

## INSTRUCTION MANUAL

# Orion® StarShoot™ G3 Deep Space Imaging Cameras

Color #53082, Monochrome #53083



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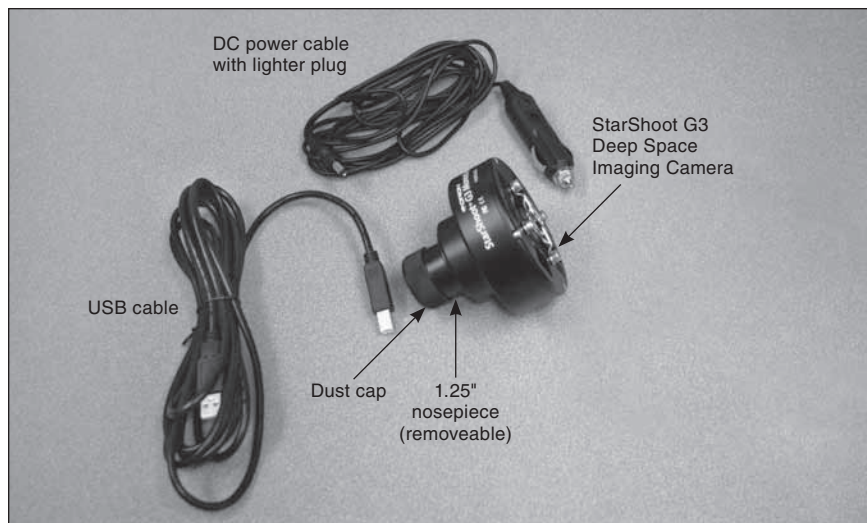
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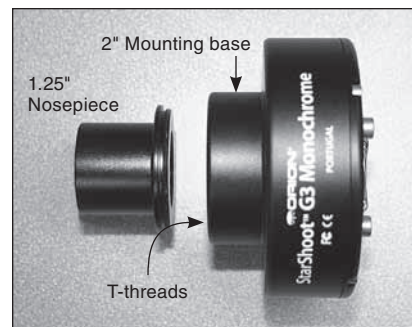
**Figure 1.** StarShoot G3 Imaging Camera and included items.

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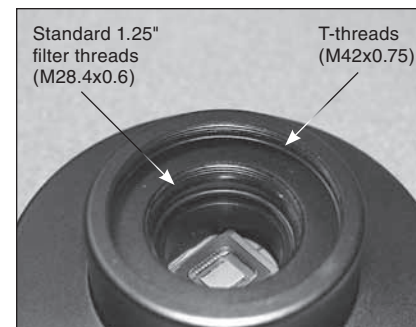
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## 1. Introduction

Welcome to the exciting world of astro-imaging. Your new StarShoot G3 Deep Space Imaging camera is capable of capturing impressive celestial objects like galaxies, star clusters, and nebulae, as well as the planets, Moon, and the Sun (with an optional solar filter). Additionally, the StarShoot G3 can be used as a dedicated autoguider for any other astro-imaging camera you might use like a DSLR camera or large array CCD camera. This manual will show you how to install and use your new StarShoot G3. In a short time, you will be capturing astrophotos and sharing them with friends, family, and the world!



**Figure 2.1.** The G3 can be connected to your telescope in three different ways, 1.25", 2", or T-thread.



**Figure 2.2.** Standard 1.25" filter threads add versatility to allow additional accessories to be used.

### 1.1. The StarShoot G3

The StarShoot G3 is an astronomical imaging CCD camera with a 16-bit image output and a regulated thermoelectric cooler to enable maximum imaging performance. Both the G3 Color and G3 Monochrome are very sensitive and capable of detecting faint deep sky objects in a short exposure; and longer exposures can reveal extremely deep fields with subtle nebulosity and galaxies in the background.

You may also choose to use the G3 as a dedicated autoguider. The highly sensitive, low noise, 16-bit camera allows faint guide stars to be detected. The on-board autoguiding output allows you to connect the autoguide cable directly from the camera to your ST-4 compatible mount.

### 1.2. Feature Highlights

- **Simple interface:** A USB port is all that's needed to connect the G3 to your computer (Figure 3). The power port is used to power the thermoelectric cooler, which is recommended for the best imaging performance.
- **Regulated cooling:** Enables you to set the exact temperature within the cooling range of the camera. This allows you to take calibration images like dark frames at the exact same temperature as your light frames, making for the cleanest images possible. Additionally, since you can match the CCD temperature at any time (within the range of the cooler), you have the freedom to take dark frames when it's most convenient for you, so you don't have to use up valuable imaging time to take dark frames.
- **Vibration-free MagLev Cooling Fan:** This essential component of the cooling system vents out the heat generated by the TEC.
- **Autoguider output:** (Figure 3) When used as an autoguider, the G3 can connect the autoguider relays directly from the camera body to your equatorial mount. This eliminates the need to relay an additional adapter from your PC.

## 2. Getting Started

### 2.1. Parts List (Figure 1)

- StarShoot G3 Deep Space Imaging Camera
- USB Cable
- DC power cable with lighter plug
- Removable 1.25" nosepiece (threaded to camera)
- Dust cap for 1.25" nosepiece

### 2.2. System Requirements

#### Telescope

The StarShoot G3 fits any telescope equipped with 1.25" or 2" focusers, or it can also fit to any focuser or camera adapter with male T-threads (M42 x 0.75). Refer to Figures 2.1 and 2.2.

*Caution: Be sure to always firmly tighten the thumbscrew(s) that secure the StarShoot G3 in the telescope focuser, or it could fall out and onto the ground!*

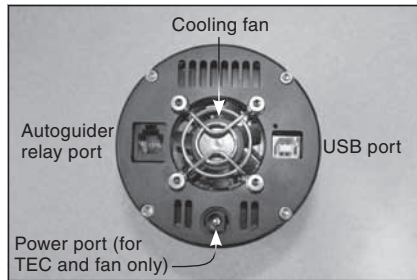
If your telescope has T-threads for direct camera attachment, a more secure connection can be made. First, unthread the nosepiece from the G3. This exposes the camera's T-threads. Then, simply thread the camera onto your telescope (Figure 2.2).

#### Backfocus Requirement

The G3 only requires 3.5mm of inward focus travel (also sometimes called backfocus) when connecting it to a 2" focuser on your telescope. If using the 1.25" nosepiece, the backfocus is 23mm; if connected via T-threads the backfocus is 19mm.

#### Mount

Deep sky imaging with the G3 requires an equatorial mount with a right ascension (R.A.) motor drive. The goal for your mount is to seamlessly track the apparent movement of the sky as the Earth rotates. The tracking must be very accurate, or the object you want to image will drift and blur across the camera's field of view while the exposure is taken. Even a small amount of drift will cause



**Figure 3.** The USB, power, and autoguider ports.

a star to look oblong instead of a round point. We recommend using a high-quality equatorial mount which utilizes periodic error correction (PEC) or has the ability to interface with an autoguider.

#### Computer

The G3 requires a PC to operate the camera. For astro-imaging in the field at night, a laptop computer is highly recommended. The included software is Camera Studio which requires Windows XP and above to operate.

The following hardware is also required:

- Processor – 700 MHz speed or higher, Pentium™ III equivalent or higher
- Recommended minimum memory size is 1GB.
- Disk Space – 55 MB for software installation, 500 GB or more to store images is recommended.
- Video Display – 800 X 600 or higher, 16-bit color or higher.
- Mouse
- High-speed USB 2.0 port

#### Power

The StarShoot G3's thermoelectric cooler (TEC) requires 12 volts DC (12VDC) with approximately 1 ampere of current. The camera itself can operate without the cooler just by connecting to the computer's USB port. For the best imaging performance, we recommend using the TEC. The supplied 12V power cable will plug into a cigarette style socket commonly available on power supplies or field batteries available from Orion. If you have access to an AC outlet at your imaging site, you can use a 110VAC to 12VDC adapter for the camera, available from Orion.

### 2.3. Software and Driver Installation

Before the G3 can be used, the software and camera drivers must be installed onto your computer. Do not connect the camera to your computer before you have installed the software.

*All software, manuals and guides can be downloaded directly from the Orion G3 product support page located at the link below:*

[www.telescope.com/g3c](http://www.telescope.com/g3c)

The following software can be located on the right hand side of the product support page.

1. Download, unzip and run the installer that is compatible with your operating system.
2. Run "GlobalSetup.exe" to run the install wizard. Select language to install and go through the prompts to install the G3 camera driver and prerequisite software (Figure 4.1). The wizard will automatically detect which prerequisites you need and prompt you to install them (Figure 4.2).
3. Next select to install the G3 ASCOM driver (Figure 4.3). Note that ASCOM is only required if you wish to use the camera in another program, such as Nebulosity and MaximDL, or if you wish to use the camera as an autoguider. Select language to install and go through the prompts until the software is installed.
4. Next select to install the Camera Studio Application (Figure 4.3). Select language to install and go through the prompts until the software is installed.

### Connecting the Camera to the PC

After the software and drivers have been installed, connect the camera to the USB port on your computer using the supplied USB cable. You do not need to plug in external power yet.

Windows will automatically detect the camera and install it onto your computer. Wait for the message to appear, **Device Installed Successfully**.

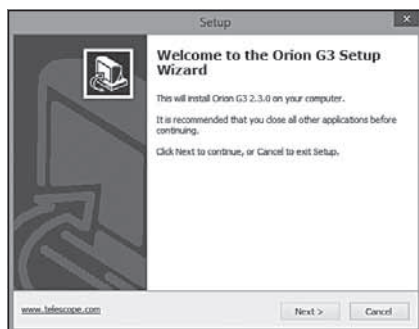


Figure 4.1.

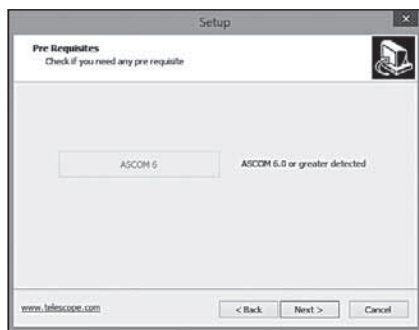


Figure 4.2.

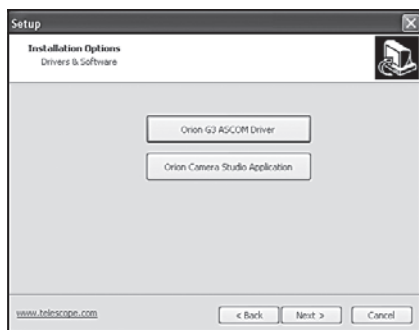


Figure 4.3.

## 3. Software Walk-Through

Camera Studio is an easy to use yet comprehensive imaging program that controls your G3 for image capture, and provides the processing tools to assemble your image and export it. The following section of the manual will walk you through the basic features of the software – **Camera Control, Capture, Calibrate, Process** and **Save & Export**.

### 3.1 Camera Control (Figure 5)

The **Camera Control** tab first appears on the right hand side of the screen when you open **Camera Studio**. This tab allows you to connect to the camera, activate the cooler and set the cooling temperature, adjust the gain and offset (not recommended), or enable faster readout for quick image downloads.

#### Connect/Disconnect

Connects the G3 and instantly displays the CCD temperature. The G3 camera must be plugged into your PC before you click **Connect**.

#### Cooling

The **CCD Temperature** will always display while the camera is connected. To use the TEC, plug the 12V power cable from your power source (field battery or other) to the G3 camera. The fan will automatically power on. Click **Cooler On**. Set the **Target (°C)** to approximately 7°C lower than the current CCD temperature reading. Do not click **Cooler On** until external power has been plugged into the G3.

#### Gain

This feature allows you to manually adjust the analog gain and offset. The default values have been selected for your camera and should normally not need adjustment. However, you may make adjustments to customize your settings. Default values are **Offset 127** and **Gain 185**.

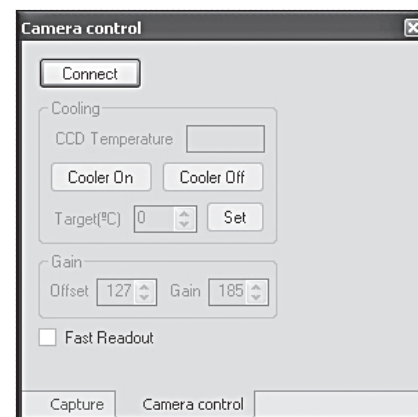


Figure 5. Camera Control window.



### 3.2 Capture (Figure 6)

The **Capture** tab sets your exposure time, exposure type, save path, subframing, and other options.

#### Exposure

Set the exposure time in seconds. You can also specify fractions of seconds, like 0.5 seconds or 1.75 seconds, for example.

#### Type

Choose from **Light**, **Dark**, **Flat**, and **Bias**. Most of the time you will only need to choose from **Light** and **Dark** frames, but for the best results, you can also take **Flat** frames. See “Astronomical Imaging – Dark Frames, Flat Fields”. To start imaging or focusing, take **Light** frames.

#### Bin

You can bin **1x1**, **1x2**, **2x1**, and **2x2**. For most imaging, you should always keep the setting at **1x1**, which provides the full resolution of the camera. Binning **1x2** or **2x2** for example, will group the pixels together to collect more light at the expense of resolution. **1x2** will group 2 vertical pixels for every 1 horizontal pixel, **2x2** will group 2 horizontal and 2 vertical pixels, and is most commonly used to quickly find and frame a celestial object. Binning in these modes provides faster download times and greater sensitivity.

#### Subframe

You can selectively download a segment of the whole field of view to provide extremely fast download times. This is useful for focusing since you typically just concentrate on one star. Click and drag the mouse across part of the image to form a square (Figure 7), then check the **Subframe** box. The subframe size and coordinates will also be displayed in the **Subframe** dialog.

*Note: Make sure the **Subframe** box is unchecked when you start capturing your astrophotos, or you could unintentionally subframe your images into a small square!*

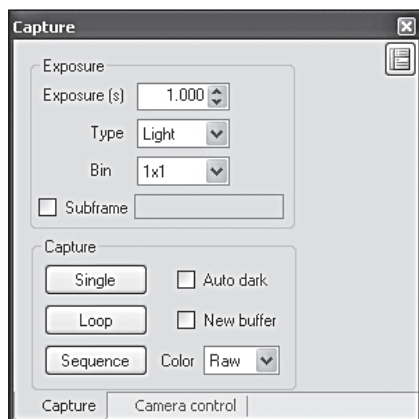


Figure 6. Capture window.

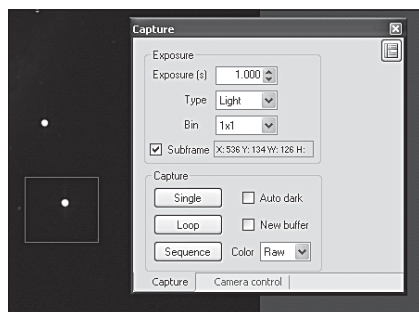


Figure 7. Subframing a small area speeds up the download time and allows you to concentrate on one area of the chip; ideal for focusing.

### Capture – Single

Takes a single exposure only. The exposure length will be determined by the **Exposure** value in seconds you entered.

### Capture – Loop

Continuously takes exposures until you press **Stop**. The **Stop** button will only appear when taking a single or looping exposure. The **Loop** is useful for focusing when you are at the telescope and wish to monitor the focusing progress on your monitor.

### Capture – Sequence

Automatically capture and save images. This is a very convenient feature. It allows you to save your images while you sleep or do other tasks. In the **Sequence** window (Figure 8), you can set your destination **Directory** to save your images to, as well as specify the same parameters you would in the **Capture** tab, like **Exposure**, **Type**, and **Bin**. In the **Sequence** window you can also specify **Repeat**, to set the total number of exposures you want to automatically capture. Click **Run Sequence** when you are ready to begin.

### Capture – Color: Raw, YCbCr, RGB (for StarShoot G3 Color only)

These modes determine what kind of images will be captured. If you are using the StarShoot G3 Color, we recommend always capturing in **Raw** to allow for image calibration later (See “Image Processing – Calibrate Raws”). The image will appear black and white at first, but can later be converted to color. But for quick imaging to instantly get color, you can select **YCbCr** (the most natural color from the camera), or software-processed **RGB**.

*Note: The StarShoot G3 Monochrome will have this feature disabled since the images can only be captured in monochrome.*

### Capture – Auto dark

If you save a dark frame you can optionally check the **Auto dark** box to automatically calibrate the saved dark frame each time you capture an image. While this can be convenient, we recommend keeping this feature off under normal use, since enabling it permanently affects the raw data you capture.

### Capture – New buffer

Check this box to display a new window each time a new image is captured. This is useful to compare or keep the image open without saving it. Keep in mind that more images will consume more system memory. The **New buffer** box should be left unchecked during multiple looping exposures or long sequences.

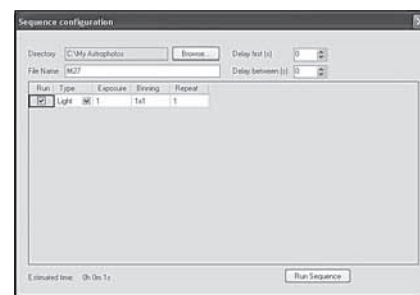
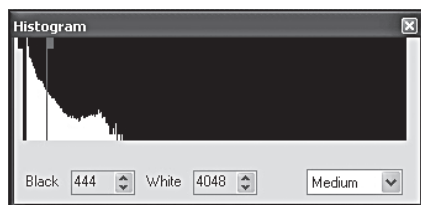


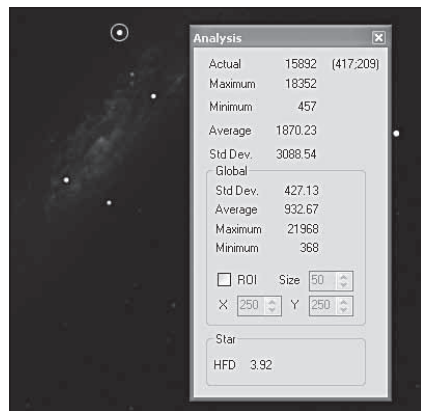
Figure 8. The Sequence dialog allows you to set your exposure then automatically image while you are away from the computer.

### 3.3 Histogram (Figure 9)

The **Histogram** window displays how the bright and dark pixels are distributed in your image. You can make all the adjustments to the **Histogram** you want to reveal the details within the image, and it will not affect the image data, only the way it is displayed. Choose the presets like **Medium**, or drag the light and dark markers manually to adjust the image on your screen. Your computer monitor only displays 8-bits of depth from black to white, whereas your StarShoot G3 camera takes images with 16 bits of depth. That's the difference between 255 counts and 65,535 counts! So you need to check the **Histogram** to see how much image detail you really have.



**Figure 9.** The sliders on the Histogram can be adjusted to reveal lighter or darker depths of the image.



**Figure 10.** The Analysis window displays useful data about your image. Hovering the mouse over a star will also display the HFD value which indicates the star diameter for best focus.

### 3.4. Analysis (Figure 10)

The **Analysis** window displays quantitative data from the image pertaining to pixel brightness and star diameter. Your mouse cursor position will focus on that region of the image for the **Analysis** display (Figure 10). The information displayed is very useful, but for beginning astro-imagers, concentrate mainly on getting the smallest **HFD** possible when focusing on a star.

To aid in focusing turn on the Large HFD display window.

#### Actual

Displays the brightness value of the pixel your mouse cursor is pointing at (Figure 10). This value is known as an Analog to Digital Unit (ADU). The camera can theoretically get as high as 65535 ADUs in value. The image will start to saturate (or overexpose) at around 50,000 ADU. This demonstrates the large range in brightness that 16 bits of data has, and is one of the reasons the StarShoot G3 can capture dynamic images with faint detail.

#### Maximum

Displays the highest ADU pixel value for the immediate area.

#### Minimum

Displays the lowest ADU pixel value for the immediate area.

#### Average

Displays the average ADU pixel value for the immediate area. This is useful to see the general value of an area without letting a hot pixel throw off your reading.

#### Std Dev

Displays the standard deviation for the immediate area.

#### Global

Displays the **Std Dev.**, **Average**, **Maximum**, **Minimum** pixel values for the entire image.

#### Star

Pay attention to the Half-Flux Diameter (**HFD**) value when pointing the mouse cursor at a star (Figure 10), to determine the best focus. The smaller the **HFD** value, the better the focus.

The following sections will describe more software features which you will encounter during your imaging session, and later on when you are ready to process your images.

## 4. Astronomical Imaging

Now that you have familiarized yourself with the basic functions of the camera and software, you are ready to begin using the StarShoot G3 to capture images!

### 4.1. Focusing

Focusing the CCD camera is one of the most critical parts of imaging. It can be challenging, but Camera Studio has some helpful features which will assist you when focusing your G3. Before focusing, make sure your mount is polar aligned and tracking. For best results, we recommend focusing on a star at least 30° above the horizon (or higher). Follow these steps to achieve an accurate focus:

5. Find and center a moderately bright star through your finder scope. Try to find a star around magnitude 4 or 5. If you are not using an optical finder or just using your unaided eye, the star should look relatively faint. This is important because brighter stars will easily over saturate the camera and compromise the focus accuracy.
6. Center your telescope on the star using an eyepiece. Make sure the right ascension (R.A.) tracking motor is engaged on your mount.
7. Replace the eyepiece with the G3.

8. Connect the G3 to your computer and open Camera Studio. In the **Camera Control** tab, click **Connect**.

9. Go to the **Capture** tab, set the **Exposure** to 1 second and click **Single**. You should see the out of focus star in the image. If you do not see anything, you need to increase the exposure time.

10. Draw a small box around the unfocused star with your mouse (hold-click and drag the mouse cursor around the star to draw the box, Figure 11). Check the **Subframe** box.

11. In the **Capture** tab, click **Loop**. The camera will only download the area you previously selected, which makes each image download significantly faster than the whole frame. The exposures will display continuously. Adjust the focuser as needed to get the sharpest looking star.

12. Once the star looks sharp, hover the mouse cursor over the star and pay attention to the **HFD** value. Make additional adjustments to the focuser if needed to achieve the smallest **HFD** possible.

Be sure to uncheck the **Subframe** box once you are done focusing.

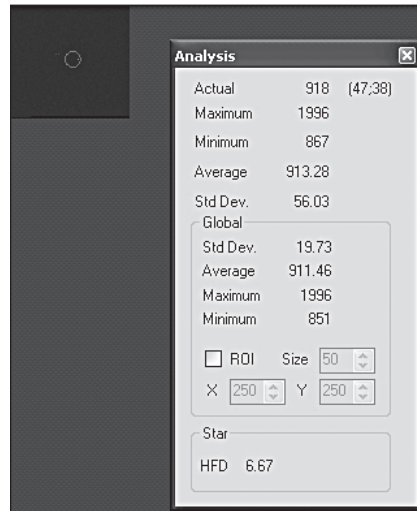
*Note: If the G3 is grossly out of focus, no object will appear in the image, not even a blur. Increase the exposure time if needed and patiently move through the focus range of your telescope until you see the centered star come into view.*

#### 4.2. Using the Thermoelectric Cooler (TEC)

The StarShoot G3's cooling system was designed to reduce the noise in your astro-images. All digital cameras, whether CCD or CMOS have inherent noise. Taking longer exposures at night on a target that is very faint will have little signal, so the noise will be more apparent.

Cooling the CCD camera suppresses the most prominent noise, the thermal noise. You will see bright pixels in most of the images you capture. These bright pixels, and a lot of the noise you see will be reduced by activating the thermoelectric cooler (TEC).

Just as importantly, the noise stays fairly consistent at the same temperature. You should take your dark frames (see "Dark Frames" in Section 4.3) at the same temperature as your light frames, which will remove most of the noise effectively.



**Figure 11.** Create a subframe around the star you want to focus on.

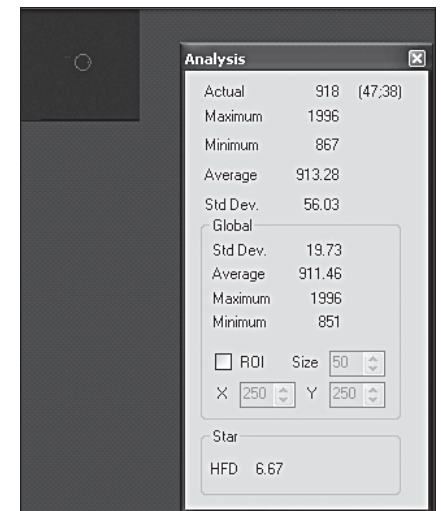
The StarShoot G3 can cool the CCD to about 10°C below the ambient temperature. But remember that the ambient temperature changes and you want to have enough cooling capacity to take dark frames at the same temperature later.

To set the cooler:

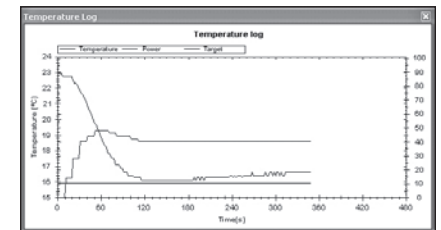
1. With the G3 already connected to your computer, plug the 12V power source into the G3's power port. The fan will immediately power on.
2. Click **Connect** in the **Camera Control** tab if you have not already done so.
3. Click **Cooler On**, and the CCD temperature will begin to drop.
4. Enter a target temperature for the CCD in **Target (°C)**, and remember you can only cool to about 10°C cooler than the outside air temperature. The CCD temperature will naturally heat up on its own. To start with, set the **Target (°C)** to about 7°C lower than the current **CCD Temperature**, to allow yourself some margin for outdoor temperature changes. (Figure 12)
5. Let the camera temperature stabilize. You can resume imaging while this takes place. It's common for the CCD temperature to fluctuate to within about 1°C of your target temperature.

You can view the **Temperature Log** (Figure 13) to monitor the status of the cooling system. Go to the **Camera** menu, and click **Temperature Log**. If the cooler power remains at 100% after 20 minutes, you need to reduce the target temperature. Most of the time you can simply monitor the CCD temperature by looking at the **CCD Temperature** in the **Camera Control** tab.

*Note: Being able to **match the light and dark frame temperature** is more important than trying to cool the CCD more than the TEC will allow. Matching the dark frame temperature to your light frames ensures a very effective calibration to remove unwanted noise from your images.*



**Figure 12.** Monitor the CCD temperature and determine the best target temperature to set.



**Figure 13.** The temperature log can help you determine how much margin you have to cool the camera based on the cooler power and current CCD temperature.

Additionally, you will notice the CCD temperature will rise if multiple fast exposures are taken in succession. This is normal and the temperature will drop back to your target temperature shortly.

### 4.3. Imaging Deep Sky Objects

Capturing impressive images of deep sky objects, such as galaxies, nebulae, and star clusters, require relatively long exposures. You will take several individual images and stack them together to form one high-quality resultant image.

Very accurate polar alignment is essential for deep sky imaging. Stars will streak across the field of view without precise polar alignment and tracking. Longer exposures of 60 seconds or more also require autoguiding with a separate camera. The Orion StarShoot AutoGuider (available separately from Orion) can be operated with the G3 in PHD Guiding.

To start:

1. Acquire and center the deep sky object into the field of view of your eyepiece. If you are using a mount with an accurate computerized go-to system, you can keep the camera installed in your telescope's focuser without using the eyepiece.
2. Remove the eyepiece and replace it with the G3 camera.
3. Focus the camera as outlined in Section 4.1. If necessary, move the telescope to a nearby star to determine the best focus.

For best results we recommend selecting **Raw** in the pull down menu next to the **Color** label in the **Capture** tab (Figure 6). For StarShoot G3 Monochrome users, no special selection is needed, all images will be raw.

4. In the **Capture** tab, set the **Exposure** value to around 10-20 seconds and click **Start**. After the image downloads check to see if the deep sky object is centered well in your camera. Adjust the camera orientation if needed, keeping in mind that you may have to refocus the camera after making the adjustment. Reposition the telescope if needed to center the deep sky object.
5. Click **Sequence** and set the **Directory** save path, and **File Name** for your images as well as your exposure details (Figure 8). For most deep sky imaging, set:

**Run:** Always check on

**Type:** Light 1x1

**Exposure:** Greater than 30 seconds (to your choosing)

**Binning:** 1x1,

**Repeat:** multiple exposures, we recommend more than 5.

6. Click the **Run Sequence** and the G3 will immediately begin the sequence of exposures. A naming convention is assigned to your **File Name**. If you

called your image Dumbbell and you are capturing 10 images, the sequence will save them in your specified directory as Dumbbell1L1.fit, Dumbbell2L1.fit, Dumbbell3L1.fit and so on.

Naming conventions are most important for StarShoot G3 Monochrome users who may be using LRGB or narrowband filters. Change your file name to indicate what filter you are imaging through. For example, Dumbbell\_Luminance, or Dumbbell\_Red, etc.

### Dark Frames

Dark frames are images taken with no light coming into the camera. A dark frame is typically taken with the telescope's objective capped. The only data in the image is the inherent camera noise (Figure 14). The noise contains the dark current, read noise (noise introduced during camera readout and download) and hot pixels (bright dots in the image). All of this noise exists in your raw astro-image too, which distracts from the detail you want to see. To eliminate most of the camera noise, you can take several dark frames, average them, then subtract them from your astro-images, also called, "light" images.

*Note: Make sure the CCD temperature is the same as was when took your light frames.*

To take dark frames for subtraction from "light" images:

1. Set the **Exposure Type** to **Dark** in the **Capture** tab. Or if you are taking a sequence of images, set the **Type** in the **Sequence** window to **Dark**, this will also assign a "D" suffix to your saved file name so you can easily identify your darks later.

*Note to StarShoot G3 Color users: You must take Raw Light frames in monochrome BEFORE converting to color in order to utilize dark frames.*

2. Use the same exposure time as the light images you have or will take. If your light image is 60 seconds, the dark frame must also be 60 seconds.
3. Click **Start** or **Run Sequence** if you are taking several darks. Camera Studio will remind you to cover your telescope. Remember to always cover your telescope before taking a dark – and be sure to uncover it again when taking light frames.



**Figure 14.** A dark frame contains the thermal and background noise, as well as any read noise. The same noise appears in your "light" images. Dark frames isolate the noise so it can later be subtracted from your "light" images.



## Flat Fields

A flat field is an image taken with uniform featureless light entering the telescope, such as a blue sky in the early morning or after sunset. Flat fields solve a number of issues in your astro-images. However, for the beginner astro-imager, you may choose to skip this step for the time being.

### Vignetting

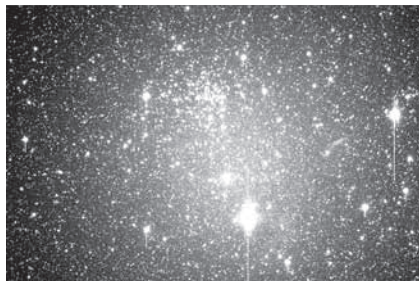
Vignetting (Figure 15.1) in a telescope reveals edge-darkening in the astroimage. The sensitive CCD chip can easily detect vignetting through a telescope, even specialized astrographs. Vignetting is more apparent when the telescope's illuminated field is not large enough to illuminate the full area of the CCD chip. As a result, more light is detected in the center of the image compared to the edge. In general, vignetting should not be a problem on the 1/2" format CCD inside the G3.

### Dust and Particles

Dust and particles (Figure 15.2) will inevitably show up in your raw astroimages. Large particles on the CCD optical window sometimes look like unfocused circles or doughnuts in your images. It's too late to clean your camera if you are already imaging in the field at night. And even when the camera is clean, dust usually finds a way to show up in your images.

To take a flat field image:

1. Ensure that the telescope is focused and ready for astro-imaging.
2. Point the telescope at a uniform and featureless light source, like the sky at dusk or dawn, or a blank white sheet of paper. Make sure the camera orientation is exactly the same as it is or was for astro-imaging (Although the telescope is pointing at a featureless surface, the focus and orientation must be set as it normally would be for astro-images.)
3. Set the **Exposure Type** to **Flat** in the **Capture** tab. Or if you are taking a sequence of images, set the **Type** in the **Sequence** window to **Flat**, this will also assign a "F" suffix to your saved file name so you can easily identify your flats later.



**Figure 15.1.** Larger format CCD cameras like the Parsec reveal vignetting through most telescopes. Vignetting occurs when the edge of the image plane has less illumination than the center.



**Figure 15.2.** Dust or other particles on the camera's optical window can show up as distracting dark shapes in your images.

4. Set the **Exposure** value to **0.1** seconds for now and click **Start** or **Run Sequence**. Looking at the **Global** section of the **Analysis** window, you want the **Maximum** to read somewhere around 10,000-15,000. Adjust the exposure time as needed until the **Maximum** is close to this range. It's a good idea to take several flat frames and try different exposure times until you find the correct exposure. If you are taking your flats near dusk or dawn, the sky brightness will change rapidly.

## 5. Image Processing

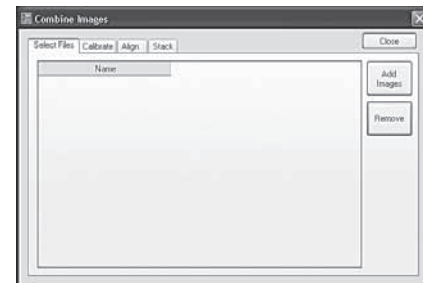
After you have captured your astro-images (with or without dark frames), you will need to:

1. Calibrate Raws
2. Convert to Color (only applicable to StarShoot G3 Color)
3. Align
4. Combine

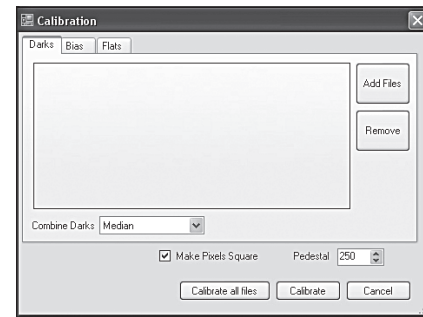
If you are using the StarShoot G3 Monochrome, all of these steps can be performed in the **Combine Images** window (Figure 16). For StarShoot G3 Color users, the calibration and color conversion should be done separately before proceeding to align and stack.

### Calibrate Raws

1. Open your saved astro-images. They should be saved as **Raw** to enable the following steps. Do not convert your raws to color yet.
2. Go to the **Process** menu and select **Calibrate**. The **Calibration** window will appear (Figure 17).
3. Click **Add Files** and select your saved dark frames and flat fields if applicable.
4. Click **Calibrate all files**, and you will notice most of the hot pixels and noise should disappear from your images.



**Figure 16.** The Combine Images window allows StarShoot G3 Monochrome users to calibrate, align, all in a streamlined task.



**Figure 17.** The Calibration window lets you select your darks and flats (if applicable). Bias frames are not typically needed if you have dark frames.

### Convert to Color (For the StarShoot G3 Color only)

1. With your calibrated images still open, goto the **Process** menu and select **Color**, then **CMYG Raw** conversion. We recommend using the default values (Figure 18), but you may adjust them to your liking.
2. Click apply to complete the color conversion. Repeat color conversion for all open files. Color conversion can alternatively be done after combining images by using the “Convert to color” checkbox.

*Note: All files must be in same color format in order to align and combine.*

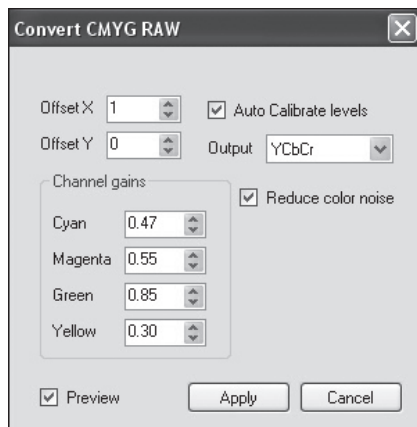
*Note: If using RAW files within other processing software such as MaximDL select convert color->Generic CMYG to convert the RAW file to color.*

### Align

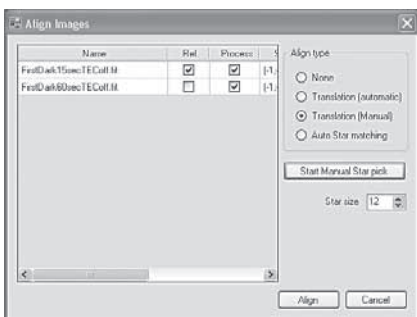
1. With your images still open, goto the **Process** menu and select **Align**. The **Align Images** window will appear.
2. Select **Auto Star matching** and click **Align**. The images should automatically align. If they do not appear to align correctly when they are combined later, you can manually align the images by selecting **Translation (Manual)** and select a star in each image to align to by clicking **Start Manual Star Pick** (Figure 19).

### Combine

1. With your images still open, goto the **Process** menu and select **Combine**. The **Combine Images** window will appear (Figure 16).
2. Since you have already calibrated and aligned your images, proceed to the **Stack** tab. Remember that if you are using the StarShoot G3 Monochrome, you can perform all of these tasks in each of the tabs of the **Combine Images** window.
3. Select **Add Images**, then **Select All**, then **Apply** (Figure 20).



**Figure 18.** For G3 Color users: Convert CMYG Raw is the best way to convert raw images to color.



**Figure 19.** Manual Star Pick can be used if you have difficulty aligning your images with the automatic methods.

4. Proceed to the **Stack** tab. Keep the default settings. We recommend **Sigma Reject** which is effective at removing unwanted leftover hot pixels, satellite trails, or other unwanted artifacts from your image.
5. Click **Combine**, and your resultant image will appear. If the image did not appear to combine correctly, go back to the **Align** tab and try to use a different alignment method. Normally the **Auto Star matching** is the easiest method.

Check the box “Convert to Color” to automatically convert a raw image to a color image after combining images.

### Getting a Color Image with the G3 Monochrome

The G3 Monochrome requires capturing images through a series of filters, such as Luminance, Red, Green and Blue filters to obtain a color image, or with specialized narrowband filters. The image processing program ultimately wants to have image data for Red, Green and Blue.

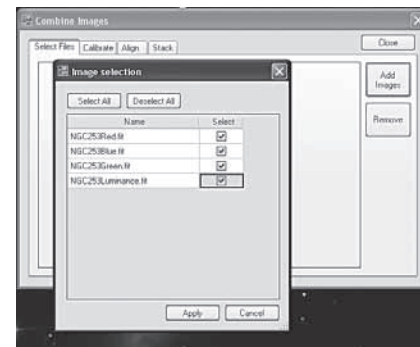
### RGB/LRGB Combine Using CameraStudio

After aligning and combining each of the individual RGB or LRGB file groups the resultant images can now be combined into RGB or LRGB channels by selecting process->color->RGB combine and assigning open files to one of the RGB or LRGB channels (Figure 21).

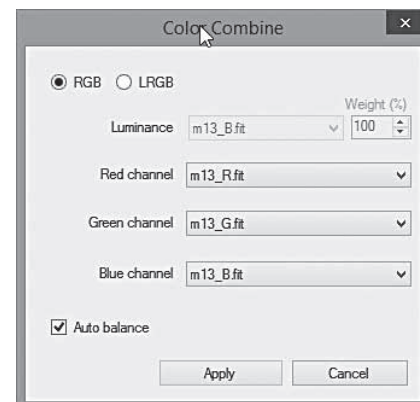
### RGB/LRGB Combine Using Photoshop

Camera Studio allows you to export 16 bit TIFF files or the raw FIT files to your favorite post image processing program such as Photoshop. Save and export each of your color channel images from the Monochrome G3. If you used LRGB filters, export each of the LRGB images to a program like Photoshop. Before exporting, align and combine each of the LRGB images individually, then align the LRGB together, but do not combine them yet.

Add the RGB images to a new RGB layer in Photoshop or similar program that uses layers. Assign your red image (which will still look monochrome) to the red



**Figure 20.** Select the open images to align.



**Figure 21.** RGB and LRGB Color combine.

channel, green to the green channel, and blue to the blue channel. The image should then appear in color. Then add the L (luminance) layer and select “color” in the layer mode. This can also be performed in freeware programs like Paint.Net. Import the luminance layer and select “color” in the layer mode. The image detail will come from your luminance image, and all color detail will come from your RGB images. There are several different ways to process the color this way, especially if you use narrowband filters. This will give you complete control over the color balance in your image.

Donald Waid of “Waid Observatory” provides an excellent step-by-step video tutorial of LRGB processing in Photoshop (or similar program that uses layers). Visit [www.waid-observatory.com/article-LRGB.html](http://www.waid-observatory.com/article-LRGB.html).

#### Color Balance

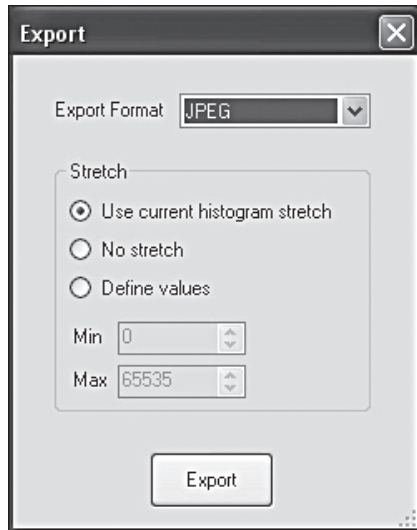
Select Process->Color->Color Balance in order to tune each individual color channel.

### 5.1 Save and Export

Always save your work in the native .FIT format which will preserve all of the image data you worked on. .FIT is a common file format for CCD imaging, and is understood by many other image editing programs, including plugins that are available for Adobe Photoshop.

You may choose to edit your image further. Camera Studio has several other image enhancement features, such as sharpening, low pass filters, Gaussian blur filters as well as color balance adjustments to enhance your image. Explore these features in the **Process** menu. But always save your original FIT file. Choose **Save As** in the **File** menu to save different versions of your edited work.

If you have completed and saved your astro-image and wish to export it in a common JPEG or TIFF file format, choose **Export** from the **File** menu. The **Export** window will appear (Figure 22).



**Figure 22.** Choose your file format and export settings to export your image as a TIFF or JPEG.

### JPEG

Choose JPEG if you want a smaller file size. JPEGs are saved in 8-bits of depth only, so you should specify the histogram stretch you want. Choosing **No Stretch** in JPEG will not work properly, since you will be throwing away most of the dynamic range of the image. Instead, adjust the histogram until the image looks to your liking, then choose **Use current histogram stretch**. This will save the JPEG image to look exactly as it does on your screen.

### TIFF

TIFFs are saved in 16 bits and are a good choice to export your image to Photoshop for additional image editing.

When you have made your selection for **Export**, click **Export** and specify the file name and folder destination, then click **Save**.

#### Link to PHD Guiding

The Camera Studio software allows you to link to the popular freeware “PHD guiding”. This gives the benefit of being able to pause guiding during the download of the main image. Some cameras are sensitive to interruptions on the USB bus and if the guide camera shares the USB bus, the image quality can be degraded.

Additionally a dithering feature is available that when enabled will add a small random amount to the guide stars locked position.

To enable first run PHD guiding software and select tools->Enable Server. Then within Camera Studio select Camera->PHD Link. A green icon should show up on the bottom left of Camera Studio when the connection is successful.

## 6. Using the StarShoot G3 as an Autoguider

The StarShoot G3 also functions as a very high performance autoguider.

Use the included ASCOM drivers for the camera to operate it in any number of ASCOM compatible programs. We recommend **PHD Guiding**, which is freeware and rated as one of the best autoguiding software programs available. Visit [www.stark-labs.com/downloads.html](http://www.stark-labs.com/downloads.html)

We recommend setting the camera to bin 2x2 when autoguiding, especially for StarShoot G3 Color users. Using the TEC will reduce the noise, but is generally not a requirement for autoguiding. You can save power and leave the TEC off while autoguiding.

Connect a standard RJ-12 cable from the G3's autoguider relay port to the ST-4 compatible autoguider port on your equatorial mount (Figures 23.1 and 23.2). Connect the G3 to the USB on your computer as you normally would, and operate the camera with an ASCOM compatible program like PHD Guiding.

## 7. Optional Accessories

### For the StarShoot G3 Monochrome

We recommend Orion 1.25" LRGB and narrowband imaging filters and a filter wheel to capture high quality color images.

### For the StarShoot G3 Color

An optional IR-blocking filter can be threaded to the G3 camera body to block the IR. This can help sharpen your images, and is especially helpful when used with some refractors which may allow more unfocused IR light to create color halos around bright stars.

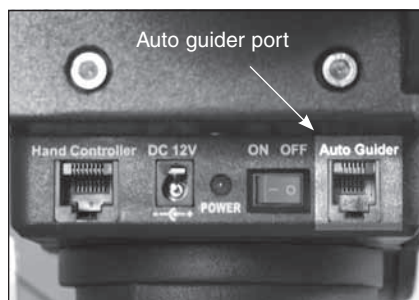
Both cameras can benefit from a USB extension cable, available from Orion.

We recommend a portable field battery to power the TEC.

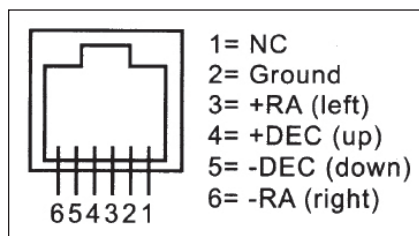
## 8. Specifications

### StarShoot G3 Color

CCD Sensor:	Sony® ICX419AKL Color
Sensor format:	1/2"
Pixel array:	752 x 582 (437,664 total)
Pixel size:	8.6µm x 8.3µm
Exposure range:	Indefinite
A/D conversion:	16 bit
Binning:	1x1, 1x2, 2x1, and 2x2
Read Noise:	Approximately 9e-



**Figure 23.1.** The G3 works with any mount equipped with an ST-4 compatible autoguider port, shown here on the Sirius EQ-G mount.



**Figure 23.2.** This is the pin diagram for the G3 and ST-4 compatible mounts.

Thermoelectric cooling:	10°C below ambient temperature, sealed dry air chamber to prevent CCD icing
Operating Power Range:	10VDC to 13.8VDC
Camera current draw:	Approximately 1A (at 12VDC) with TEC on
USB connection:	2.0 High speed
IR-cut filter:	No
Optical window:	Fully coated with anti-reflection coatings
Backfocus:	3.5mm via 2" attachment 23mm via 1.25" nosepiece attachment 19mm via T-thread attachment
Weight:	12 oz.
Autoguider capability:	Yes
Mounting:	1.25" nosepiece, 2" nosepiece or T-thread

### StarShoot G3 Monochrome

CCD Sensor:	Sony® ICX419ALL Monochrome
Sensor format:	1/2"
Pixel array:	752 x 582 (437,664 total)
Pixel size:	8.6µm x 8.3µm
Exposure range:	Indefinite
A/D conversion:	16 bit
Binning:	1x1, 1x2, 2x1, and 2x2
Read Noise:	Approximately 9e-
Thermoelectric cooling:	10°C below ambient temperature, sealed dry air chamber to prevent CCD icing
Operating Power Range:	10VDC to 13.8VDC
Camera current draw:	Approximately 1A (at 12VDC) with TEC on
USB connection:	2.0 High speed
IR-cut filter:	No
Optical window:	Fully coated with anti-reflection coatings
Backfocus:	3.5mm via 2" attachment 23mm via 1.25" nosepiece attachment 19mm via T-thread attachment
Weight:	12 oz.
Autoguider capability:	Yes
Mounting:	1.25" nosepiece, 2" nosepiece or T-thread



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*This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.*

*Changes of modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.*

*Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:*

*Reorient or relocate the receiving antenna.*

*Increase the separation between the equipment and receiver.*

*Connect the equipment into an output on a circuit different from that to which the receiver is connected.*

*Consult the dealer or an experienced radio/TV technician for help.*

*A shielded cable must be used when connecting a peripheral to the serial ports.*

## **One-Year Limited Warranty**

This Orion product is warranted against defects in materials or workmanship for a period of one year from the date of purchase. This warranty is for the benefit of the original retail purchaser only. During this warranty period Orion Telescopes & Binoculars will repair or replace, at Orion's option, any warranted instrument that proves to be defective, provided it is returned postage paid. Proof of purchase (such as a copy of the original receipt) is required. This warranty is only valid in the country of purchase.

This warranty does not apply if, in Orion's judgment, the instrument has been abused, mishandled, or modified, nor does it apply to normal wear and tear. This warranty gives you specific legal rights. It is not intended to remove or restrict your other legal rights under applicable local consumer law; your state or national statutory consumer rights governing the sale of consumer goods remain fully applicable.

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