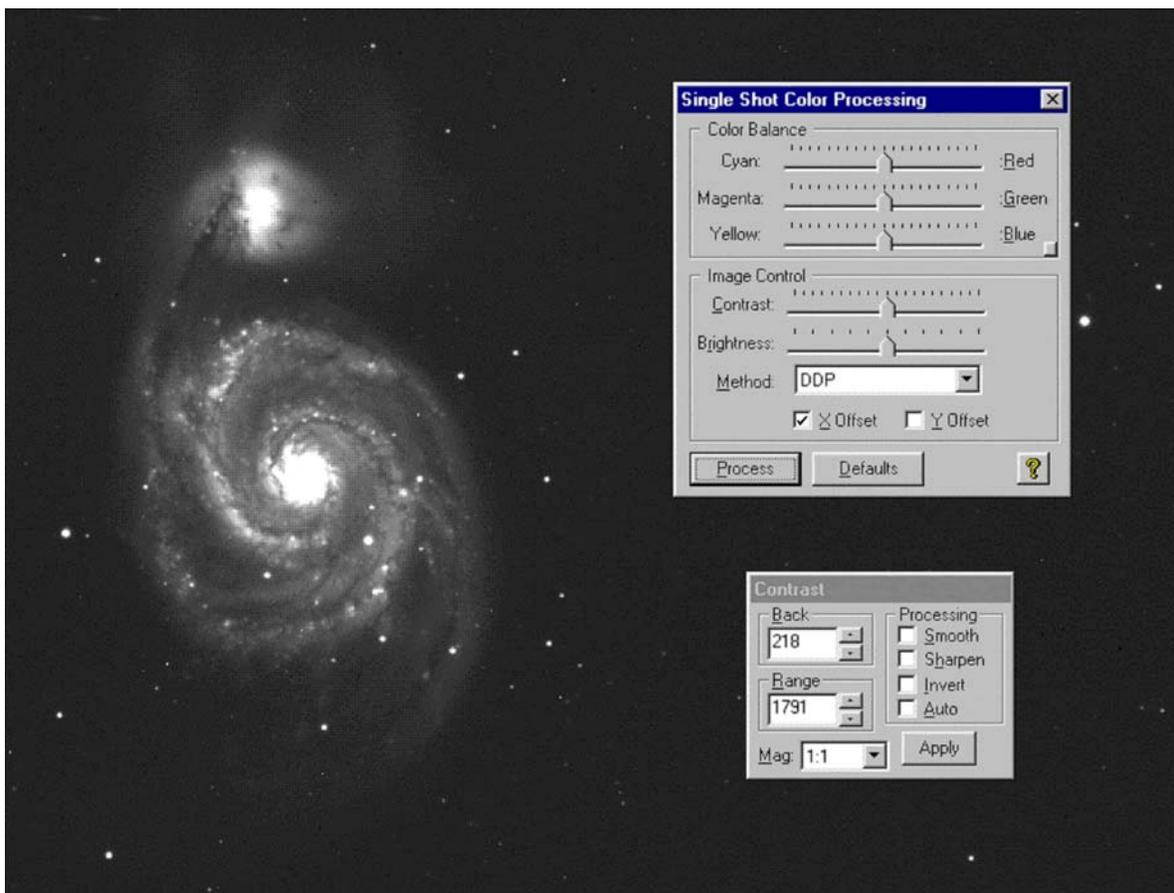
Single-Shot Color (SSC) cameras like the STL-11000CM, STL-4020CM, ST-2000XCM, and ST-4000XCM produce raw images that CCDOps displays as monochrome until they are color processed. The Color Process command in the Single Shot Color menu of the Utility menu converts these raw images into color as shown in the dialog below. Once you have captured the image, from the **Utility** drop-down menu in CCDOPS select:

### Single Shot Color --> Color Process

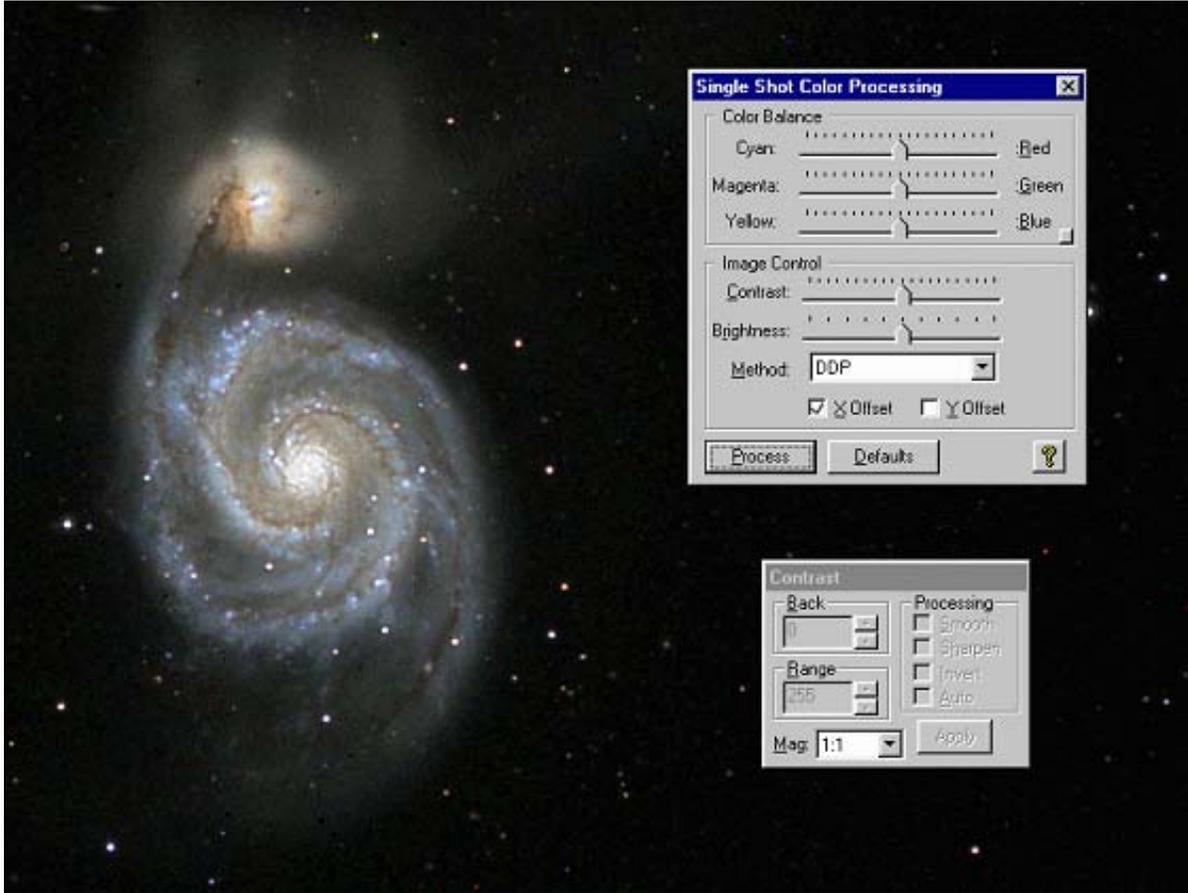
and you are ready to go. Processing of Single-Shot Color Camera images is easy. Start by clicking the Defaults button and selecting RGB or DDP for the Method (DDP works great on galaxies with bright cores).

The images below are actual screen captures of the single step process. The first image is the B&W raw frame displayed from an ST-2000 camera. The second frame (color) was created by clicking the "process" button in the dialog box with the settings in their default positions using DDP as the method:

### Step 1: Capture the image and save the raw data:



Step 2: Click the "PROCESS" button to create the color image:



If you don't like the color balance of the result, simply modify the color balance pointers and click the "process" button again. For more in-depth color image processing, you can extract the RGB color channels and perform more traditional tri-color image processing techniques (see Processing Separate RGB Images, below).

### Color Balance

Any color image, even those from monochrome camera with external filter wheels or from consumer digital cameras, may require minor corrections to achieve the best color balance. This is done in CCDOPS by simply sliding the Color Balance Sliders at the top of the dialog box. To make the image more Red (or less Cyan) move the top slider towards Red then hit the Process button again. If there's a star or an area of the image you know is White you can White Balance on it by positioning the Crosshair over that area then right-click the mouse and select Set White Balance. It is a very simple process.

### Brightness and Contrast

Use the Brightness and Contrast sliders to adjust the image and then hit the Process button to see the results.

## Enhancements

Images of galaxies tend to have a lot of dynamic range and you may find it difficult to reveal the faint details in the arms without causing the core to saturate. Try selecting the DDP instead of RGB in the "Method" drop down box. Hit the Process button. DDP compresses the dynamic range of the image. This may not look natural on all images but don't be afraid to try it. An example is shown below.



Another selection available is sRGB. This stands for subtracted RGB color processing. The color filter mask on the CCD isn't perfect. Some blue light leaks through the red filter, and some red light leaks into blue, and so on. We have measured this leakage at SBIG using RGB filters, and have determined a first order correction that subtracts out the leakage. For example, based on the signal in the red channel, some percentage of the red signal is subtracted from the blue data. The result is purer, cleaner colors, but a bit more likely to boost the noise on a weakly exposed image. sRGB with Gamma mode does the same with some log scaling to compress the dynamic range. We are currently in the process of adding this unique correction process to the EXTRACT COLOR CHANNELS command in CCDOPS.

The initial color processing doesn't have to be difficult or complicated. Once you have saved the original B&W image you can experiment over and over with different settings until you achieve the results you like. Of course, if you want more control over the image you may wish to process the R,G and B frames separately and combine them just as you would if the three frames were taken separately though RG and B filters as they are with monochrome cameras. See below for more about extracting, processing and combining RGB frames.

## Easy Processing of Separate R,G and B Images with CCDOPS

Monochrome cameras with filter wheels are used to make color images by shooting separate red, green and blue frames through color filters. Separate Red, Green and Blue frames may also be extracted from a Single Shot Color Camera image for more control during the processing stages. To do this using CCDOPS select:

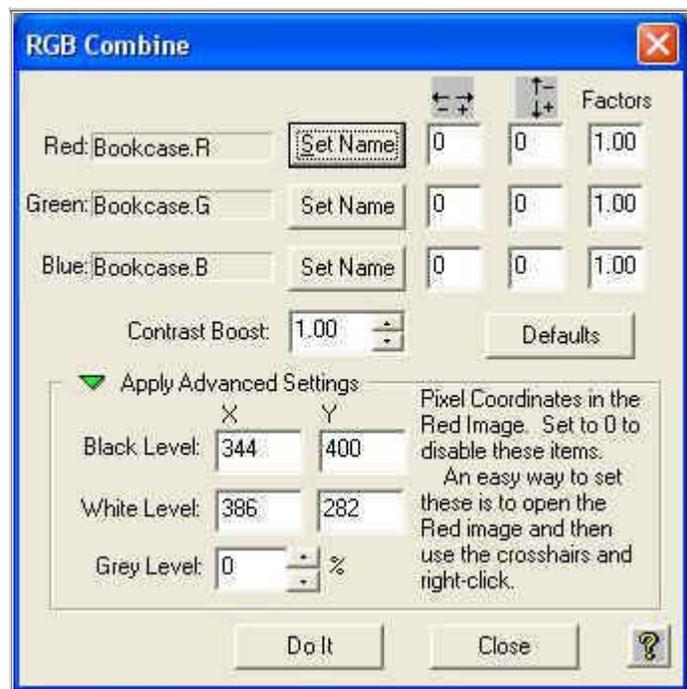
**Utility --> Single Shot Color --> Extract Color Channel(s)...**

Once extracted, the R,G and B frames from a Single Shot Color Camera are treated the same as RGB frames shot with a monochrome camera and color filter wheel. Processing separate RGB images to create a color image involves the following steps: 1. Co-aligning the images 2. Normalizing the Sky Background 3. Setting the White Balance. CCDOps makes this relatively easy. Here's a step-by-step procedure for quick and easy RGB Processing:

**1. Co-align the images** - Open the Red, Green and Blue images and then open the Crosshairs. Visually identify a common star or feature in the images to serve as an alignment reference. Starting with the Red image, position the Crosshair on the reference position, using the peak pixel brightness on a star for example, then right-click the mouse. Select the Set RGB Red Position item to mark the reference position. Do the same in the Green and Blue images, selecting the Set RGB Green Position and Set RGB Blue Position respectively. This tells CCDOps how it will co-align the images

**2. Normalize the Sky Background** - Normalizing the Sky Background means making sure it comes out a neutral gray in the final image, not having a subtle color tint. Bring the Red image to the foreground and then position the Crosshair on an area of the image that represents the Sky Background, free of any stars or faint nebulosity. Right-click the mouse and select the Set RGB Black Level. This tells CCDOps how to normalize the sky background.

**3. Set the White Balance** - Again, bring the Red image to the foreground and then position the Crosshair over a star or area of the image that you feel represents the White Balance. If you get it wrong it's easy to adjust so don't worry about it. Once the Crosshair is positioned, right-click and select the Set RGB White Level. This tells CCDOps two things: how to set the color balance and how to set the contrast of the RGB image such that the star you identified comes out white (neutral color) and just saturates in the RGB image. Now that the hard work is done you can close the Red, Green and Blue images and then invoke the RGB Combine command in the Utility menu. You'll be shown the dialog at right. If the Advanced Setting section is not visible, click the green triangle to reveal it. To finish the color processing do the following:



**4. Identify the images** - Click the Set Name button to the right of the Red and navigate through your folders on your hard drive to find the Red image. Double-click the Red Image or select it and hit Open. If you used CCDOps to acquire the images they will be named XXXX.r, XXXX.g and XXXX.b and at this point CCDOps will fill in the names of the Green and Blue images for you. If not then click the Set Name button to the right of the Green and Blue and identify those images.

**5. Initial RGB image** - Click the “Do It” button to see the results of merging the Red, Green and Blue images into a single RGB image. 6. Tweak the parameters – [a] Co-alignment - Modify the Horizontal and Vertical adjustments edit fields to the right of each image to tweak the co-alignment. The easiest way to do this is to look at the outer fringes of stars by zooming in on the RGB image. If the stars have a Red tint to the right then you would reduce the Red Horizontal item by 1. After each adjustment hit the “Do It” button to see the results. [b] Color Balance – Raise or lower the Factors column to adjust the Color Balance. For example, to make the image redder, raise the Red factor. Hit the Do It button to see the results. [c] Brightness and Contrast - Raise or lower Grey Level item to adjust the Brightness and raise or lower the Contrast Boost item to adjust the image contrast. Hit the Do It button to see the results.

**6. Exporting to Other Image Processing Programs** - If you have a favorite image processing program like PhotoShop that you would rather use to process and combine the RGB frames into a color image, then simply save the extracted R,G, and B images in a format of your choice such as TIFF or FITS and use any other image processing program to manipulate and combine the images. It is recommended, however, that you keep your original 16 bit data file in SBIG or FITS format in the event that some step along the way results in an irreversible change to your image file(s) that is not to your liking. You can always extract the raw RGB channels again from the original.

## Special CCDOPS Functions for Single Shot Color Cameras

### Filter Routines Specific to Single Shot Color Images

The raw images (monochrome, prior to conversion to color) from Single Shot Color cameras like the ST-2000XCM require special handling when it comes to filtering the images so that you don't co-mingle the color data in the filtering process. CCDOps has enhanced filtering routines in the Smooth, Sharpen, Column/Row Repair, Kill Warm Pixels and Remove Cool Pixels commands from the Filter sub-menu of the Utility menu. As shown in the dialog below, these commands allow you to check a Single Shot Color Image checkbox that applies those enhancements to Single Shot Color images.



### Track & Accumulate Single Shot Color Cameras

You didn't used to be able to do this and many people don't realize that now you can use SBIG patented Track and Accumulate with Single Shot Color (SSC) cameras. CCDOps has been updated to recognize SSC cameras and Track and Accumulate will then make sure it co-aligns images correctly, taking into account the Bayer Color filter Matrix applied to these cameras.

## ST-4000XCM Typical Specifications

CCD	
<b>CCD</b>	Kodak KAI-4020CM
<b>Pixel Array</b>	2048 x 2048 pixels
<b>CCD Size</b>	15.2 x 15.2 mm (active area)
<b>Total Pixels</b>	4.2 million (active)
<b>Pixel Size</b>	7.4 x 7.4 microns square
<b>Full Well Capacity</b>	~35,000 e- unbinned ~70,000 e- binned
<b>Dark Current</b>	< 0.1e-/pixel/sec at 0 deg. C.
<b>Antiblooming</b>	Standard
Readout Specifications	
<b>Shutter</b>	Electromechanical + Electronic
<b>Exposure</b>	0.001 to 3600 seconds
<b>Correlated Double Sampling</b>	Yes
<b>A/D Converter</b>	16 bits
<b>A/D Gain</b>	0.6e-/ADU unbinned 0.9e-/ADU binned
<b>Read Noise</b>	7.9e- rms
<b>Color Binning Modes</b>	1 x 1
<b>Monochrome Binning Modes</b>	1 x 1, 2 x 2, 3 x 3
<b>Pixel Digitization Rate</b>	up to 425kps
<b>Full Frame Download</b>	~ 10 seconds
System Specifications	
<b>Cooling - standard</b>	Single Stage Thermoelectric, Water Assist: -40C from ambient with water, -30C w/air
<b>Temperature Regulation</b>	±0.1°C
<b>Power</b>	5VDC at 1.5 amps, +/-12VDC at 0.5 amps, power supply included
<b>Computer Interface</b>	USB 1.1
<b>Computer Compatibility</b>	Windows 98/2000/Me/XP Mac OS-X
<b>Guiding</b>	Self-Guiding with built-in TC- 237 or Optional Remote Guide Head (external TC-237 CCD)
Physical Dimensions	
<b>Optical Head</b>	5 inches diameter x 3 inches 12.5 cm diameter x 7.5 deep
<b>CPU</b>	All electronics integrated into Optical Head, No CPU
<b>Mounting</b>	T-Thread, 2" nosepieces included
<b>Weight</b>	Approx. 2 pounds/0.9kg
<b>Backfocus</b>	0.92 inches / 2.3 cm

**Application Note**  
**Dark Frames and Column Defects**  
**May 25, 2005**

Over the past few years Kodak has improved the classification specification for most of its CCDs to eliminate column defects in Class 2 or better cosmetic grades. The two exceptions to cameras currently offered by SBIG are the Class 2 STL-1001E and Class 2 STL-11000CM (This applies to the color CCD only - the monochrome CCD is available only in Class 1). In these two specific cases a Class 2 CCD may have a certain number of column defects, while the Class 1 versions do not. In all other cases for SBIG cameras, Class 2 CCDs have a zero column defect specification.

Since most of our cameras use Class 2 or Class 1 CCDs with no column defects, the issues we often have to address are whether a line that is visible in a dark frame is actually a column defect or something else, and what effect it has on an image. To illustrate, a typical looking raw dark frame is shown in Figure 1. Several bright lines can be seen.

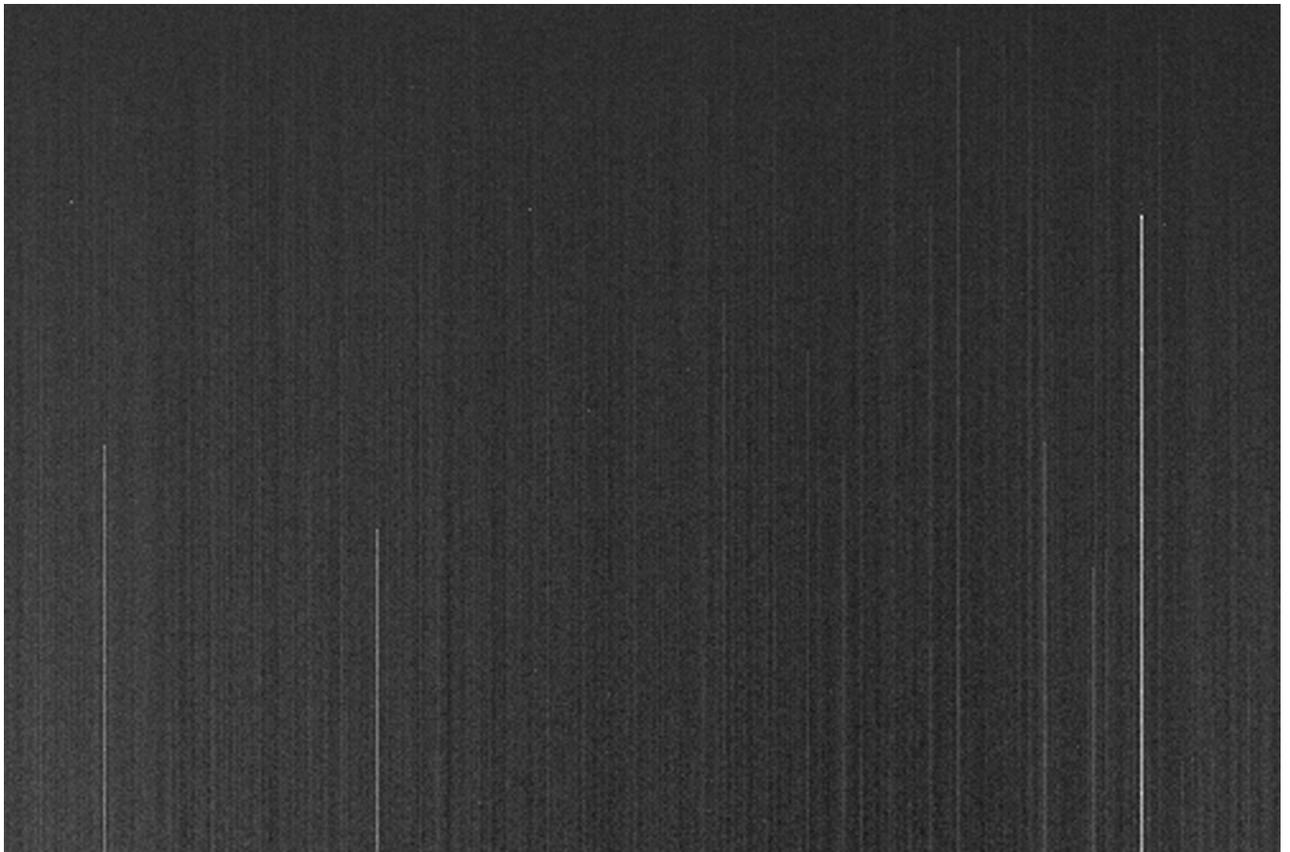


Figure 1

While the lines seen in Figure 1 look like bright columns they are actually just artifacts of the read out process and not CCD defects. There are defects present in the form of hot pixels at the top of each of these lines, but hot pixels are normal occurrences in both Class 2 and Class 1 CCDs. The readout process shifts each one of these hot pixels down the CCD, line by line as it is read out and the resulting raw dark frame looks like it contains bad columns. But the effect is completely repeatable and is removed when the dark frame is subtracted from the light frame as the sequence in Figure 2 demonstrates:

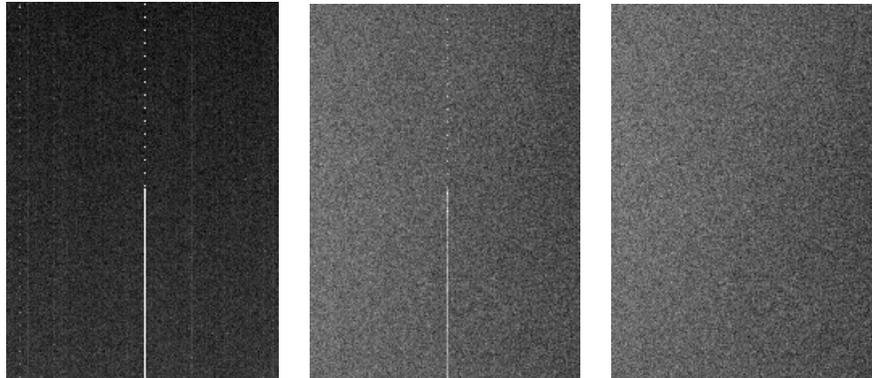


Figure 2

The leftmost frame in Figure 2 is a cropped portion of the raw dark frame from Figure 1 showing the bright line originating from a hot pixel. Note that there is also a dotted line above the hot pixel. The center frame in Figure 2 is a raw light frame showing the same artifact. The final frame on the right is the light minus the dark frame.

There are various reference works and software available to help owners test and evaluate the performance of their CCD camera. Often, a new owner will put the camera through some paces on the bench before using it at night at the scope. These are good practices, but it is also important for new users to know that it is normal for raw dark frames to contain a variety of bright points and lines. With the development of much larger CCDs such as the 11 Megapixel KAI-11000M, the odds of seeing these kinds of things have increased. After all, with 11,000,000 pixels, one can expect a few odd ones. So long as these things disappear when subtracted from a light frame, leaving only the allowed number of warm or cool pixels per the Kodak specification, then the CCD is operating normally and the camera need not be returned for inspection or repair.

A very simple test any user can do to determine if there is a problem or not is to take a single light frame of several hundred counts or more and subtract a single dark frame taken at the same time and of the same duration and temperature and examine the result. Most of the time any bright lines otherwise seen in the dark frame will disappear after the reduction.