INSTRUCTION MANUAL

Orion® StarShoot™ Deep Space Color Imaging Camera

#52065

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Welcome to a new world of adventure. Your new StarShoot Deep Space Color Imaging Camera (SSDSI) is capable of capturing detailed, full-color images of astronomical objects. Galaxies, star clusters, and nebulae, as well as the planets, Moon, and Sun (with optional solar filter) can all be imaged to create spectacular views on your computer (laptop recommended, see "System Requirements") which can be saved for emailing or printing later. You'll find that this relatively inexpensive, yet powerful, camera will enhance your astronomical journeys with your telescope.

Please read this instruction manual before attempting to use the camera or install the needed software. For the most detailed information on specific camera and software functions, consult the Maxim DL Essentials **Help** menu; the tutorials found there are especially useful for familiarizing yourself with how the software and camera are typically used.

Parts List

- StarShoot Deep Space Color Imaging Camera
- IR filter
- USB cable
- 12V DC power cable (for TEC power)
- Parfocal ring
- CD-ROM

System Requirements (refer to Figure 1)

Telescope

The SSDSI can be used with virtually any telescope that is compatible with 1.25" format eyepieces. The camera simply is inserted into a focuser in the same way as a standard eyepiece (Figure 2).

Important Note: Be sure to always firmly tighten the thumbscrew(s) that secures the SSDSI in the telescope focuser, or it could fall out and onto the ground!

Figure 1: To use the SSDSI, a telescope, mount, computer, and 12VDC power source (for TEC usage only) are required.

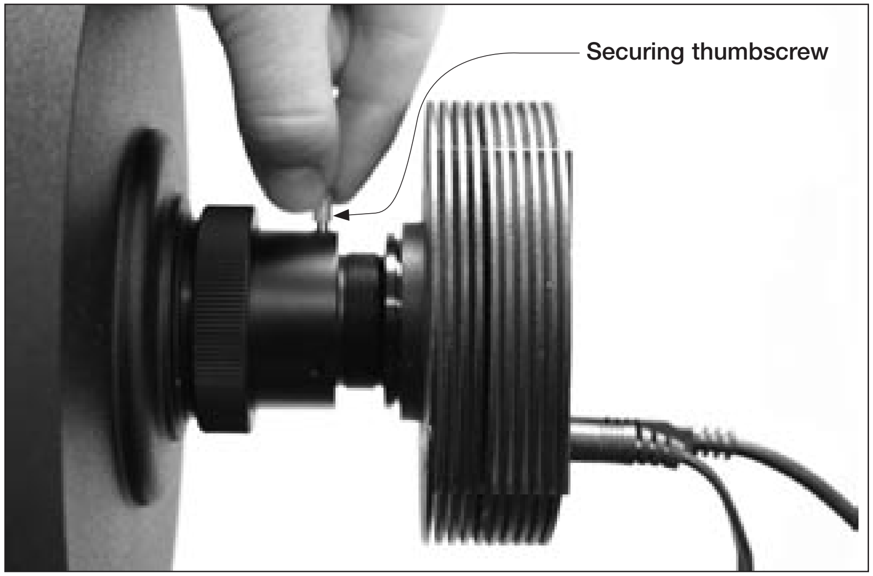

Figure 2: The SSDSI fits into 1.25" focuser, just like a standard 1.25" eyepiece. Firmly tighten the thumbscrew that secures the SSDSI in the focuser.

In order to reach focus, the telescope must have approximately 0.8" (20mm) of inward focus travel relative to where a standard eyepiece focuses. If your telescope does not have enough inward focus travel, you will need to use and optional 1.25" barlow lens to extend the telescope's focal plane to the camera's imaging plane.

For most types of astro-imaging with the SSDSI (except planetary imaging), using a telescope with a focal length of under 1000mm is recommended. Otherwise, the field of view may be too small to capture the entire deep sky object. To decrease the effective focal length of your telescope, use a focal reducer lens (available from Orion). If you are imaging planets, however, you will benefit from using a telescope with a long (over 1000mm) focal length. Or you can use a barlow lens to extend the effective focal length of your telescope to increase planetary image scale.

Mount

An equatorial mount with right ascension motor drive is required for deep sky imaging with the SSDSI. Otherwise, objects will drift in the field of view as the image is being captured. It is also very important that the mount tracks very accurately with little periodic error. If not, stars will not appear round in the final image. Use a sturdy mount that is appropriately sized for the telescope tube being used. Accurate polar alignment will also be required.

Computer

A computer is needed. For astro-imaging in the field at night, a laptop computer is highly recommended. Maxim DL Essentials requires Windows 98™, Windows ME™, Windows NT™ 4.0, or Windows 2000™ (or higher).

The following hardware is required:

- Processor – Pentium™ or equivalent, or higher
- Recommended minimum memory size is 64 MB.
- Disk Space – 67 MB for program installation, 100 MB swap file recommended
- Video Display – 800 X 600, 16-bit color or higher. 1024x768 or higher is recommended.
- Mouse
- Internet Explorer 4 or higher required to display on-line help
- USB port (USB 2.0 recommended)

Note that Maxim DL Essentials benefits greatly from increased memory size.

Figure 3: Connect the 12VDC power supply to the SSDSI's TEC with the supplied cable.

12VDC Power source

In order to provide power for the SSDSI's thermoelectric cooler (TEC), an external 12VDC power source is needed. A portable rechargeable battery, like the Orion Dynamo, will generally be most convenient to use. The TEC draws about 0.5A of current, so make sure your battery has enough amp-hours of storage to handle your observing sessions (7amp-hours or more recommended). When the external 12VDC power supply is connected to the SSDSI (via the supplied 12VDC power cable, see Figure 3) the TEC is on. When no power supply is connected, the TEC is off.

Keep in mind that the SSDSI camera will run off the power supplied by your computer's USB port, it is only the TEC that needs external power. So if you do happen to run out of external 12VDC power in the field, you can still run the camera without the TEC. If very cold outside (around or below freezing), it may not be necessary to use the TEC.

Software and Driver Installation

Before the camera can be used, software and camera drivers must be installed onto your computer. Turn on your computer and allow the Windows operating system to load as normal. Insert the included CD-ROM into your computer's CD-ROM drive, and the Launcher will appear (Figure 4). This allows you to install the Maxim DL Essentials software. After the software is installed, the drivers will install automatically once the SSDSI is initially connected to the computer. Do not connect the camera to your computer before you have installed the software.

Figure 4: The **Launcher** provides an easy menu for software installation.

Software Installation

To install Maxim DL Essentials Edition:

1. Insert the CD-ROM into the drive. The **Launcher** will appear.
2. Click **Install.**
3. The InstallShield Wizard will start. Click **Next.**
4. Read the Maxim DL License Agreement. If you agree with the terms, then select **I accept the terms in this license agreement** and click **Next.**
5. You are now ready to install. Click **Install.** The installation will proceed.
6. Microsoft DirectX 9 or higher is required. Click **Yes** to install the update.
7. The installation is now complete. Click the **Finish** button.

You can start Maxim DL Essentials Edition using the desktop icon, or using the Windows Start menu.

Camera Driver Installation

Now that the software is installed, the camera driver must also be installed. The system will automatically guide you through driver installation when the SSDSI is initially connected to the computer. You must plug-in the camera before starting Maxim DL Essentials Edition, or the software and computer will not recognize the camera.

To install the camera driver:

Figure 5: When initially connecting the SSDSI to a computer, the **Found New Hardware** Wizard will appear and guide you through driver installation.

1. Make sure the CD-ROM is in the drive.
2. Connect the Orion StarShoot Deep Space Imager to a USB port on the computer with the supplied USB cable. Windows will automatically detect the camera and start the **Found New Hardware Wizard** (Figure 5).

Note: For best results, use a USB 2.0 port. If you only have USB 1.1, the camera will run slower. We highly recommend upgrading to USB 2.0 if you have USB 1.1. A USB upgrade card can be found from a computer parts supplier.

Note: You do not need to connect the SSDSI to the external 12VDC battery (via the supplied 12VDC cable) at this time. The external power is for the camera's thermoelectric cooler (TEC) only, and normal camera operation does not require it to be on (i.e. when the TEC is powered it is on, when it is not powered it is off). Use of the TEC is highly recommended for long exposure astro-imaging, however (see "Imaging Deep Sky Objects").

3. Select **Install from a list of specific location (Advanced)** and click **Next.**
4. Select **Search removable media (floppy, CD-ROM...).** Turn off the other options. Click **Next.**
5. Windows will start looking for the driver files on the CD-ROM.
6. Windows will note that the driver is not signed. This is normal. Click the **Continue Anyway** button.
7. When the Wizard has completed, click the **Finish** button. This completes the first part of a two-part installation process. (The first step installs the driver for the camera's chipset; the second step installs the camera driver.)

8. The **Found New Hardware Wizard** appears again. Select **Install the software automatically (Recommended)** and click **Next.**
9. Select the driver with the location **c:\windows\inf\dj.inf** and click **Next**. Your system should automatically locate the ezusb.sys driver file; if it does not, manually select it from its location on the CD-ROM.
10. Windows will note that the driver is not signed. This is normal. Click the **Continue Anyway** button.
11. When the installation completes, click **Finish.**

If you are already running the **Maxim DL Essentials Edition** software, close it and restart it. The camera will now be recognized, and the **Camera Control Window** (Figure 6) will appear. Once the driver is installed, the computer and software will recognize the SSDSI whenever it is plugged in.

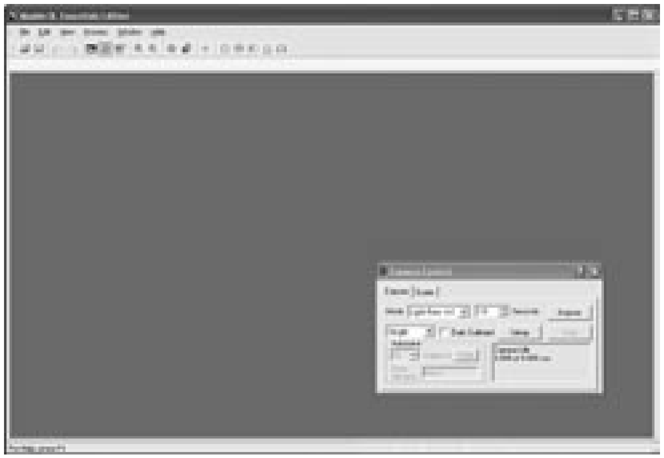

Figure 6: The **Camera Control Window** automatically appears when the SSDSI is connected to the computer and the Maxim DL Essentials program is opened.

Getting Started During Daylight

We recommend using the SSDSI for the first time during the day. This way, you can become familiar with the camera and its functions without having to stumble around in the dark. Setup your telescope and mount so the optical tube is pointing at an object that is at least a couple of hundred feet away. Insert an eyepiece and focus as you normally would.

Since the SSDSI camera is so sensitive to light, you will need to "stop down" your telescope aperture to do any imaging in daylight. This can be done by creating a simple aperture mask out of a piece of cardboard. The piece of cardboard should be larger than the telescope's aperture. Cut a circular hole in the cardboard approximately 1⁄2" in diameter, and place the cardboard over the front of the telescope so that it completely covers the aperture except for the 1⁄2" circle. Affix your aperture mask to your telescope with tape (Figure 7).

Figure 7: Because the SSDSI is so sensitive to light, an aperture mask is needed on the telescope for any imaging during daylight.

Installing the IR Filter

When using the SSDSI in daylight, the included IR (infrared) filter should always be installed. This is because the camera is sensitive to the infrared frequencies of light, while the human eye is not. Without the filter installed, the camera will pickup infrared light, which will ruin the contrast of the view. For certain types of astronomical imaging at night, however, you may want to remove the IR filter. This is especially true for imaging red nebulae.

To install the IR filter on the SSDSI, first unthread and remove the camera's "nosepiece" (Figure 8a). Then, thread the filter into the now-exposed filter threads (Figure 8b). Thread the filter so that it is completely seated. Replace and rethread the nosepiece, and the IR filter is now installed on the SSDSI. It should generally be left on the camera, expect for specific types of astronomical imaging.

Obtaining First Images

To obtain first images (in daylight) with the SSDSI, follow these step-by-step instructions:

Figure 8a-b: (8a.) To install the IR filter, first remove the nosepiece by unthreading it from the SSDSI. **(8b.)** The IR filter then threads directly onto the SSDSI.

1. Plug the camera into your computer's USB port.
2. Open Maxim DL Essentials by clicking on the icon now installed on your computer's desktop.
3. Once open, Essentials should connect directly to your camera with the **Camera Control Window**.
4. To connect the camera to the telescope, simply replace the telescope's eyepiece with the camera. Make sure the securing thumbscrew on the focuser drawtube is firmly tightened.
5. You will now need to refocus the camera for the centered object. Focusing will be the hardest thing to do in the initial stages. For daytime imaging, open the **Screen Stretch Window** (in the **View** menu), and set the stretch mode to **Moon**.
6. In the **Camera Control Window**, set the mode to **Light Color 1x1**. Set the **Seconds** (exposure time) to .002 to begin with. In the box underneath the **Mode** box, select **Fast Focus**. Make sure the **Dark Subtract** box is unchecked.
7. Press the **Expose** button in the **Camera Control Window**. The camera will now rapidly take short exposures and display them on the computer screen. If the image brightness is too bright for the camera, an all (or mostly) black screen will result. You will also notice that the **Max Pixel** (in the lower right corner of the **Camera Control Window**, see Figure 6) will be at 65535, which is the maximum pixel brightness value. You can turn down the camera's gain setting by clicking the **Setup** box in the **Camera Control Window**, then adjusting the **Analog Gain** slider. Try to get a **Max Pixel** of around 50000 to 60000. If the (daytime) image is still too bright to produce an acceptable image on your computer screen, you may need to stop-down the aperture of your telescope further. Try making another aperture mask than has a diameter of only 1⁄4".

8. Now, turn the telescope's focus knob so the focuser drawtube moves slowly inward. The drawtube needs to go approximately 20mm inward from where the eyepiece focuses (for most eyepieces). Look at the computer screen and adjust the focus knob accordingly to determine best image focus.

Note: The camera's field of view is fairly small. It is approximately equivalent to the field of view through the telescope when looking through a typical (i.e. not wide-field) 5mm focal length eyepiece. So make sure the object to be imaged is well centered in the telescope before connecting the SSDSI, otherwise it may not appear in the field of view of the camera.

9. Once focused, image orientation can be changed by rotating the camera within the focuser drawtube. Simply loosen the thumbscrew on the drawtube and rotate the camera until the desired image orientation is achieved. Retighten the thumbscrew on the focuser drawtube when done. You may need to slightly refocus (using the telescope's focus knob) if the focuser drawtube has moved a bit inward or outward when the camera was rotated.
10. When the image is focused and the image looks acceptable, press the **Stop** button in the **Camera Control Window**.
11. Beneath the **Mode** box in the **Camera Control Window** select **Single**.
12. Click the **Expose** button in the **Camera Control Window**. An image will appear in a window.
13. You can now save the image for later processing, if you wish. This is done by selecting **Save** from the **File** menu.

You have taken your first picture with the SSDSI! This simple method of imaging is exactly how the camera could be used to capture terrestrial subjects during daylight hours. Close-up images of birds and other wildlife or faraway vistas can all be obtained in this way with the SSDSI. Solar images can also be taken during the day with an optional full-aperture solar filter over the front of the telescope.

Take some time to use the camera and Maxim DL Essential software during the day to become familiar and comfortable with their basic operation.

Screen Stretch Window

The function of the **Screen Stretch Window** (Figure 9) is to properly map the image brightness levels captured by the camera into corresponding image brightness levels on the computer screen. A typical camera image has each pixel (light detecting site, over 437,000 pixels form a single SSDSI image) represented as a number (from 1 to 65535) depending on brightness. This has to be mapped into the video monitor's brightness range (from 1 to 255). It is important to set the screen stretch appropriately, or a great image may look terrible!

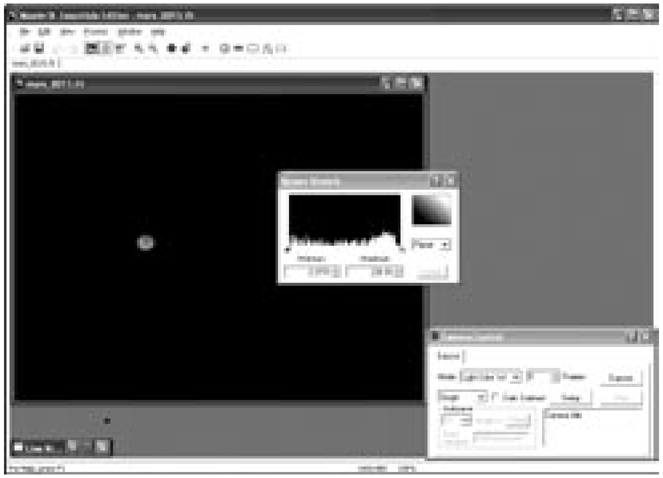

Figure 9: The settings in the **Screen Stretch Window** greatly determine how an image will appear on your computer screen.

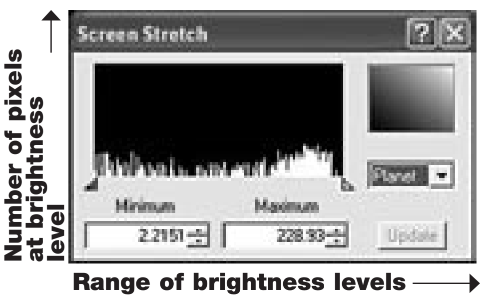

Figure 10: A histogram is a visual representation of the range and levels of brightness in an image.

When an image is displayed, you will notice a graph in the **Screen Stretch Window**. This is called the "histogram" of the currently displayed image (Figure 10). A histogram is a simple bar graph that shows the range of brightness in an image. Each bar in the graph represents a level of brightness; the bar to the far left in the histogram represents the dimmest pixels, and the bar to the far right is for the brightest pixels. The height of the bar is the total number of pixels at that brightness level in the image. Every image has a different histogram depending on how much of the image is bright or dark. Directly viewing the histogram of your image in the **Screen Stretch Window** provides an easy interface for making decisions on how the screen stretch should be set.

In Maxim DL Essentials, the two parameters entered in the **Screen Stretch Window** are **Minimum** and **Maximum**. A pixel that is at the **Minimum** value is set to zero (black), and a pixel at the **Maximum** value is set to 255 (white). An easy way to adjust the **Maximum** and **Minimum** values is to move the slider arrows located directly under the histogram of the image in the **Screen**

Stretch Window. The red slider arrow corresponds to the **Minimum** value and the green arrow corresponds to the **Maximum** value. Simply left-click and then drag each arrow to adjust it to the desired level. The best results are obtained by tweaking the arrows (numbers) until the most pleasing display appears.

There are also seven automatic settings in the **Screen Stretch Window**. Typically, **Medium** will give good results for deep sky objects, so the default screen stretch setting is **Medium**.

Instead of using the **Screen Stretch Window**, it is faster to use the **Quick Stretch** facility. This allows you to modify the image appearance instantly with small up/down and left/right movements of the mouse. To do this, hold down the Shift key, then left-click and drag the mouse on the image. You'll find this feature to be a great convenience when fine adjusting the screen stretch to get an image to look its best.

The trick with stretching is determining exactly how to stretch the image for best effect. Often there are several different possibilities for the same image. Trial-and-error will be the best way to judge what the best screen stretch setting is. Try several different settings until you find one you think looks best. When the image is subsequently saved, the screen stretch setting information will be kept when the image is next opened.

Use Of The Parfocal Ring

A parfocal ring is included with your camera to help with focusing. The ring is intended to be used with a 1.25" eyepiece (not included), preferably one with a focal length of at least 10mm to provide high enough magnification for precise focusing. The ring goes on the barrel of the eyepiece. When the ring is properly positioned on the barrel, you can use the eyepiece to focus, replace the eyepiece with the camera, and the camera should be close to focused.

To properly position the parfocal ring on the eyepiece barrel, first insert the camera into the telescope's focuser drawtube. Set Maxim DL Essentials so the camera displays on the computer's screen in **Fast Focus** mode. Focus the camera as precisely as possible by visual inspection of the image on your computer screen; you do not need to actually capture an image. If you have a focus lock thumbscrew on your telescope's focuser, tighten it firmly once sharp camera focus is achieved (Figure 11a). Place the parfocal ring on the eyepiece barrel, and slide it up the barrel as far as it will go and loosely tighten the thumbscrew on the ring (Figure 11b). Now, replace the camera with the eyepiece, being careful not to change the position of the focuser drawtube. Bring the eyepiece into focus by sliding it in and out of the focuser drawtube (Figure 11c). Do not use the focus knob of your telescope to focus at this time.

Note: If you cannot obtain a focus with the eyepiece by pulling it out of the focuser drawtube, you will need to try another eyepiece. The eyepiece barrel should be at least 1" long. Try an Orion 10mm Ultrascopic eyepiece (see the catalog or www.OrionTelescopes.com).

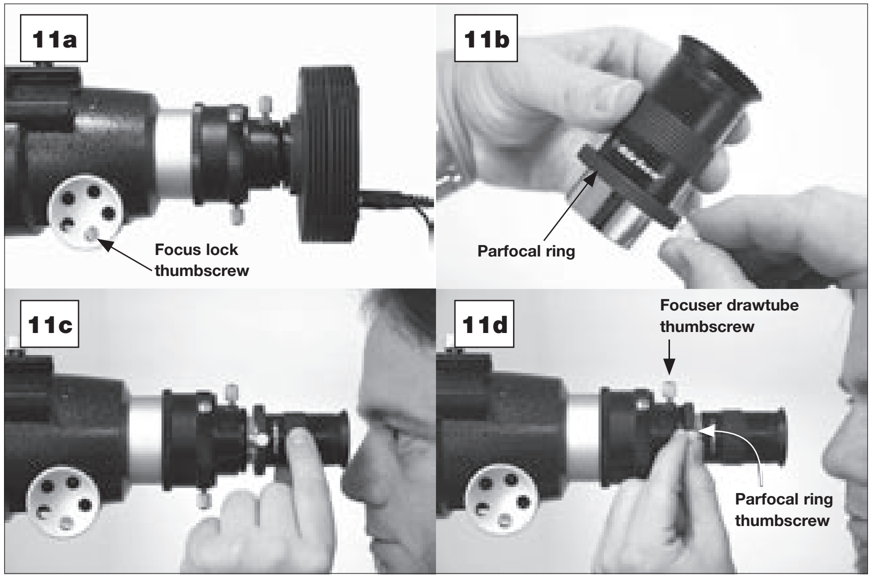

Figure 11a-d: (11a.) To properly set the position of the parfocal ring on an eyepiece, first focus the camera in the telescope. If you have a focus lock thumbscrew on your telescope's focuser, tighten it. **(11b.)** Place the parfocal ring on the eyepiece's barrel and slide it all the way up. Tighten the thumbscrew on the ring. **(11c.)** Remove the camera, and focus the eyepiece by sliding it in-and-out of the focuser drawtube. When eyepiece focus is achieved, tighten the thumbscrew on the focuser drawtube to secure the eyepiece in that position. **(11d.)** Now, loosen the thumbscrew on the parfocal ring, slide the ring all the way forward, and retighten the thumbscrew on the ring.

When the eyepiece is in focus, tighten the securing thumbscrew on the focuser drawtube to secure the eyepiece in that position. A significant portion of the eyepiece's barrel should be extending out from the focuser drawtube. Now, slide the parfocal ring down the eyepiece barrel, and seat it against the focuser drawtube (Figure 11d). Securely tighten the thumbscrew on the ring. The parfocal ring is now properly positioned on the eyepiece's barrel.

Now that the parfocal ring is properly positioned, focus the camera by first focusing with the eyepiece. Simply insert the eyepiece as far as it will go into the focuser drawtube, and focus with the telescope's focusing knob. Then, replace the eyepiece with the camera, and the images on the computer screen should be very close to focused. Use **Fast Focus** (or just **Focus**) to achieve a precise focus with the camera. You'll find that using the parfocal ring on an eyepiece will serve to focus the camera much more quickly.

Astronomical Imaging

Now that you're familiar with basic camera and software operation, it's time to take the SSDSI out at night under the stars to capture some astronomical images. We recommend starting with the Moon, as it is easy to acquire into the camera's field of view, and typically does not require stacking of multiple exposures as planetary and deep sky images do.

Imaging the Moon

Imaging the Moon is much like imaging terrestrial objects during the day. Since the exposure is very short, it is not critical that the telescope mount be precisely polar aligned. Best focusing will be achieved by first focusing on a bright star near the Moon. Start with short exposures of less than 0.1 seconds.

When the moon is past half full, it is hard to get detail due to the tremendous glare off of the lunar surface. Most detail, even on a sliver of a moon, will be at the terminator (the tiny thin line between the shadow and light, see Figure 12). To get more of the moon in the image, a focal reducer will need to be used. For close-ups of craters use a barlow lens (see "Using Focal Reducers and Barlow Lenses").

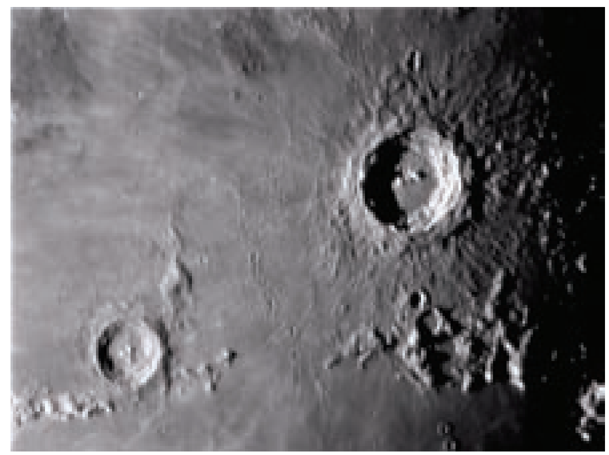

Figure 12: The Moon's surface detail looks the best along the terminator.

Imaging Planets

The best planetary images will be obtained by stacking (combining) many individual images in order to improve image contrast, brightness, and detail. Because the angular diameter of planets is quite small, you will need to use a barlow lens between the SSDSI and telescope to extend the effective focal length of the system and increase image scale (see "Using Focal Reducers and Barlow Lenses").

Since you will be taking multiple images over a period of time, it is important the mount be polar aligned in order to keep the planet within the field of view of the camera and to prevent image blurring due to poor tracking during each exposure. To this end, you should also have the right ascension (R.A.) motor drive engaged. Do not bother trying to obtain a perfect polar alignment, as that will only be important for taking longer exposure images of deep sky objects; most planetary exposures will be less than a few seconds.

To take multiple images of a planet for stacking:

1. Acquire the planet into the field of view of your telescope (barlow lens attached) with the eyepiece that has the parfocal ring attached to the planet, and center the planet in the eyepiece's field of view. Focus the eyepiece with the telescope's focuser.
2. Now, remove the eyepiece and replace it with the SSDSI. If the parfocal ring was set properly on the eyepiece, the camera should be close to focused.
3. In the **Camera Control Window**, set the **Mode** to **Light Color 1x1**. Set **Seconds** (exposure time) to 0.5 seconds to begin with. In the box below the **Mode** box, select **Fast Focus** (**Focus** can also be used here). Click the **Expose** button.
4. Focus the camera using the telescope's focus knob. If you are having trouble determining best focus, try focusing on a bright star near the planet. You can also use the histogram functions for most accurate focus; this will be explained later (see "Focusing"). Click the **Stop** button in the **Camera Control Window** when camera focus is achieved.
5. Now, in the box beneath the **Mode** box, choose **Autosave**. Set the number of images you would like the camera to take under **Autosave** (start with 10 or so), select the file folder in which you would like to save the images with **Folder**, and enter in a **Base filename** for the captured images. Typically the name of the object being imaged, such as "Mars1", will be entered here. If "Mars1" is the **Base filename**, and you choose to **Autosave** five images, then the images will appear in the selected file folder as "Mars1_0001.fit", "Mars1_0002.fit", "Mars1_0003.fit", "Mars1_0004.fit", and "Mars1_0005.fit".
6. Click **Expose**, and the camera will commence capturing and saving the images.

Now that we have multiple images of the planet, we will combine the imagesto form one high-quality resultant image. To do this:

7. Select **Open** from the **File** menu. Find the folder you indicated with **Folder**, open it, and select all images for stacking using the mouse left-click and the Shift key. All of the individual images selected will open in Maxim DL Essentials.

Note: In order to combine images, the images must first be opened in Maxim DL Essentials.

8. Select **Combine** from the **Process** menu. In the pop-up window, you will see all of the images currently open in Maxim DL Essentials. Choose the individual images you want to stack and press the >> button, or simply click **Add All**. Click the **OK** button when done.
9. The **Combine Images** window will appear (Figure 13). For **Align Mode**, choose **Planetary.** In the **Output** box, select **Average.**

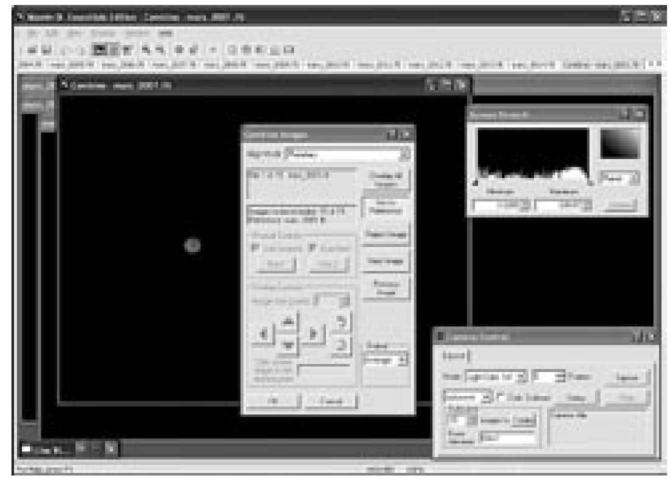

Figure 13: The **Combine Images** window allows "stacking" of individual images into one high-quality resultant image.

10. Now, you can see how each individual image looks by using the **Next Image** and **Previous Image** buttons. If you see an image that looks poor, you can reject it from the stack by clicking the **Reject Image** button.

*Note: At least one image must be used as the reference image for the stacked images to be overlaid upon. The default uses the first image for the reference image. If you reject the first image or otherwise want to use another image as the reference, click the **Set As Reference** button when the desired reference image is actively displayed. If the image currently chosen as the reference is rejected from the stack, and another reference image is not selected, you will not be able to **Overlay All Images.***

11. Now, click the **Overlay All Images** button. All of the selected images will stack on top of each other to form one resultant image. Click **OK**.

You have now composed your first planetary image. Use **Save** under the **File** menu to save your image at this time. To make it look its best, you will want to adjust the **Screen Stretch Window** to **Planet.** You may also want to do some image processing, see the section entitled "Image Processing" for more information.

Imaging Deep Sky Objects

To capture breathtaking images of deep sky objects, such as galaxies, nebulae, and star clusters, much longer exposures are needed. As with planetary imaging, we will take several individual images and stack them together to form one high-quality resultant image. But while planetary images are formed by stacking many exposures of less than 5 seconds, deep space images will generally be comprised of individual images of a minute or longer!

Because of this, polar alignment and motor drive tracking must be very accurate. If not, images will be blurred and stars will not appear round. Also, because camera noise increases greatly over exposure time (due to internal heat generation), we will need to suppress the inherent camera noise with the built-in thermoelectric cooler (TEC). The 12VDC cable should be connected to an appropriate power source and plugged into the SSDSI to turn the TEC cooling unit on.

To start:

1. Acquire the deep sky object into the field of view of your eyepiece that has the parfocal ring attached to it, and center it in the eyepiece's field of view. Focus the eyepiece with the telescope's focuser. Make sure your equatorial mount is well polar aligned, and the R.A. motor drive is on and engaged.
2. Remove the eyepiece and replace it with the SSDSI. If the parfocal ring was set properly on the eyepiece, the camera should be close to focused.
3. Precisely focus the camera by using the telescope's focus knob and the **Fast Focus** (or **Focus**) setting in the **Camera Control Window**. Set the **Mode** to **Light Color 1x1**, and try an exposure time of a few seconds to start. If you are having trouble determining best focus, try focusing on a bright star near the deep sky object. If there are no suitably bright stars in the camera's field of view, you may need to slew the telescope away from the deep sky object to a bright star, focus on the bright star, and then re-center the deep sky object in the camera. When you have a good focus, press the **Stop** button in the **Camera Control Window**
4. Now, in the box under the **Mode** box in the **Camera Control Window**, select **AutoSave**. Set the number of images you would like the camera to take under **Autosave** (start with 5 or so), select the file folder in which you would like to save the images with **Folder**, and enter in a **Base filename** for the captured images. Typically the name of the object being imaged, such as "OrionNebula1", will be entered here. If "OrionNebula1" is the **Base filename**, and you choose to **Autosave** five images, then the images will appear in the selected file folder as "OrionNebula1_0001.fit", "OrionNebula1_0002.fit", "OrionNebula1_0003.fit", "OrionNebula1_0004.fit", and "OrionNebula1_0005.fit". Try exposures of 30 **Seconds** to start.
5. Click **Expose**, and the camera will commence taking the images.

Note: When the camera is taking long exposure images, it is critically important not to touch, shake, or otherwise disturb the telescope, or a blurred image will result. Also, make sure no surrounding light shines into the telescope during the exposure.

Now that you have multiple images of the deep sky object, we will combine the images to form one high-quality resultant image. To do this:

6. Select **Open** from the **File** menu. Find the folder you indicated with **Folder**, open it, and select all images for stacking using the mouse left-click and the Shift key. All of the individual images selected will open in Maxim DL Essentials.

Note: In order to combine images, the images must first be opened in Maxim DL Essentials

7. From the **Process** menu, select **Combine**.
8. In the **Select Images** window, click **Add All**. Then click **OK**.
9. The **Combine Images** window will appear. For **Align Mode**, choose **Manual 1 star – shift only**. (If you have field rotation due to a poor polar alignment, then you can use the **Manual 2 stars** align mode.) In the **Output** box, select **Average.** Make sure the **Use Centroid** and **Auto Next** boxes are checked.
10. Now, find a well-shaped (circular) star in the first image displayed. Use the mouse to center the crosshairs on the selected star and left-click.
11. The next image will now be displayed; center the crosshairs on the same star in this new image, and left-click again. Repeat this for all the open images; a chime will sound when you have gone through all the open images. (If you use the **Manual 2 stars** align mode, then select another alignment star in the first image displayed after you hear the chime.)
12. If you find an image that looks poor, you can reject it by clicking the **Reject Image** button. Use the **Next Image** (and/or **Previous Image**) button to continue going through the open images after an image is rejected.

*Note: At least one image must be used as the reference image for the stacked images to be overlaid upon. The default uses the first image for the reference image. If you reject the first image or otherwise want to use another image as the reference, click the **Set As Reference** button. If the image currently chosen as the reference is rejected from the stack, you will not be able to **Overlay All Images.***

13. Now, click the **Overlay All Images** button. All of the selected images will stack on top of each other to form one resultant image. Click **OK**.

Adjust the **Screen Stretch Window** to **Medium** (or otherwise manually adjust for best image appearance), and use **Save** under the **File** menu to save your image. You can now perform any wanted imaging processing (see "Image Processing"). To get the very best images, however, you should subtract "dark frames" from images prior to stacking with the **Combine** function.

Dark Frames

To completely eliminate any remaining camera noise, you can take several "dark frames", average them, and subtract them from images before stacking. A dark frame is an image taken with no external light coming into the camera. What results is an image of the camera's remaining background noise only. When a dark frame containing the camera's noise pattern is subtracted from images (prior to combining them), the noise is essentially eliminated. The dark frames can be taken before or after the "light" images are acquired, but if they are taken beforehand, the dark frame subtraction process can be automated.

Note: To most effectively use dark frames to subtract noise out of resultant SSDSI images, it is important to take dark frames close to the actual time of taking the "light" images. This is because temperature changes will cause the noise pattern in the SSDSI to change over time. So, it is best to take some dark frames immediately before or after the "light" images are taken.

*Important Note: Dark frames (**Dark Raw 1x1**) should only be subtracted from **Light Raw 1x1** images. If you try to subtract dark frames from images that are already color-converted (i.e. **Light Color 1x1** images) the resultant image color will be incorrect .*

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

1. In the **Camera Control Window**, set the Mode to **Dark Raw 1x1**.
2. Set the exposure time to whatever you set it to (or will set it to) for taking actual ("light") images.

*Note: When taking dark frames, do not change any of the settings in the **Setup** button from what they were (or will be) when "light" images are taken.*

3. In the box beneath the **Mode** box, choose **Autosave.** Now set the number of dark frames you would like the camera to take under **Autosave** (3 to 10 will generally suffice, as these will be averaged together), select the file folder in which you would like to save the dark frames with **Folder**, and enter in a **Base filename** for the captured dark frames. Typically the name of the object being imaged with the word "dark" added, such as "OrionNebula1dark", will be entered here. If "OrionNebula1dark" is the **Base filename**, and you choose to **Autosave** five images, then the images will appear in the selected file folder as "OrionNebula1dark_0001.fit", "OrionNebula1dark_0002.fit", "OrionNebula1dark_0003.fit", "OrionNebula1dark_0004.fit", and "OrionNebula1dark_0005.fit". Using the word "dark" in the **Base filename** will help you distinguish between light and dark frames when combining later.
4. Click **Expose**, and Maxim DL Essentials will indicate the camera needs to be covered to take a dark frame. Cover the front of the lens you are imaging through, and then click **OK**. The camera will commence taking and saving the dark frames.

Now that you have acquired several dark frames, combine them into a single averaged dark frame for subtraction from "light" images:

5. In the Process menu, select **Setup Dark Subtract**.
6. In the window that pops-up, click **Remove All** if any filenames appear in the window.
7. Click **Add**, and select the file folder location for the dark frames taken. Select the dark frames and click **Open**.
8. The selected dark frames will now appear in the pop-up window. Click **OK**.

You are now ready to subtract the averaged dark frame from "light" images. This should be done to individual light images BEFORE combining them together. There are two ways to do this. If you take dark frames first, before taking light images, then you can automatically subtract the averaged dark frame from each individual light image as it is captured. If you take dark frames after you have already taken the light images (using **Light Raw 1x1**), then you can subtract the averaged dark frame from each individual image before you combine them into a single, final resultant image.

To automatically subtract the averaged dark frame from "light" images as they are captured:

1. Setup the averaged dark frame as outlined previously.
2. Acquire the deep sky object into the field of view of your eyepiece that has the parfocal ring attached to it, and center it in the eyepiece's field of view. Focus the eyepiece with the telescope's focuser. Make sure your equatorial mount's motor drive is on and engaged. Remove the eyepiece and replace it with the SSDSI. If the parfocal ring was set properly on the eyepiece, the camera should be close to focused. Precisely focus the camera by using the telescope's focus knob and the **Fast Focus** (or **Focus**) setting in the **Camera Control Window**.
3. In the **Camera Control Window**, click the **Dark Subtract** square so it is checked. Once this box is checked, every subsequent light frame taken with the camera will have the averaged dark frame automatically subtracted.
4. Now, set the **Mode** to **Light Raw 1x1**. In the box under the **Mode** box, select **AutoSave**. Set the number of images you would like the camera to take under **Autosave** (start with 5 or so), select the file folder in which you would like to save the images with **Folder**, and enter in a **Base filename** for the captured images. Set the exposure time equal to that of the dark frames taken prior.
5. Click **Expose**, and the camera will commence taking the images. When it saves each image file to its designated **Folder** location, it will automatically subtract the averaged dark frame.

6. Before these images are ready for stacking, they must be converted from raw format to color format. To do this, open all images to be stacked in Maxim DL Essentials. Click on one of the images and select **Covert Raw to Color** from the **Process** menu. For convenience, there is a button on the toolbar that you can click instead of using the menu. Click the **Reset Background Level** and the **Reset Scaling** button (scaling can be used to fine-tune the color balance later on). Turn off **Anti-Alias Filter**. Click **OK**. Repeat this for all the open images.

These images have the averaged dark frame subtracted and have been color converted. These are now ready for stacking (using the **Combine** function). You can **Save** the individual images, or just save the combined image after stacking.

If you have already taken your "light" images (remember that these must be **Light Raw 1x1** NOT **Light Color 1x1**), then you will need to manually subtract the averaged dark frame from each image prior to stacking them into one combined image. To do this:

1. Open all "light" images to be stacked in Maxim DL Essentials. Do this with the **Open** command in the **File** menu.
2. Click on one of the opened images, and select **Dark Subtract** from the **Process** menu. The averaged dark frame has now been subtracted from the selected "light" image. Repeat this process for all of the "light" images opened in Maxim DL Essentials.
3. Before these images are ready for stacking, they must be converted from raw format to color format. To do this, click on one of the opened images and select **Covert Raw to Color** from the **Process** menu. For convenience, there is a button on the toolbar that you can click instead of using the menu. Click the **Reset Background Level** and the **Reset Scaling** button (scaling can be used to fine-tune the color balance later on). Turn off **Anti-Alias Filter**. Click **OK**. Repeat this for all the open images.

You can save each image after dark frame subtraction and color conversion (using **Save** from the **File** menu), or you can just save the final combined image once the individual images have been stacked using the **Combine** function.

Note that the **Light Color 1x1** mode is really just for quick previewing how an image might look, and is generally not often used. For most astronomical imaging, the **Light Raw 1x1** is the mode that should be used; this allows for **Dark Raw 1x1** frame subtraction, with subsequent color conversion with the **Convert Raw to Color** command.

Light and Dark Mono 2x2 Modes

For added convenience and versatility, the SSDSI's individual pixels (light-detecting sites) can be "binned" into units of two-by-two pixels (i.e. four individual pixels create one binned 2x2 pixel). This creates larger and more sensitive pixels, but with decreased resolution. This can be useful for some types of astronomical imaging, such as capturing faint nebulae. It can also be useful for quick-checking the aiming of the telescope or framing of objects within the field of view of the camera before using the normal **Light Raw 1x1** mode to actually capture images.

To use in "2x2" mode, select **Light Mono 2x2** mode for capturing "light" images, and **Dark Mono 2x2** mode to capture dark frames for averaging and subtracting. Images can be combined and processed in the same way as **Light Raw 1x1** images, except the **Convert Raw to Color** command does not apply (as the 2x2 images are monochrome only).

Image Processing

After you have captured and combined individual images (with or without dark frame subtraction) into a single resultant image, you may want to perform some additional image processing to bring out subtle details or to make the image appear more pleasing overall. Maxim DL Essentials contains several functions which serve to do this.

Make Pixels Square

This command provides a one-step adjustment of the image aspect ratio. It uses the pixel aspect ratio determined by the file header and interpolates the image to make the aspect ratio 1:1. This generally has a very mild affect when applied to images. For best results, this function should be applied to individual images before stacking (for best image alignment), but can be used after stacking as well.

To use this function, simply select **Make Pixels Square** from the **Process** menu for any image currently opened in Maxim DL Essentials.

Unsharp Mask

An **Unsharp Mask** is fairly simple in concept. First, a copy of the original image is smoothed (low-pass filtered) to create the mask. This mask is then scaled down in intensity by some factor (usually 50-95%), and then subtracted from the original image. The result of subtracting a blurred copy of the image from itself is to make a sharper image. This works because you are partially removing parts of the image that are smoother, while leaving untouched the parts of the image with fine detail. Usually the math is adjusted so that the average pixel values in the final image are the same as the original.

To apply **Unsharp Mask** to an image:

1. Select **Unsharp Mask** from the **Process** menu.
2. In the pop-up window (Figure 14), the **Low-Pass Filter** can be set to **Mild** or **Strong**.
3. The **Mask Weight** is used to control the strength of the mask. The mask weight is in percent; the higher the number, the stronger the mask.

4. Reference the **Preview Image** (or click on the **Auto Full Screen** preview button), and adjust the settings. This allows you to rapidly adjust the settings until you are satisfied with the results.
5. Click **OK** when the image looks its best.

It is best to use a light touch with this command, to avoid over-processing the image. Over-processing can create artifacts; i.e. features in the image that are not real. It also amplifies the noise in the image.

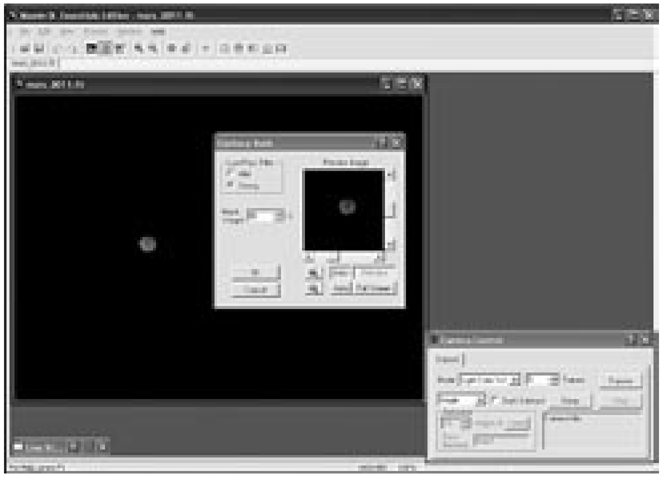

Figure 14: The **Unsharp Mask** function can help bring out subtle detail in an image.

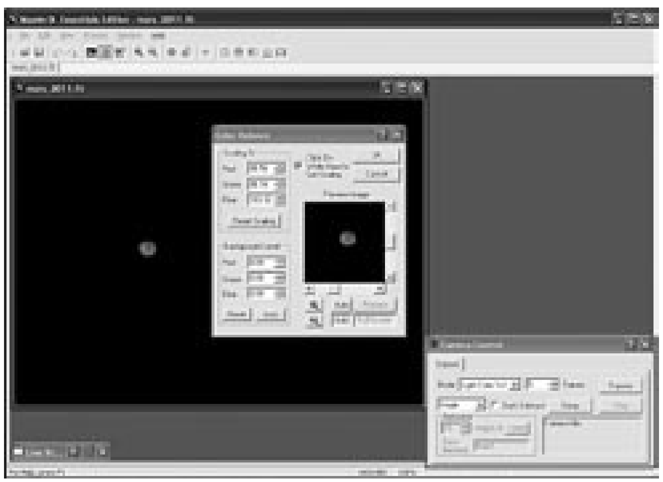

Figure 15: The **Color Balance** command allows weighting of each color plane to improve the overall color appearance of an image.

Color Balance

The sensitivity of most CCD cameras as a function of wavelength (color) is different from the response of the human eye. The filters used for creating color composites also have their own characteristics, as do the telescope optics. Although "perfect" color rendition is an elusive if not impossible goal (all individuals see colors slightly differently), it is straightforward to get "good" color balance with simple weightings. This is where the **Color Balance** command (in the **Process** menu, Figure 15) comes in handy to touch up the resultant colors in your images. Use the **Preview Image** to see how altering these parameters will affect your image (or click the **Full Screen** button to see the changes applied to your full image).

Color images from CCD cameras typically require a background level adjustment. This is accomplished by bringing the background level (or bias) in each color plane down to zero. Each of the **Background Level** values is subtracted from every image pixel in its color plane. Any pixel values that become negative are forced to zero. The **Auto** button automatically determines the settings necessary to equalize the image background in all three color planes. The **Reset** button resets the background level subtraction to zero on all planes.

Scaling adjustment (entered as a percentage) allows you to compensate for transmittance differences between the filters used to acquire the three color planes. Values of 100% result in no change. The scaling percentages can be typed in or adjusted using the "spin" controls (small up and down click arrows to the right of the scaling numbers). The **Preview Image** is particularly helpful in monitoring the results when using the spin controls. The **Reset Scaling** button resets to 100% on all three planes.

The **Click On White Area to Set Scaling** check box enables the operation of the mouse to set the scaling. Set the **Background Level** first (you can use **Auto**), then click on a white object (e.g. a neutral-colored star) in the image (not the **Preview Image**) with the mouse. The **Scaling** settings will automatically be adjusted to make the selected point appear white. If an area of the image is known to be white (or gray), this is an easier way to determine the scaling factors, and can be used to instantly color balance the image.

Stretch

The **Stretch** command (located in the **Process** menu, Figure 16) modifies the brightness and contrast, and optionally the range (maximum and minimum pixel values) of an image. Unlike the screen stretch settings in the **Screen Stretch Window,** which only affects the how an image appears on the computer screen, the **Stretch** command actually changes the image data pixel values in the memory buffer. In reference to the histogram, the **Screen Stretch Window** changes how the histogram is displayed on the computer screen, the **Stretch** command alters the histogram itself.

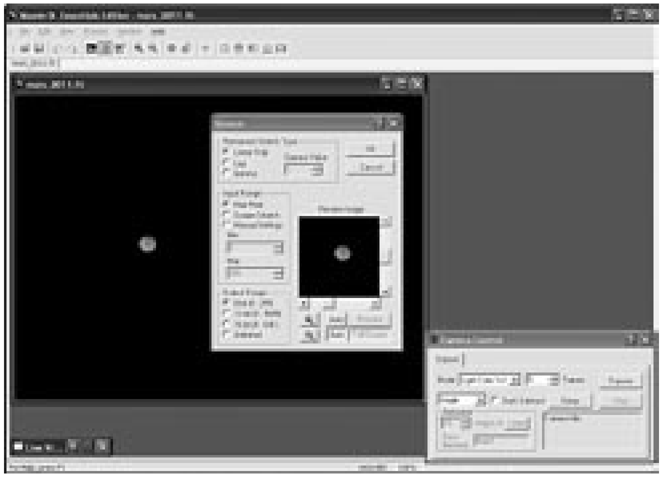

Figure 16: The **Stretch** command modifies the data contained within the image in order to improve contrast and brightness.

There are three elements which must be set: the **Permanent Stretch Type**, the **Input Range**, and the **Output Range**. You can use the **Preview Image** to see how changing these parameters will affect the resultant image (or click the **Full Screen** button to see the changes applied to your actual image). You can also open the **Screen Stretch Window** to see how changing these parameters change the histogram.

For the **Permanent Stretch Type**, the **Linear Only** mode is useful for adjusting the range of pixels to match a particular file format. The **Log** mode is useful for compressing the dynamic range of the image, but can be rather harsh. The **Gamma** mode allows you to selectively emphasize bright or dim parts of the image by entering a suitable **Gamma Value**. A **Gamma** of 1 has no effect, less than 1 will emphasize faint details, while a value greater than 1 will emphasize bright details.

The **Input Range** can be set to **Screen Stretch**, which in **Linear Mode** produces an output matching the current screen appearance. This is useful in producing final images for output to 8-bit image formats which have limited range. Note that the minimum and maximum values are always taken from the screen stretch settings for the original image. These can be adjusted dynamically using, for example, **Quick Stretch**. The **Max Pixel** selection sets the input range from 0 to the brightest pixel in the image. This prevents any image pixels from being saturated in the final result, but may produce images with low contrast. You can also manually set values with **Manual Settings** in a similar fashion to the **Screen Stretch Window**.

The **Output Range** is used when preparing a file to be saved in a format that has limited range. The **Output Range** maps minimum input to zero, and maximum input to 255, 4095, or 65535 depending on the settings. Any values that

exceed the limits are clipped. The **Unlimited** setting disables all limiting and is recommended when performing **Gamma** and **Log** stretches; it is appropriate when the image will be saved in floating point format.

Recommended Processing Sequence

What is the best order to apply the processing functions in? Here is a recommended sequence:

1. **Dark Subtract**
2. **Convert Raw to Color**
3. **Make Pixels Square**
4. **Combine**
5. **Unsharp Mask**
6. **Color Balance**
7. **Stretch**

For convenience, you can **Make Pixels Square** after the combine, unless alignment requires rotating the images (i.e. **Manual 2 stars** is used as the **Align Mode** in the **Combine Images** window). If you need to rotate the images by more than a small amount, then you should make them square first to avoid geometric distortion between the frames.

Once you have the combined image, there is a lot more room for experimentation and tinkering. Be sure to **Save** a copy of the combined image; otherwise you might have to go back to the beginning and stack individual images again!

Note on File Format

When saving images (using **Save** or **Save As** in the **File** menu), you have a choice of file formats. The default produces .fit files, but .tif, .jpg, .png, and .bmp file formats can also be selected. Having a choice of output file formats is useful, especially if images will be exported to other software programs for additional image processing (like Adobe Photoshop, for instance).

If you save to a file format other than .fit, you will need to check the **Auto Stretch** box, or otherwise **Stretch** the image to change the **Output Range** (in the **Stretch** command window) to match the **Size Format** (in the **Save As** window). Otherwise, the **Output Range** will likely exceed the **Size Format**, and the saved image will be ruined (will turn all white).

For example, say the **Output Range** is set to create image brightness values in 16-bit format, while the **Size Format** of a specific file format (.jpg, for example) may only support 8-bits. Since the 16-bit format sees 65535 brightness levels, and the 8-bit format can only support 255 levels, all of the levels above 255 in the 16-bit image (i.e. the vast majority of the 16-bit brightness levels) will be saved at the maximum 8-bit value of 255. So the saved .jpg will have very little brightness information from levels 1 to 254 and almost all the brightness information at level 255. Thus a white image results.

Using The SSDSI As An Autoguider

A great feature of the SSDSI is its ability to be used as an autoguider for telescope mounts. You can use the SSDSI to autoguide a mount while images are being taken with another camera, such as a DSLR.

Tracking errors are usually sufficiently small on short duration images (15 to 90 seconds depending on the mount) that guiding is not required. Therefore a series of short exposure images can be taken and combined together later using the **Combine** command. However, in many cases a single long exposure is superior due to the elimination of extra readout noise and the residual blurring caused in realigning the images.

When taking long exposures with astronomical telescopes, motorized tracking is required to compensate for the Earth's rotation. Most telescope mounts do not track accurately enough for long-exposure imaging without some form of additional "guiding". Manual guiding can be done by an observer watching a star ("guide star") through a telescope ("guide scope") mounted next to the main imaging telescope (on the same mount). The observer makes manual corrections to the motor drives via a pushbutton hand controller to keep the star centered in the guide scope's eyepiece over time. In this way the tracking accuracy of the main telescope (with imaging camera attached) can be assured. Stars in the resultant images will be crisp and round. Manual guiding can be very tiresome and tedious, however, especially if taking many long exposures throughout the night.

The SSDSI can be used as an "autoguider" to take the place of the observer so that no manual guiding corrections are needed during long exposure imaging. Keep in mind, however, that when the SSDSI is used in this way, you will need another telescope and camera (such as a DSLR) on the mount to actually take images with; the SSDSI takes the place of the observer viewing through the guide scope, but cannot autoguide and image at the same time.

So, in order to use the SSDSI as an autoguider, the following equipment will be required:

- Astronomical telescope mount capable of accepting autoguider drive commands.
- Cable to connect computer (serial port) to mount's autoguider jack (mount specific).
- Main telescope for imaging.
- Camera for imaging (which may require its own computer).
- Guide scope for guiding.
- Any required rings or brackets for guide scope attachment to the mount along with the main telescope.

Computer to Mount Connection

In order for autoguiding with the SSDSI to work, you need a way to send commands from the computer to the telescope mount. This is generally done with a cable connecting the computer's serial (COM) port to the mount's autoguider jack; this cable is generally mount specific, so contact the dealer you purchased your mount from for the proper cable for your mount.

If your telescope mount is supported by the ASCOM platform, it is a simple task to setup the autoguider to send commands (through the computer) to the telescope mount. To do this:

1. Insert the included CD-ROM into your computer.
2. When the **Launcher** appears (Figure 4), click on the **Install ASCOM** button and follow the automatic ASCOM platform installer instructions. Restart your computer as indicated when done.
3. Connect the SSDSI to your computer and open the Maxim DL Essentials software.
4. In the **Camera Control Window**, click on the **Guide** tab (Figure 17).

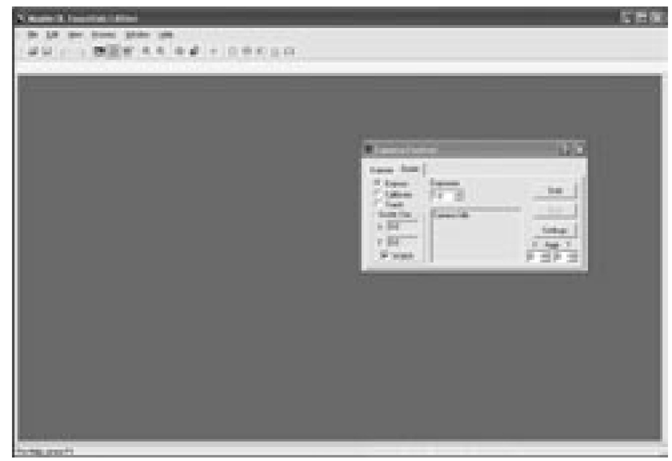

Figure 17: The **Guide** tab in the **Camera Control Window** is where the SSDSI's autoguider functions can be accessed.

5. Click on the **Settings** button.
6. In the window that pops-up (Figure 18), select **ASCOM** for the **Autoguider Output Control Via.** Click the Setup button under the **Autoguider Output** heading.
7. The **ASCOM Telescope Chooser** (Figure 19) will appear. Select your telescope model from the provided choices. If your model does not appear, it is not supported by the ASCOM platform.

Figure 18: The autoguider **Settings** window is where the **Autoguider Output** is defined.

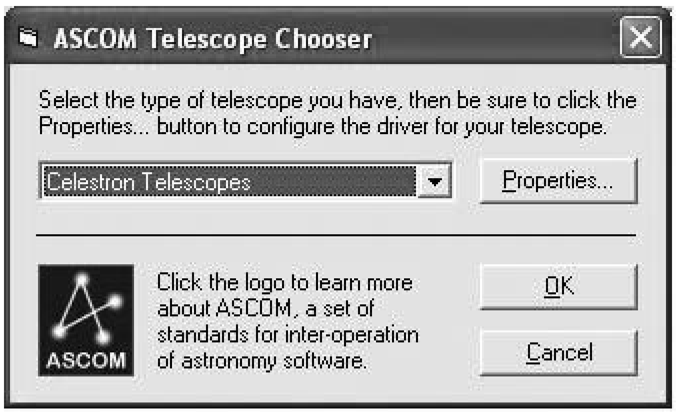

Figure 19: The **ASCOM Telescope Chooser** provides an easy way to establish a computer-to-mount communications link if the mount is supported by the ASCOM platform.

8. After you have selected your telescope model, click the **Properties** button.
9. In the window that pops-up, choose your specific **Scope Type** and desired **Serial Port** where the computer will send commands to the mount. Click **OK** when done.
10. Click **OK** in the **ASCOM Telescope Chooser** window.
11. In the **Settings** window, click the **Close** button.

Some telescope mounts accept commands in the “LX200 Protocol”. For these mounts, it is not necessary to install the ASCOM platform to have the computer “talk” to the mount. To setup the autoguider for mounts that use the LX200 Protocol:

1. Connect the SSDSI to your computer and open the Maxim DL Essentials software.
2. In the **Camera Control Window**, click on the **Guide** tab.
3. Click on the **Settings** button.
4. In the window that pops-up, select **LX200 Protocol** for the **Autoguider Output Control Via.** Select the **COM Port** of the computer you would like to use to send commands to the telescope
5. Click the **Apply** button, then click the **Close** button.

Autoguider Calibration

In order to properly control the mount, you must calibrate the system. The exact orientation of the SSDSI, the focal length of the guide telescope optics, and the speed of the motor drive all affect the calibration. To perform autoguider calibration:

1. Switch to the **Guide** tab.
2. Set the **X** and **Y Aggr** (aggressiveness) to 8 to start with. Set the **Exposure** to 1.0 second. Under **Guide Star**, make sure the **Watch** box is checked.

*Note: The **X** and **Y Aggr** (aggressiveness) controls on the **Guide** tab allows you to adjust how vigorously star motions are tracked out in each axis. An aggressiveness setting of 10 means that the SSDSI attempts to track out 100% of the motion, whereas a setting of 1 means that the SSDSI only tracks out 10% of the motion. Usually a setting of around 8 or 9 provides the best tracking, since it reduces overshoot and helps ignore random motions due to atmospheric seeing and wind loads. You should experiment to determine the best setting for your particular telescope.*

3. Click the **Settings** button.
4. Maxim DL Essentials needs to know how fast the telescope moves in right ascension (R.A.) and declination (Dec.) when the autoguider commands are issued. To do this, the software will **Calibrate** the mount by moving it back and forth on each axis. The **Calibration Time** determines how long it activates the motors each time. The usual value is 5-10 seconds; start out with a value of 5.
5. Make sure all of the **Guider Enables** boxes are checked.
6. For **Autoguider Output**, set **Control Via** and **COM Port** as required for your telescope equipment. See “Computer to Mount Connection” if you have not already done this.
7. Click **Apply.** You can leave this dialog box open, or **Close** it if you wish.

8. Make sure that the telescope mount is set to move at 1X sidereal or slower. For some mounts, you must set the guide rate manually. The maximum usable rate is 1X sidereal. If your mount does not drift quickly, then 0.1X is recommended; otherwise use a value between 1X and 0.1X.
9. On the **Guide** tab, set to **Expose**, and click the **Start** button. A single image will be taken. Ensure that a well-focused bright star (near the actual object to be imaged) appears in the image. If not, adjust the guide scope and try again. Make sure the star is roughly centered.

Note: The algorithm can be confused if another star appears in the frame; to minimize this risk, calibrate on an isolated bright star.

10. Now, set to **Calibrate**, and click the **Start** button. A series of five exposures will be taken; each time the telescope will be moved slightly. If the telescope does not move, check the **Settings**. Remember, you have to set up a method for sending the autoguider commands to the telescope!
11. The star should move in an L shape. If it does not move enough, a warning message will appear. The recorded positions will be displayed in the scrolling log, along with any error messages.

*Note: If the star does not move far enough, or moves too far (i.e. the star leaves the field), the duration of the calibration move commands can be adjusted by clicking the **Settings** command and changing the **Calibration Time** fields (measured in seconds). A longer calibration time will increase the motion of the star; a shorter time will decrease the motion. Typical values range from five to ten seconds, depending on the correction speed, focal length, and pixel size.*

12. Once you have successfully calibrated, switch to the **Track** mode. Click **Start**, and watch the star. It should move to the center of the small track box, and whenever it drifts off it should be pulled back again. You can zoom in the window for a better look. Also the tracking errors will be displayed in the scrolling log.
13. If the star bounces back and forth, reduce the aggressiveness for that axis. If it corrects too slowly, increase the aggressiveness. Changes to the aggressiveness settings take effect immediately.

You are now ready to take a long-exposure image through the main telescope and imaging camera. The SSDSI will continuously send small correction factors to the mount's motor drive to insure steady and accurate tracking throughout the duration of the exposure, however long that may be.

Other Autoguiding Notes:

• If you are using a German equatorial mount you must calibrate with the tube on the same side of the mount as it will be when actually imaging.

*• The calibration settings need changing if you move the telescope in declination by more than about five degrees. Select another bright star, and **Calibrate** again.*

*• If you experience bad guiding in declination and cannot resolve it through adjusting the calibration or aggressiveness, you may have a stiction problem with your declination drive. Watch which way the star drifts, and turn off the **Guider Enable** checkbox (in the **Settings** window) that pushes the star in that direction. That will prevent the stiction cycle from happening.*

• Make sure that any backlash compensation in the mount is turned off.

• On most telescopes, the Right Ascension drive likes to have some load pushing against sidereal tracking. If the mount is balanced such that it is pulling the mount forwards slightly, the gear teeth may bounce back and forth resulting in terrible guiding that cannot be corrected by an autoguider. Be sure to always balance the telescope such that it "lifting the weight" rather than "allowing it to fall"; i.e. heavier on the East side. Note that this may require balancing the telescope differently when it is pointed East versus West.

Other Features Of Maxim DL Essentials

Edit Menu

Flip - Flips image orientation. "Folds" image about vertical center.

Mirror – Creates mirror image of current image orientation.

View Menu

Zoom – Increases or decreases level of image magnification on computer screen. When you zoom in too much, you will start to see the squares of individual pixels. When zoomed in, you can use **Quick Pan**; simply hold down the Ctrl key, then left-click and drag the mouse on the image.

Night Vision – Toggles Night Vision mode. The red background helps preserve your night vision.

Window menu

These functions alter the way multiple open image frames are arranged and displayed within Maxim DL Essential. These functions are very useful for organizing the visual display when processing large numbers of raw images for stacking.

*Note: The **Open or Convert AVI File** command in the **File** menu is for the StarShoot Solar System Imager, not the SSDSI.*

Tips

Polar Alignment

Good telescope mount polar alignment is of critical importance for long-exposure CCD imaging. Inaccurate polar alignment leads to image movement over time (even with motor drives running and engaged), which limits the amount of time an exposure can be taken before the stars begin to streak and blur.

If your equatorial mount uses a polar axis finder scope, we highly recommend utilizing it for polar alignment. If not, a technique known as the "drift method" of polar alignment has been used for many years, and can achieve an extremely accurate polar alignment. Unfortunately it is very time consuming, since the drift of a star over time must be observed. The basic idea is to let the telescope mount track while watching a star to see which way the star drifts. Note the direction of the drift, and correct by moving the mount in the appropriate direction.

To perform the drift method of polar alignment:

1. Do a rough polar alignment by pointing the R.A. axis of the mount at Polaris (the North Star).
2. Find a bright star near the meridian (the imaginary line running north-to-south through zenith) and near the celestial equator (zero degrees declination). Point the telescope at this star, and center it in an illuminated reticle eyepiece (available from Orion). If you don't have an illuminated reticle eyepiece, use your highest- magnification eyepiece.
3. Determine which way is north and south in the eyepiece by moving the telescope tube slightly north and south.
4. Now, let the mount's motor drive run for about five minutes. The star will begin to drift north or south. Ignore any east-to-west movement.
5. If the star drifts north, the telescope mount is pointing too far west. If the star drifts south, the telescope mount is pointing too far east. Determine which way the star drifted and make the appropriate correction to the azimuth position of the mount. Rotate the entire mount (and tripod) slightly east or west as needed or use the azimuth adjustment knobs (if your mount has them) to make fine adjustments to the mount's position.
6. Next, point the telescope at a bright star near the eastern horizon and near the celestial equator (Dec. = 0).
7. Let the telescope track for at least five minutes, and the star should begin to drift north or south.
8. If the star drifts south, the telescope mount is pointed too low. If the star drifts north the telescope mount is pointed too high. Observe the drift and make the appropriate correction to the mount's altitude (or latitude); most mounts have some sort of fine adjustment for this.

Repeat the entire procedure until the star does not drift significantly north or south in the eyepiece. When this is accomplished, you are very accurately polar aligned, and should be able to produce good (unguided) images of up to several minutes long, assuming the mount's drives track well with little periodic error.

Focusing

One of the hardest things to do in imaging is achieving good focus. You can simply watch the computer screen to focus (using **Fast Focus** or **Focus** in the Camera Control Window), but you can focus "by the numbers" on a bright star to get the best focus possible. To do this:

1. In the **Camera Control Window**, select **Light Raw 1x1** mode.
2. Set the exposure time to 1 to 5 **Seconds**, depending on how bright the star is.
3. Turn off **Dark Subtract**.
4. Now beneath the **Mode** selector, pick **Focus**, and then click **Expose**. The camera will take repeated exposures, until you click **Stop**.
5. Point the telescope at a bright star, and you can focus "by the numbers":

   • **MaxPixel** is the value of the brightest pixel in the image. When you are in focus, it will be at its highest value. You will need to look at the value for several images in succession, because the number will bounce around with the seeing.

*Note: If the **MaxPixel** reaches 65535, the image is saturated and all three focus numbers will be inaccurate. Either pick a fainter star, adjust the camera's **Analog Gain** settings using the **Setup** button, or use a shorter exposure time.*

   • **FWHM**, or Full-Width Half Maximum, is the width of the star half-way down the sides. This provides a highly accurate measurement when you are close to focus. When you are at focus, it will be at its lowest value. This number will vary due to seeing, so it is best to look at several images before decided.

   • **HFD**, or Half Flux Diameter, is similar to FWHM, but works much better than FWHM when the star is badly out of focus. It can produce a usable number even when the star looks like a donut.

Refocus often throughout your imaging session. This ensures at least some of your images will have an excellent focus. It is also not uncommon for telescope motions or movements to alter the focus slightly, so be sure to refocus after slewing to any new astro-imaging targets.

Choosing a Site for Astro-imaging

Once you have a focused image, you may find your image shifting and washed out. This can be caused by many environmental factors. Poor seeing (movement of molecules in the air, such as heat rising) and poor transparency (moisture, smoke, or other sky contaminants) will all serve to reduce image quality. That is why most major astronomical telescopes are on high mountains in thin air, to get above much of the transparency and seeing problems. Also, wind will move your telescope and affect images. Your eyes viewing through an eyepiece can change slightly to compensate for disturbances like these, but the camera can not. Keep these factors in mind when choosing an observing site for astronomical imaging.

For the best astro-images, we recommend finding a location with dry air, some altitude, and away from city or streetlights. Even a nearby hilltop in the countryside can provide better viewing conditions than many convenient backyard locations.

Loss of Camera Connection

If the computer connection to the camera is interrupted, you will need to re-establish connection. This can happen due to several reasons; if a cable becomes unplugged, the computer "freezes", or the software/hardware otherwise temporarily loses the data coming from the camera.

To re-establish camera connection, first close the Maxim DL Essentials program on your computer. Then, unplug and re-plug the camera into the computer's USB port. Now, open Maxim DL Essentials, and the **Camera Control Window** should appear indicating re-established connection between camera and computer.

Using Focal Reducers and Barlow Lenses

Focal reducers and barlow lenses change the effective focal length of a telescope. These lenses are inserted between the camera and telescope when imaging to change image scale.

Focal reducers serve to decrease the focal length of your telescope. This increases the field of view seen by the camera (decreases camera magnification). This can be very useful for obtaining images of wide-field deep sky objects, such as the Andromeda Galaxy or the Pleadies star cluster. Focal reducers will usually thread onto the nosepiece of the SSDSI.

Barlow lenses increase the focal length of your telescope, which makes the camera's field of view narrower (increases camera magnification). This is useful for planetary imaging. Keep in mind that when the focal length is doubled, the image will become four times dimmer, so a longer exposure may be necessary. Barlow lenses are generally inserted in the focuser's drawtube and secured with the thumbscrew on the focuser's drawtube, and the SSDSI's nosepiece is inserted into the barlow and secured with the thumbscrew on the barlow lens.

Filters

Any standard Orion 1.25" filter will thread into the front of the SSDSI's barrel.

For some types of planetary imaging, you may want to use color filters to bring out subtle details. Try using several different color filters on a planet to see which filters help best show planetary details.

For imaging deep sky objects under light-polluted skies, you can try a SkyGlow Broadband light pollution filer. This helps suppress the light emitted by streetlights, but still lets most of the light from deep sky objects through. An increase in overall image contrast results.

USB Extension Cable

In many instances, it is likely a longer cable for the SSDSI will be needed in order to comfortably setup telescope, camera, and computer. We recommend purchasing a 10' USB extension cable if you need more cord length (available through Orion, check the catalog and/or www.OrionTelescopes.com).

Care and Maintenance

When the SSDSI is not in use, the cover cap should be replaced on the end of the nosepiece. This prevents dust from accumulating on the IR filter or the SSDSI's optical window. If significant dust does accumulate on the filter or optical window, or any of the optical surfaces are touched, then they should be cleaned.

Any quality optical lens cleaning tissue and optical lens cleaning fluid specifically designed for multi-coated optics can be used to clean the glass surfaces of the IR filter and the SSDSI's optical window. Never use regular glass cleaner or cleaning fluid designed for eyeglasses.

Before cleaning with fluid and tissue, blow any loose particles off the surfaces with a blower bulb or compressed air. Then apply some cleaning fluid to a tissue, never directly on the optics. Wipe the optical surfaces gently in a circular motion, then remove any excess fluid with a fresh lens tissue. Oily fingerprints and smudges may be removed using this method. Use caution; rubbing too hard may cause scratches.

Specifications

CCD Sensor	Sony® ExView HADTM ICX259AK Color
Sensor size	1/3"
Pixels	752x582 (437,664 total)
Exposure range	0.002 seconds to 9.3 hours
A/D conversion	16 bit
Thermoelectric cooling	Yes, via onboard TEC
TEC current draw	Approximately 0.5A (12VDC), requires optional external power supply
Analog gain control	+10 dB
Oversampling	2x (increases signal-to-noise ratio)
Autoguider capability	Yes
USB connection	2.0 or 1.1
Camera current draw	Aproximately 0.3A (12VDC), powered by USB computer connection
IR filter	Yes, removable
Optical window	Fully coated with anti-reflection coatings
Weight	14 oz.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device nay 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 no 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 in 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 StarShoot Deep Space Color Imaging Camera 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 to: Orion Warranty Repair, 89 Hangar Way, Watsonville, CA 95076. If the product is not registered, proof of purchase (such as a copy of the original invoice) is required.

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, and you may also have other rights, which vary from state to state. For further warranty service information, contact: Customer Service Department, Orion Telescopes & Binoculars, P. O. Box 1815, Santa Cruz, CA 95061; (800) 676-1343.

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