Imaging

The days of film cameras for astronomy are just about over. Few can wait for the film to be processed, only to (typically) find that the focus was incorrect, etc. TP2415 film and the like are no longer available, good though it was (especially when “hypered”). Charge-Coupled Devices (CCD) are so much more versatile and have virtually instantly visible results.

There are basically two types of CCD cameras in use for astro-imaging: Conventional general purpose Digital Single-Lens Reflex (DSLR) and specialised astro-imaging cameras.

General purpose cameras (DSLR)

DSLR cameras, are used as such for astronomical imaging, especially when fitted with a long focal length lens. Many astronomical objects are of extended size, better suited to a DSLR than almost anything else. And, of course, the image is in colour.

The silicon light-sensitive chip is very sensitive to red, and especially Infra-Red light. DSLR cameras are fitted with a suitable filter for general purpose use to correct this effect. However, many astro users remove this filter (possibly infringing their warranty). Since many extended astronomical objects (e.g. nebulae) emit H-alpha (deep red) light, this filter removal considerably benefits imaging (but makes general purpose use subject to some gruesome colour aberration).

Since most extended astronomical objects have a low surface brightness, time exposures have to be used. There are two particular problems with this. Firstly; to hold the mechanical shutter open uses up battery charge. Secondly; the longer exposures risk star-trailing due to the Earth’s rotation.

There are several Scotch (Haig) mount (aka “Barn Door”) alternatives on the market, including a Mini-equatorial mount by Orion just for a DSLR. These will almost eliminate star-trailing for the necessary longer exposures.

Rather than use the DSLR stand-alone, it is more usual to mount the camera body directly onto the Optical Tube Assembly (OTA) at the prime focus. This is done by fitting the camera with a T-ring (instead of a lens) and the telescope with a T-ring adaptor (T-ring threads are standard and universal) instead of eyepiece. This is now a very common arrangement, but does make colour balancing a trifle difficult. Also, there may be problems with pixel size. Hence the burgeoning market for specialised astronomical imaging cameras.

Specialised astro-imaging cameras

This used to be the prerogative of serious (i.e. well off!) amateur astronomers. But there are now several really good manufacturers of these specialised CCD cameras.

Hence the competition has tended to keep the prices down. Technically significant improvements in the imaging chips have also helped.

Some CCD chips image in full-colour, but most are monochrome. This allows optimum performance for imaging, but requires a filter wheel and serial exposures to produce colour images.

Some of the later CCD cameras are fitted with an internal filter wheel. Because of size limitations, this is usually only of 5-filter capacity. Many cameras, especially older ones, require an external filter wheel. This may be a 5-filter capacity, but is more usually a 8-filter capacity.

In order to use the best resolution and exposures, four images to a set are required. Viz. Red, Green, Blue and Luminance. The colour filters are Wratten type (coloured glass), while the Luminance “filter” is plain glass. This latter ensures that all filters are par-focal, so maintain focus. For a 5-filter wheel, the last position is usually taken by an H-alpha filter. Larger capacity filter wheels often add an OIII filter at least.

Astro-imaging cameras are always run by external software since there are few, if any, controls on the camera body and only the odd LED for status. Most often this control is by use of a laptop, with communication via USB, Ethernet, etc. Camera control software allows each colour to have individual exposures to suit the object and automatically controls the filter wheel too. Images are stored in the FITS format on the laptop.

These cameras and their controlling software also have a focussing mode (clear filter!). Allowing fine alignment and focussing. With a good optical train focus should hold good even for long imaging sessions. Software also allows for the occasional Dark Frame. This shows CCD noise and “hot” pixels and is automatically subtracted from observing images. However, the observer is usually responsible for the Dome Flat image also a necessary part of the imaging correction. Normal practice is to take a number of RGBL image sets and “stack” the good ones.

CCD cameras work best when cold, since electronic noise is then greatly reduced. Thus almost all good astronomical imaging CCD cameras are fitted with a Peltier cooler for the CCD chip. Hence there is a short cool-down time before good imaging is possible. Some good camera systems also allow for a secondary, water circulation system, to conduct heat away from the hot side of the Peltier cooler.

Since long-exposures are now very feasible with this type of camera, faint objects can now can be imaged. But to avoid smearing the image (star trailing) this relies on the telescope mount to provide error-free tracking. This is usually not achievable for a number of reasons. Hence the solution is usually some form of self-guiding. This is usually provided by a separate small CCD camera. This is aligned on a suitable guide-star and “bumps” the mount should the star drift out of position.

The guiding CCD camera (and associated guiding OTA) generally has to be mounted separately on the OTA, and maintained in exact alignment, except for SBIG cameras which incorporate a separate pickoff within the main camera. This used to be located after the filter wheel, which sometimes made finding a bright guide star difficult. Modern ones locate the guiding pickoff in front of the filter wheel.

All CCD cameras may be rotated to optimally align the image onto the sensor chip. Additionally, for SBIG cameras this allows for guide star selection.

Image processing

Inevitably this usually involves Photoshop with all the plethora of image manipulation (especially the Curves feature). FITS extensions are freely available on the Internet for Photoshop.

Usually there will be a number of sets of images, rather than just the one long exposure set. Delete the poor image sets and stack the remainder together using Deep Sky Stacker or RegiStax, etc (all freebies on the Internet). GIMP is another Internet freebie, almost equivalent to Photoshop. IRIS is another good software package for astronomical image processing, also free to use, and especially designed for DSLRs.

There are some very good books on this subject and some very good magazine articles for further information.

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