



## ***Manual for the TRIUS PRO 694 mono CCD camera***



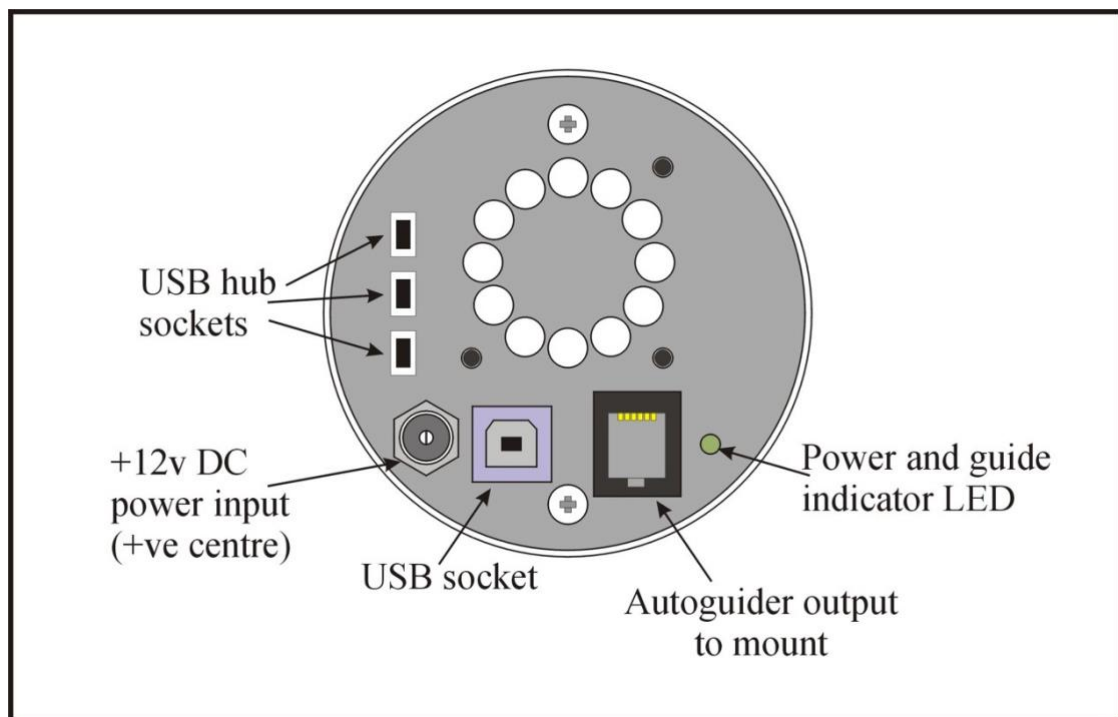
Thank you for purchasing a Starlight Xpress 'TRIUS PRO 694' camera. We hope that you will be very pleased with the performance of this product. Please register your product and warranty at <https://forms.gle/tmsHEJfQG2bLJr57> .

The TRIUS-PRO 694 is an advanced, high resolution, cooled CCD camera, especially designed for astronomical imaging. It uses a 6 Megapixel third generation version of the very popular Sony 'EXview' CCDs that offer very high QE and extremely low thermal noise. This 'PRO' camera uses an updated version of the original TRIUS main board and has both improved read noise and faster download time. It features an internal USB hub with 3 external ports and a dry argon CCD chamber fill. The USB hub permits several other devices to share the single USB connection and greatly reduces the number of cables required in a typical set-up. For example, a Lodestar PRO or Ultrastar PRO guide camera and an SX filter wheel could use two of the USB ports and the third might connect to an electric focuser, or similar peripheral. The argon fill, along with other improvements to the cooler stack, has improved the delta T to about -42 degrees C below ambient. The camera also includes a CCD temperature monitoring circuit that provides regulated set-point cooling of the chip, an adjustable chip alignment plate and a very compact overall size.

The TRIUS-PRO 694 uses a Sony ICX695AL 'EXview' progressive scan CCD, with 2750 x 2200 x 4.54uM pixels in a 12.5 x 10mm active area. This EXview device has an excellent quantum efficiency, with a broad spectral response peaking at around 77% in yellow light, and an extremely low dark current, well below that of most other CCDs. While this device also has an excellent blue light sensitivity, it has a strong infra-red response, which makes it ideal for all aspects of both planetary and deep-sky imaging, especially with an H-alpha filter. The H-alpha QE is about 65%, considerably better than many other interline chips.

The full-frame download time is only around 2.5 seconds and a binned 4x4 download takes only 0.3 seconds, so finding and centring are very quick and easy in this mode.

Here is a diagram of the connectors to be found on the rear panel of the camera:



Please take a few minutes to study the contents of this manual, which will help you to get the camera into operation quickly and without problems. I am sure that you want to see some results as soon as possible, so please move on to the 'Quick Start' section, which follows. A more detailed description of imaging techniques will be found in a later part of this manual.

## **‘Quick Starting’ your TRIUS-PRO system**

In the shipping container you will find the following items:

- 1) The TRIUS-PRO 694 camera head.
- 2) A universal AC power supply module.
- 3) A 3 metre USB camera cable.
- 4) An adaptor for 2” drawtubes and M42 Pentax thread lenses.
- 5) A guider output to guider port RJ12 lead.
- 6) Two USB Mini to Mini 0.5m USB Cable.
- 7) Two USB Mini to Male B 0.5m USB Cable.
- 8) A 'Y' power lead for connecting the cooling fan.
- 9) A stick with the TRIUS-PRO control software and this manual.

You will also need a PC computer with Windows10 installed. Most older versions of Windows will work (XP and above) but our Starlight Vision software is not supported by versions below Windows7. The machine must have at least one USB 2.0 port available and at least 4GB of memory. If you intend to view the finished images on its screen, then you will also need a graphics card capable of displaying an image with a minimum of 1024 x 768 pixels and 24 bit colour. A medium specification i7 machine is ideal, but most modern computers are OK. Please note that USB 2.0 operates at a very high speed and cannot operate over very long cables. Five metres of good quality cable is the maximum normally possible without boosters or extra powered hubs, although you can sometimes get good results at longer distances with very high quality cables.

### **Installing the USB system:**

First, find a free USB socket on your PC and plug in the USB cable (do not connect the camera at this time). The camera requires only a USB2.0 port, but will work OK on most USB3 ports, if that is all that is available.

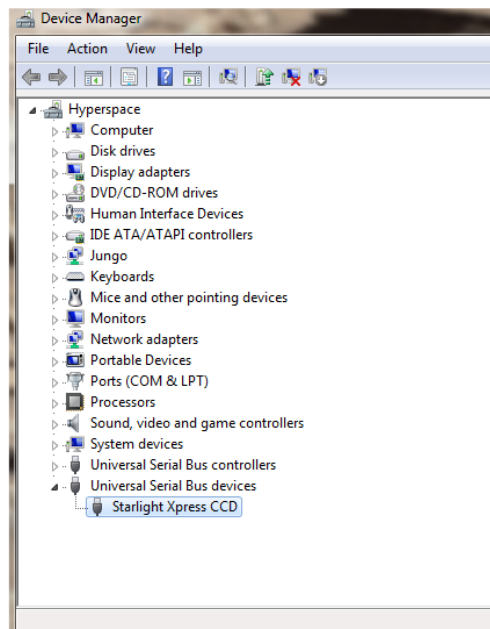
The next operation is to run the software installer from the USB stick provided. Insert the stick into the computer and wait for Windows Explorer to open with the list of folders on the ROM. Now run the SETUP.EXE file that it contains – this will initiate the self-install software which will guide you through the process of installing the SX camera software onto your computer. Note that XP machines require an older driver version and you can find this at

[https://www.sxccd.com/downloads/32bits\\_drivers.zip](https://www.sxccd.com/downloads/32bits_drivers.zip) if required.

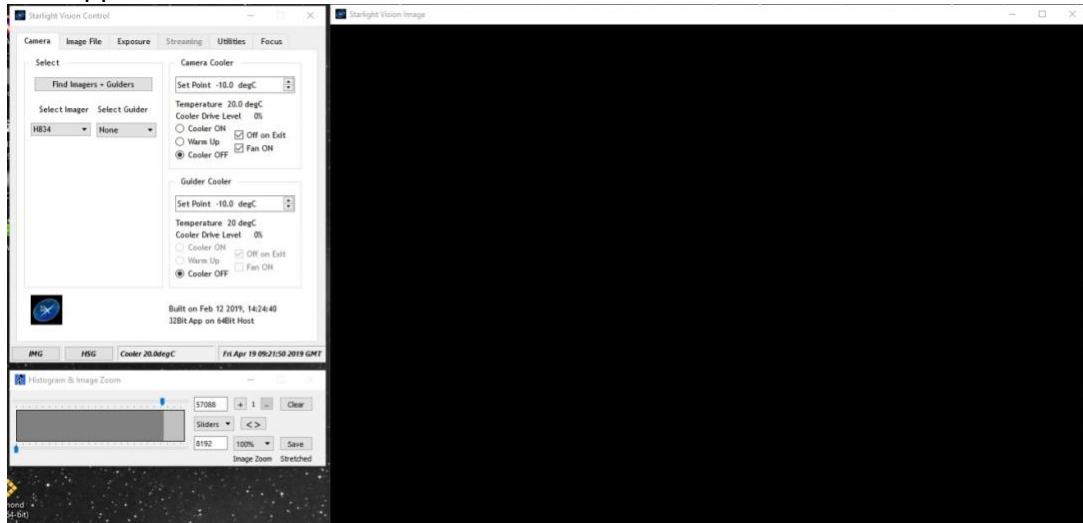
Now connect the USB cable to the socket on the camera rear panel.



Windows will report 'Found new hardware' and will automatically find the drivers. You can check this by opening 'Device Manager' and looking for a 'Starlight Xpress CCD' in the USB Devices list.



Now connect up the power supply and switch it on. The supply is a very efficient 'switch mode' unit, which can operate from either 110v or 220v AC, via an appropriate mains power cable (supplied). You can now start the software by double clicking on the Starlight Vision icon, when you should see the main menu and image panel appear.



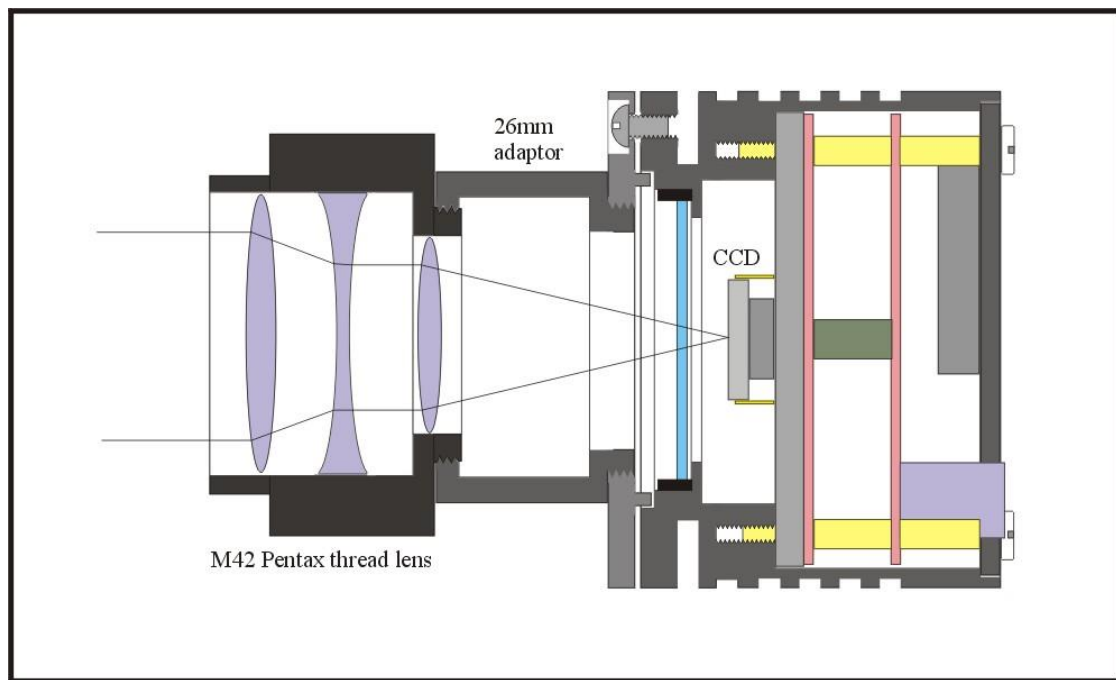
As can be seen above, there is a CCD temperature monitoring window at the top right hand side of the panel. I recommend using the set point to about -10C for general imaging, but you can go much colder - especially if you are imaging during the winter months. Under indoor conditions, the low airflow will limit the cooling capability, and you should use a set point of no lower than -10C for stable cooling. You can determine the optimum settings for your camera and ambient conditions when you have some experience of using the system, but do not try to operate at extreme cooling when the air temperature is high. The external fan is helpful and is connected by using the 'Y' lead provided in the camera component set, as below:



### Recording your first image:

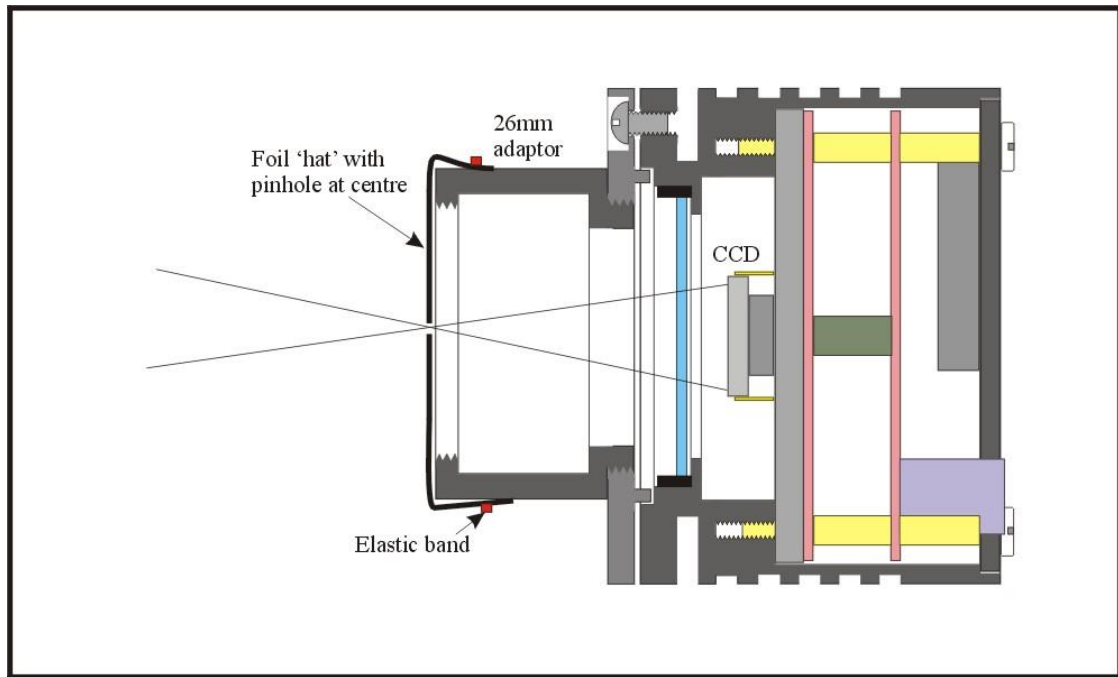
We now have the camera and computer set up to take pictures, but an optical system is needed to project an image onto the CCD surface. You could use your telescope, but this introduces additional complications, which are best avoided at this early stage. There are two simple options, one of which is available to everyone with a sheet of aluminium baking foil:

- 1) Attach a standard 'M42' thread SLR camera lens to the camera, using the 26mm spacer to achieve the correct focal distance.



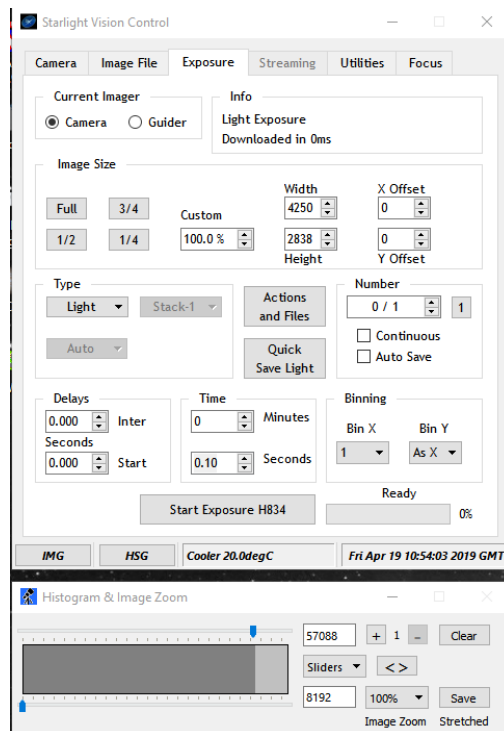
Or

- 2) Create a 'Pin hole' lens by sticking a sheet of aluminium baking foil over the end of the adaptor and pricking its centre with a small pin.



If you use a normal lens, then stop it down to the smallest aperture number possible, (usually F22), as this will minimise focus problems and keep the light level reasonable for daytime testing. The pin hole needs no such adjustments and will work immediately, although somewhat fuzzily!

Point the camera + lens or pinhole towards a well-lit and clearly defined object some distance away. Now enter the 'Exposure' menu in the software, set an exposure time of 0.1 seconds, then press 'Start Exposure'.





After the exposure and download have completed (about 4 seconds) an image of some kind will appear on the computer monitor. It will probably be poorly focused and incorrectly exposed, but any sort of image is good. In the case of the pinhole, all that you can experiment with is the exposure time, but a camera lens can be adjusted for good focus and so you might want to try this to judge the high image quality that it is possible to achieve.

Various other exposure options are available, as can be seen in the picture above. For example, you can 'Bin' the download by 2x2, or more, to achieve greater sensitivity and faster download, or enable 'Continuous' to see a steady stream of images. The Histogram plot allows you to see the status of the image brightness distribution and you can adjust the sliders to optimise your view.

***If you cannot record any kind of image, please check the following points:***

- 1) *Ensure that the power indicator lamp is on and that the cables are properly home in their sockets.*
- 2) *If the screen is completely white, the camera may be greatly overexposed. Try a shorter exposure time, or stop down your lens. See if covering the lens causes the image to darken.*
- 3) *If the USB did not initialise properly, the camera start-up screen will tell you that the connection is defective. Try switching off the power supply and unplugging the USB cable. Now turn the power supply on and plug in the USB cable. This will re-load the USB software and may fix the problem after restarting Starlight Vision. Otherwise, check the device driver status, as previously described, and re-install any drivers which appear to be defective.*
- 4) *If you cannot find any way of making the camera work, please try using it with another computer. This will confirm that the camera is OK, or faulty, and you can then decide how to proceed. Our guarantee ensures that any electrical faults are corrected quickly and at no cost to the customer.*

**Image enhancements:**

The current version of Starlight Vision does not include any enhancement functions, but these will be added to later versions (available from [www.sxccd.com](http://www.sxccd.com)). Further image processing can be done by saving your raw images as FITS files and exporting them to third party software. PixInsight is a powerful processing software, but there are many others available. AstroArt, MaximDL, Nebulosity etc.

Your first image may be satisfactory, but it is unlikely to be as clear and sharp as it could be. Improved focusing and exposure selection may correct these shortcomings, and you may like to try them before applying any image enhancement with software.



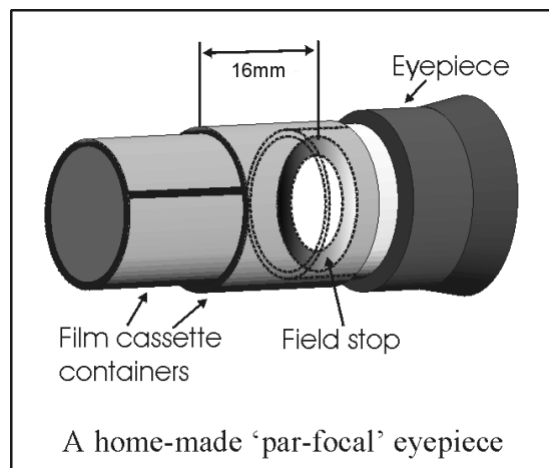
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## Astronomical Imaging with the TRIUS-PRO

### 1) Getting the image onto the CCD:

It is fairly easy to find the correct focus setting for the camera when using a standard SLR lens, but quite a different matter when the camera is attached to a telescope! The problem is that most telescopes have a large range of focus adjustment and the CCD needs to be quite close to the correct position before you can discern details well enough to optimise the focus setting. An additional complication is the need to add various accessories between the camera and telescope in order that the image scale is suitable for the subject being imaged and (sometimes) to include a 'flip mirror' finder unit for visual object location.

A simple, but invaluable device, is the 'par-focal eyepiece'. This is an eyepiece in which the field stop is located at the same distance from the barrel end, as the CCD is from the camera barrel end (approximately 16mm).



When the par-focal eyepiece is fitted into the telescope drawtube, you can adjust the focus until the view is sharply defined and the object of interest is close to the field centre. On removing the eyepiece and fitting the CCD camera, the CCD will be very close to the focal plane of the telescope and should record the stars etc. well enough for the focus to be trimmed to its optimum setting

Several astronomical stores sell adjustable par-focal eyepieces, but you can also make your own with a minimum of materials and an unwanted Kellner or Plossl ocular.

Just measure a distance of 22mm from the field stop of the eyepiece (equivalent to the CCD to adaptor flange distance of the camera) and make an extension tube to set the field stop at this distance from the drawtube end. Cut-down 35mm film cassette containers are a convenient diameter for making the spacer tube and may be split to adjust their diameter to fit the drawtube.

It is necessary to set up a good optical match between your camera and the telescope. Most SCTs have a focal ratio of around F10, which is too high for most deep sky objects and too low for the planets! This problem is quite easy to overcome if you have access to a focal reducer (for deep sky) and a Barlow lens for planetary work. As a guide, most CCD astronomers try to maintain an image scale of about 2 arc seconds per pixel for deep sky images. This matches the telescope resolution to the CCD resolution and avoids 'undersampling' the image, which can result in square stars and other unwanted effects. To calculate the focal length required for this condition to exist, you can use the following simple equation:

$$F = \text{Pixel size} * 205920 / \text{Resolution (in arc seconds)}$$

In the case of the TRIUS-PRO 834 and a 2 arc seconds per pixel resolution, we get

$$F = 0.00454 * 205920 / 2 = 467\text{mm}$$

For a 200mm SCT, this is an F ratio of  $380 / 200 = F2.33$ , which is much less than can be achieved with standard focal reducers. However, moderate deviations from this focal length will not have a drastic effect and so any F ratio from about F4.5 to F6.3 will give good results. It is clear from this result that the 'Starizona Hyperstar' adaptor is very well suited to use with the 694, as it operates at around F1.95, so you might be interested in getting one of these.

The same equation can be used to calculate the amplification required for good planetary images. However, in this case, the shorter exposures allow us to assume a much better telescope resolution and 0.2 arc seconds per pixel is a good value to use. The calculation now gives the following result:

$$F = 0.00454 * 205920 / 0.2 = 4674\text{mm}$$

This is approximately F23 when used with a 200mm SCT and so we will need a 2 or 3x Barlow lens. Barlow lenses are less critical than focal reducers and most types can be used with good results. However, if you are buying one especially for CCD imaging, I recommend getting a 3x or even 5x amplifier, or the planets will still be rather small in your images.

### **Achieving a good focus:**

Your starting point will depend on the focus aids, if any, which you are using. With the par-focal eyepiece, you should slip the eyepiece into the drawtube and focus visually on a moderately bright star (about 3<sup>rd</sup> magnitude). Now withdraw the eyepiece and carefully insert the camera nosepiece, until it is bottomed against the drawtube end, and then lock it in place.

Starlight Vision has a focus routine that will repeatedly download and display a 128x128 pixel segment of the image at relatively high speed. This focus window may be positioned anywhere in the camera field. To use this mode, start up the software and select the Exposure mode. Set the camera mode to Binned 1x1 and select an exposure time of 1 second. Press 'Start Exposure' and wait for the image to download. There is a good chance that a suitable star will appear somewhere within the image frame. Now go to the 'Focus' tab and press 'Get focus object' - you can now click on a suitable star in your main image and its co-ordinates will be shown. Now click 'Run focus exposure' and you will see a steady stream of star images in the focus window. adjust the focusing of your telescope to get the sharpest definition. Once you are happy with the focus quality achieved, you might like to trim the settings of your par-focal or flip mirror eyepiece to match the current camera position.

Although you can reach a good focus by the above method, many observers prefer to use additional aids, such as Hartmann or Bahnitov masks (an objective cover with several spaced holes) or diffraction bars (narrow parallel rods across the telescope aperture). These make the point of precise focus easier to determine by creating 'double images' or bright diffraction spikes around stars, which merge at the setting of exact focus.

### **Taking your first astronomical image:**

I will assume that you are now set up with a focused camera attached to a telescope with an operating sidereal drive. If so, you are now in a position to take a moderately long exposure of some interesting deep-sky astronomical object (I will deal with planets later). As many sidereal drives are not very accurate beyond a minute or two of exposure time, I suggest that you find a fairly bright object to image, such as M42, M13, M27 or M57. There are many others to choose from, but these are good examples.

Use the finder to align on your chosen object and then centre it accurately. Once properly centred and focused, take an exposure of about 60 seconds, and observe the result. Initially, the image may appear rather barren and show only a few stars, however, a great deal of data is hidden from view. You can get to see a lot of this, without affecting the image data, if you go to the Histogram window and adjust the two sliders to frame the main peak in the image data. The faint image details will then appear in good contrast and I think that you will be impressed by the result!

If you are happy with the image, go to the 'File' menu and save it as a FITS file in a convenient directory.

Many competitive brands of CCD camera require a 'dark frame' to be subtracted from your images to achieve the best results. A dark frame is simply a picture which was taken with the same exposure as your 'light frame', but with the telescope objective covered, so that no light can enter. It records only the 'hot pixels' and thermal gradients of your CCD, so that these defects are largely removed when the dark frame is subtracted from the light frame. The TRIUS-PRO range of CCDs is quite different from those used in other brands of camera and generates an extremely low level of dark noise. Indeed, it is so low that subtracting a dark frame can actually INCREASE the noise in your images! This is because the statistical readout noise of the dark frame can exceed the 'pattern noise' from warm pixels and hence add to that of the subtracted result. If your test pictures have an exposure time of less than about 10 minutes (as above), then don't bother with a dark frame, just 'kill' any hot pixels with your processing software. In most software the 'Median filter' can do this, but other software (e.g. Maxim DL) provide a 'hot pixel killer' that can be mapped to specific locations in the image, or cancellation methods such as a 'Sigma combine' of several images may be used.

In the unlikely event that you feel that dark frame really is necessary, please proceed as follows:

To take a dark frame, just cover the telescope objective with the lens cap and take another exposure with the same length as that of the light frame. This image will be a picture of the dark signal generated during your exposure and it should be saved with your image for use in processing the picture. If many such darks are recorded and averaged together, the statistical noise will be reduced, but the gains to be had are rather small compared with the effort involved.

As variations in ambient temperature will affect the dark signal, it is best to take the dark frames within a few minutes of capturing your images. For the same reason, it is not wise to use 'old' dark frames if you want the best possible results, however, some software allows you to scale library dark frames to match the image (e.g. AstroArt) and this can be useful as a time saver.

'Bias frames' are somewhat more useful than dark frames when using the TRIUS-PRO. A bias frame is essentially a zero exposure dark frame and records any minor readout defects that the CCD may possess, so a bias frame subtraction can clean up any 'warm columns' or shadings that are created during readout. To record a bias frame, cover the camera aperture and take a 500<sup>th</sup> of a second exposure. If you take at least 10 such frames and average them together, the resulting 'master bias' can be used to clean up readout defects for many months before CCD ageing changes require another set to be recorded.

'Flat fields' are often recommended for optimising the results from your CCD camera, but these are generally less important than dark frames, especially if you make sure that the optical window of the camera is kept dust-free. The purpose of a flat field is to compensate for uneven illumination and sensitivity of the CCD and it is better to avoid the need for one by keeping the optics clean and unvignetted.

### **Processing a deep-sky image:**

Further small refinements are usually possible and you will become expert at judging the best way to achieve these as your experience increases. As a rough guide, software filters can be used to sharpen, soften or noise reduce the image. Strong 'High Pass' filters are usually not a good idea with deep sky images, as the noise will be strongly increased and dark rings will appear around the stars, but a 'Median' filter can remove odd speckles and a mild 'Unsharp Mask' (Radius 3, Power 1) will sharpen without too much increase in noise.

Other things to try, include summing several images for a better signal to noise ratio. Summing can be done in the 'Merge' menu and involves loading the first processed image, selecting a reference point (a star) then loading the second image and finding the same star with the mouse. Once the reference is selected, you can either add directly, or average the images together. Averaging is generally better, as you are less likely to saturate the highlights of the picture. The signal-to-noise ratio will improve at a rate proportional to the square root of the number of summations (summing 4 images will double the signal-to-noise), but **different** exposures must be used. Summing an image with itself will not improve the S/N ratio. Also note that you cannot sum images before colour conversion, or the colour data will be destroyed!

Although I have concentrated on the use of a telescope for deep-sky imaging, do not forget that you have the option of using an ordinary camera lens for impressive wide-field shots! A good quality 200mm F3.5 lens with an infrared blocking filter will yield very nice images of large objects, such as M31, M42, M45 etc. If you cannot obtain a large IR blocker for the front of the lens, it is quite acceptable to place a small one behind the lens, inside the adaptor tube. You can even try using a hydrogen-alpha filter to bring out nebulae, reduce light pollution and sharpen the star images to pin-points.

### **Taking pictures of the planets:**

Planetary imaging is in many ways quite different from deep sky imaging. Most deep sky objects are faint and relatively large, so a short focal length and a long exposure are needed, while planets are bright and very small, needing long focal lengths and short exposures. High resolution is critical to achieving good results and I have already shown how a suitable focal length can be calculated and produced, using a Barlow lens.

Many camera users comment on the difficulty of finding the correct focus when taking pictures of Jupiter etc. This is usually due to poor seeing conditions, which are only too common, but may also be due in part to poor collimation of your telescope. Please ensure that the optics are properly aligned as shown by star testing, or by using one of the patent collimation aids that are widely available. It is also better to use a star for initial focusing, as planetary detail is difficult to judge in bad seeing.

Although the star will also suffer from blurring, the eye can more easily gauge when the most compact blur has been achieved!

You could begin by imaging lunar craters, or the planets, Jupiter, Saturn or Mars. The rapid variations of seeing which accompany planetary imaging, will ruin the definition of about 95% of your images and so I recommend setting the camera to run in 'Autosave' mode. This will automatically take a sequence of images and save them with sequential file names in your 'Autosave' directory. Dozens of images will be saved, but only one or two will be satisfactory for further processing. The 'Subframe' mode of Starlight Vision may be found useful for limiting the wasted area and reducing the download time of small planetary images.

To start the Autosave process, call up the Exposure tab and select the 'Actions and Files' button. You will see a default file name with a numerical suffix, and various options for the image save folders - set an appropriate file name and image save folder location. Once done, you can go to either the 'Continuous' checkbox for automatic saving of every frame, or you can set a number of exposures in the 'Number' box. The 'Autosave' option should then be checked and you are ready to start. Set an exposure time and press 'Start Exposure' - your frames will now be saved to your folder of choice. Make sure that you uncheck 'Autosave' when finished, or you will save every image that you take!

The exposure time needed for good planetary images is such that the image histogram has a peak value at around 40,000 and does not extend much above that value (ignore the major peak near zero, due to the dark background). If you use too short an exposure time, the image noise level will be increased, and if too long a time is used you will saturate the highlights and cause unresolved white patches on the image highlights. With the recommended focal length, Jupiter and Mars will both need an exposure time of between 0.1 and 1 seconds and Saturn will need between 0.5 and 2 seconds.

### **Processing a planetary image:**

Planetary images have one major advantage over deep sky images, when you come to process them – they are MUCH brighter, with a correspondingly better signal to noise ratio. This means that aggressive sharpening filters may be used without making the result look very noisy and so some of the effects of poor seeing can be neutralised.

As with deep-sky images, it is advantageous to stack planetary images together to improve the signal to noise ratio. In this case, the 'averaging' option should always be used, or the result is likely to exceed the dynamic range of the software and saturate the highlights. Aligning the images is always something of a problem, as there are rarely any stars to use when imaging the planets, but Jupiter's satellites can be useful reference points. Otherwise, you will have to find a well-defined feature on the planet, or estimate where the centre of the disk is located. Some

more sophisticated software can automatically align planetary images and you may find these programs (e.g. 'Registax') to be very useful.

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### **Taking and using a flat field:**

Flat fields are images that display only the variations of illumination and sensitivity of the CCD and are used to mathematically modify a wanted image in such a way that the errors are removed. Common flat field errors are due to dust motes on the camera window and vignetting effects in the optical system of the telescope. Dust motes act as 'inverse pinholes' and cast out-of-focus images of the telescope aperture onto the CCD chip, where they appear as shadow 'do-nuts'. Most optical systems show some vignetting at the edges of the field, especially when focal reducers are used. This causes a brighter centre to show in images, especially when there is a lot of sky light to illuminate the field.

If dust motes are your main problem, it is best to clean the camera window, rather than to rely on a flat field to remove the do-nuts. Flat fields always increase the noise in an image and so physical dust removal is the best option. If you have serious vignetting, first check whether the optical system can be improved. The most likely cause of this problem is trying to use too powerful a degree of optical compression with a focal reducer and you might want to try moving the camera closer to the reducer lens.

If you really do need to use a flat field for image correction, then it must be taken with care. It is most important that the optical system **MUST NOT** be disturbed between taking your original images and taking the flat field. Any relative changes of focus and rotation etc. will upset the match between flat field and image and the result will be poor correction of the errors. The other necessity for recording a good flat field is a source of very even illumination of the telescope field. This is surprisingly difficult to achieve and many designs of light source have appeared in the literature and on the Web. These usually consist of a large wooden box, containing several lamps and an internal coating of matt white paint, which is placed over the objective of the telescope to provide an evenly illuminated surface. These can work well, but I prefer a simpler method, as follows:

Most imaging sessions begin or end in twilight and so the dusk or dawn sky can provide a distributed source of light for a flat field. However, using the sky directly is likely to result in recording many unwanted stars, or patches of cloud etc., so a diffuser needs to be added to the telescope. An ideal material is Mylar plastic drafting film, obtained from an office supplies warehouse. It is strong and water resistant and can be easily replaced if damaged. Stretch a piece of the film loosely across the aperture of your telescope and point the instrument high in the sky, to avoid any gradient in the light near the horizon. Now take several images with exposure times adjusted to give a bright, but not overloaded, picture. A histogram



peaking at around 20,000 is ideal. Averaging flat fields together is a good way to reduce their noise contribution and so recording 4, or more, images is a good idea.

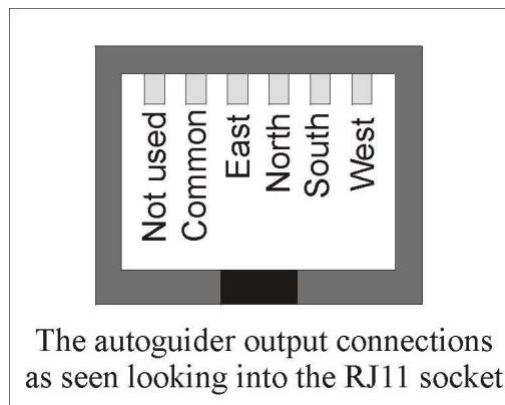
To use your flat fields, they must first have a dark frame subtracted. Although this may appear to be unimportant with such brightly lit and short exposures, there is the 'bias offset' of the camera in each image and this can produce an error in the final correction. As we are mainly interested in the bias, any very short exposure dark frame will give a good result. The dark subtracted images should then be averaged together before use.

After the above procedures have been executed, the flat field will be ready for use. Load up your image for processing, subtract the dark frame and then select 'Apply flat field' in the 'Merge' menu. The result should be an image with very few signs of the original artefacts and you can then process it in the normal way.

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### The TRIUS-PRO guider port

The TRIUS-PRO is provided with a guide port for use with ST4 compatible mounts. The Autoguider output port is a 6 way RJ11 socket, which is compatible with the standard autoguider input of most telescope mounts. It provides 4 active-low opto-isolator outputs and a common return line, capable of sinking a minimum of 5mA per output. This socket may be used for telescope control if the TRIUS-PRO is employed as an autoguider.



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### **CCD alignment:**

The front plate of the TRIUS-PRO is attached via three tip-tilt screws and locking screws. It floats on a 2.5mm thick nitrile rubber ring, which provides a light-tight seal and a degree of 'spring action' to keep the screws from becoming loose. The assembly allows the user to adjust the relationship between the focal plane of the telescope and the CCD image surface, which should be parallel to each other. If your telescope is accurately collimated, but still shows distorted stars towards one edge of the images, then the CCD may not be orthogonal to the focal plane and some

adjustment is needed. Before making any changes, you may like to see the information at [https://www.sxccd.com/maintenance\\_info/Aligning\\_CCD.pdf](https://www.sxccd.com/maintenance_info/Aligning_CCD.pdf) This describes a simple setup for checking the alignment and may save you a lot of time and effort caused by aligning by experiment.

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### **Camera maintenance:**

Very little maintenance is needed to keep the camera in excellent operating order, however two problems, which are common to all CCD equipment, might show up on occasion. These are dust and condensation.

#### **Removing Dust:**

1) Dust can be deposited on either the optical window (not a big problem to cure), or on the CCD faceplate (very difficult to eliminate entirely). When small particles collect on the window they may not be noticed at all on deep sky (small F ratio) images, as they will be very much out of focus. However, if a powerful contrast boost of the image is carried out, they may well begin to show as the shadow 'Do-nuts' mentioned earlier. Images taken with a large F ratio optical system are more likely to be affected by such dirt, owing to the smaller and sharper shadows that they cast. A light polluted sky will also make these marks much more obvious. There is no great difficulty in removing such particles on the outside surface by the careful use of a lens cleaning cloth, 'lens pen', or 'air duster' and so you should have little trouble with this aspect of maintenance. Dust on the CCD faceplate is a much greater nuisance, as it casts very sharply defined and dark shadows and it entails dismantling the camera to get rid of it! To clean the CCD you will need a good quality lens cloth (no silicone) or tissues and some high-grade acetone or isopropyl alcohol. A very suitable cloth is the 'Micro-Fibre' type marketed by PENTAX etc., and suitable alcohol solution is available from photographic shops etc. as lens cleaning fluid. Most pharmacist shops will have small bottles of pure acetone. A bright light and a strong watchmakers eyeglass will also be found to be essential.

NOTE! You will lose the argon gas fill of the CCD chamber when it is opened. The camera will operate well without the argon (replaced with dry air), but you can re-fill the chamber by following the instructions at the end of this section.

#### **Accessing the CCD faceplate:**

- 1) Disconnect the leads from the camera head and remove it from the telescope. Place it on a table with the optical window facing upward.
- 2) Examine the window retaining ring, which is screwed into the barrel and compresses a nitrile rubber O ring under the window. You will see that it has two small notches for rotating it with a suitable tool.

3) Generally speaking, it is possible to unscrew the ring by inserting the tip of a small screwdriver into one of the notches and pushing it round. Clearly, you need to be careful that the screwdriver does not slip and scratch the window! Alternatively, you can make a simple tool by cutting a rectangle of thin metal, so that it sits safely inside both notches and cannot fall out. A piece of 0.5mm steel about 42mm wide, will do the job.

4) Once the ring is out, tip the camera onto a clean cloth, so that the silica window falls out of the barrel.

5) You can now closely examine the CCD faceplate under the spotlight using the watchmaker's glass, when any dust motes will show clearly. If there is only an odd particle or two and the CCD is otherwise clean, carefully brush away the dust with a corner of your lens cloth or a clean soft brush. A smeared or very dusty CCD will need a few drops of alcohol or acetone to clean thoroughly and you may have to make several attempts before the surface is free of contamination. One gentle wipe from one end to the other, with no return stroke, will be found to be the most effective action. DO NOT rub vigorously and be very careful to avoid scratching the window. Finish off by giving the CCD a short blast from an air cannon.

6) Before re-assembly, make certain that the inside surface of the front window is also clean, and then carefully replace the window and retaining ring and screw it into place. Tighten gently, so that the window is firmly against the nitrile sealing ring.

**Dealing with condensation:**

The TRIUS-PRO is designed to avoid condensation by minimising the volume of gas trapped within the CCD cavity and by preventing moisture ingress. This normally works very well, but storage of the camera in a humid location can lead to the trapped argon becoming moist by diffusion through the optical window mounting thread etc. and can eventually result in condensation on the CCD window. If this becomes a problem, try storing the camera in a warm, dry place, or in a plastic lunch box containing a sachet of silica gel desiccant. If this is not effective, it is possible to flush the CCD chamber with dry argon from a small welding gas cylinder. Such argon gas cylinders, valves and suitable plastic tubing, are readily available from many car spares suppliers, such as Halfords, in the UK. Two ports are provided in the sides of the CCD cavity and these may be accessed by unscrewing the rear plate of the camera and then sliding off the main barrel.



The ports are sealed by M4 stainless set-screws and soft plugs, which may be removed to provide access to the chamber gas fill. You will need to make some kind of nozzle to fit the gas ports, but simply tapering the end of the standard 4 mm plastic gas tubing that is used with small welding bottles, will probably be sufficient. To recharge the chamber, first remove both gas plugs and then insert the tapered end of the argon cylinder tube into one port. Gently turn on the argon supply for about 10 seconds and then refit the plug into the output port. The filling tube may then be extracted and the second port re-sealed.

***N.B. DO NOT leave the camera cooling switched on for long periods between uses. The cold CCD will collect ice by slow diffusion through any small leaks and this will become corrosive water on the cooler and CCD pins when the power is removed. If substantial amounts of moisture are seen, dismantle the camera and dry it thoroughly.***

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### Alternative Software

Although we hope that you will be pleased with our Starlight Vision software, other companies are offering alternative programs with powerful image processing functions. One of these is programs is 'AstroArt' by MSB software. You can purchase AstroArt from many dealers Worldwide and more information may be obtained from their web site at <http://www.msb-astroart.com>

'Maxim DL' is another popular choice and you can find out more by visiting <http://www.cyanogen.com>

'Nebulosity 4' also works very well with SX cameras.  
<http://www.stark-labs.com/nebulosity.html>

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### Some details of the camera and CCD characteristics

The TRIUS-PRO 694 uses a Sony ICX695ALG 'EXview' progressive scan CCD, with 2750 x 2200 x 4.54 $\mu$ m pixels in a 12.5 x 10mm active area. This EXview device has the following parameters:

**CCD type:** Sony ICX695ALG EXview interline imager.

**CCD size:** Active area 12.5mm x 10mm

**CCD pixels:** 2750 x 2200 pixel array. Each pixel is 4.54 x 4.54 $\mu$ m square

**Well depth:** Full res. mode 17,000e. Binned 2x2 mode approx. 22,000e

**Mean visual QE:** 70%, 77% at peak (580nm)

**Useful spectral response:** 360nm – 1100nm

**Readout noise:** Approx. 3.5e RMS typical, 5e max.

**System gain:** Approx. 0.24 electrons per ADU

**Readout time:** Approximately 3.5 seconds in full resolution mode.

**Back focal distance:** The CCD is approximately 16mm from the barrel front surface.

**Camera body size:** 75mm diameter x 70mm long

**Dear Observer,**

Thank you for purchasing a Starlight Xpress CCD Imaging System. We are confident that you will gain much satisfaction from this equipment, but please read carefully the accompanying instruction manual to ensure that you achieve the best performance that is capable of providing.

Please register your product and warranty at <https://forms.gle/tmsHEJfQG2bLJr57> .

As with most sophisticated equipment a certain amount of routine maintenance is necessary to keep the equipment operating at its optimum performance. The maintenance has been kept to a minimum, and is fully described in the manual.

In the unfortunate instance when the equipment does not perform as expected might we recommend that you first study the fault finding information supplied. If this does not remedy the problem, then contact Starlight Xpress for further advice. Our message board service on the Starlight Xpress web site will normally provide a rapid response to any problems that you encounter.

The equipment is covered by a 12-month guarantee covering faulty design, material or workmanship in addition to any statutory Consumer Rights of Purchasers.

**CONDITIONS OF GUARANTEE**

- 1) The equipment shall only be used for normal purposes described in the standard operating instructions, and within the relevant safety standards of the country where the equipment is used.
- 2) Repairs under guarantee will be free of charge providing proof of purchase is produced, and that the equipment is returned to the Service Agent at the Purchaser's expense and risk, and that the equipment proves to be defective.
- 3) The guarantee shall not apply to equipment damaged by fire, accident, wear and tear, misuse, unauthorised repairs, or modified in any way whatsoever, or damage suffered in transit to or from the Purchaser.
- 4) The Purchaser's sole and exclusive rights under this guarantee is for repair, or at our discretion the replacement of the equipment or any part thereof, and no remedy to consequential loss or damage whatsoever.
- 5) This guarantee shall not apply to components that have a naturally limited life.
- 6) Starlight Xpress's decision in all matters is final, and any faulty component which has been replaced will become the property of Starlight Xpress Ltd.

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