Cameras and Photography

Todays amateur observers have access to fantastic equipment at reasonable prices; equipment that can grab faint details and reveal deep sky objects in just a few seconds of exposure. In the last 20 years, the digital revolution has changed astronomical imaging forever. Digital SLR cameras, CCD cameras and webcams now provide the user with opportunities that previous generations could only dream of.

Camera Equipment

The advent of digital SLR cameras and CCD imaging systems means that good quality photographs are within easy reach of most amateurs. However, adding such equipment to your personal store entails a bit of spending! Good quality DSLR's can be purchased for just a few hundred pounds (or dollars) and CCD cameras can also be purchased in a similar price range, though items do obviously become more expensive dependent on quality and reliability.

This is not to say that 35mm film has now been relegated to history. It is still a very versatile medium to work with and in expert hands provides images of exquisite quality. However, film has an ethos all of its own and is a vehicle that requires some knowledge of its capabilities and drawbacks. It is hard to imagine that just a few years ago, 35mm film was all that was available and its storage, processing and hypering were arts in themselves, without having to cope with coupling a camera to a telescope or getting a sharp image at the point where the observer was at the scope rather than home in the darkroom. It is best to leave the vagaries of film to one side, even though this author grew up with the method and holds a qualification in such photography.

Today, the DSLR is in the ascendant and it is becoming increasingly difficult to find good quality high ISO 35mm film in high street shops and recourse to a good photographic supplier is increasingly necessary to continue this art. For our purposes within this book, it is better to concentrate on what the market currently holds and as the majority of cameras are now in digital format, it is these types that astronomers routinely use. In fig 1 can be seen a typical series of examples; Canon 30D, Canon 400D and fitted with a T-mount and telescope adapter, a Canon 1000D

Although images of the Moon and even bright nebulae such as Messier 42 can be obtained with compact cameras or even mobile phones if held by a piece of equipment called a *Steadypix* against the eyepiece of an undriven telescope. Although the Steadypix may unite the telescope with a camera with a fitted lens such as a DSLR or even some Bridge cameras, most nebulae require longer exposures and guided mounts to achieve good results.

Ideally then, the observer should be equipped with either a CCD camera or DSLR. Choosing such equipment can be a long process of comparison and getting advice from experts in the field, but such advice is well meaning and worth considering so as to avoid common mistakes. A DSLR is a versatile piece of kit, and of course is very useful for photography outside that of astrophotography whereas a CCD camera is not. There are many manufacturers of quality DSLRs but the general consensus is to purchase either Nikon, Canon or Olympus cameras as these manufacturers have a wide range of auxiliary equipment available such as lenses, T mounts, adapters, focusing screens and filters.

Although digital, these cameras follow a similar format as 35mm film cameras in that their sizes, weight and controls are flexible and they are easy to set and control once one has some experience with them. It is not my intention to recommend any particular brand as I have seen excellent results with all the above types, it is merely a choice of preference and cost. In addition to the camera, the observer will require a cable release inimical to their camera system, which will cost a few additional pounds (dollars) to prevent shaking.

Lenses

If the observer is going to use a driven camera mount, then the choice of lens will be crucial. Occasionally a DSLR can be purchased with a choice of lenses, typically a 28-80mm focal length or a larger one with 75-300mm focal length for example. These lenses are not built for astrophotography, though they do serve to provide wide-field shots of the sky. Naturally, any image gained will be very small depending on the target subject and require a lot of enlargement and enhancement. Larger examples of nebulae such as NGC 7000 or IC 1396 or galaxies such as M31 the Andromeda galaxy may be resolved with such methods and long exposures, but smaller objects will be invisible or just splodges in the background.

Lenses are obviously a feature that will require some consideration. Is the observer going to use the standard 50mm lens that comes with most cameras or are they going to attach the camera to the telescope? If lenses are a preferred option then long focal lengths will require a driven mount as the amount of exposure will be cut down by star drift across the field.

To get sharp images of stars, one must consider the “600 Rule” where the number 600 can be divided by the lens focal length to give one an approximation of how long an exposure can be in seconds before drift of the field occurs and the stars become smeared into trails. So for example:

600 / 50mm = 12 seconds
600 / 28mm = 21 seconds
600 / 200mm = 3 seconds

The rule of 600 is a good approximation and is easy to calculate when one is out in the darkness. It also illustrates just how crucial it becomes with larger lenses to have them coupled to driven mounts.

Focal length and field of view

Camera lenses come in a variety of sizes and some of the most common ones for DSLR cameras have a variable focal length usually between 24-75mm, 18-55mm, or even long focal length ones such as 75-300mm. The versatility of these lenses cannot be overstated for terrestrial photography but there is a caveat; at night when the manual focus of these lenses is crucial, they do not always perform very well and can be difficult to focus accurately. This is due to the small amount of focal travel the lens incurs in daily operation when the servo-motors inside the lens can move the focus quite accurately. Turn off the automatic feature however and the dexterity required to get the focus just right requires some patience and effort.

Usually this can be done by small movements once an infinity focus is reached. Such lenses do not have an infinity focus at the “end” of their travel, but a little way back from the end of travel. By taking several photographs in many positions at night, the observer can get the focal point as accurate as possible for that particular lens/camera combination. This author makes a small mark on the lens that is visible in red torchlight so that faster focussing can be gained quickly.

A variety of lenses as seen in fig 2 are very useful if one wishes to use the camera on a driven platform such as the Star Adventurer (see below). The field of view of such lenses differs between each but as a general guide the longer the focal length the smaller the field of view and subsequently, the more accurate your pointing has to be.

One can see based on the foregoing 600 rule that using any long focal length lens will require something more than a tripod. Some astronomers, including this author, use a driven mount as a camera platform or piggyback the camera on a driven telescope or use a purpose made mount such as an *Astrotrac* or *Star Adventurer* which are commercially available and have varied prices. They look like this in Fig 3

Alternatively, most astronomers couple their DSLR camera directly to a telescope for the best results. There are several ways of doing this so let us now examine those.

A telescope as a long focus lens
The best approach to photographing any astronomical object is to connect the camera to a telescope at its focus point. This procedure then gives one the advantage of having a large telephoto lens with an f ratio exactly the same as the telescope. With this arrangement the observer doesn't have to do any complicated mathematics in working out f-ratios as the focal length and focal ratio of the camera and telescope system is exactly whatever is the f ratio and focal length of the telescope. One merely has to think in terms of exposure times and accuracy of guiding if necessary. With DSLR's several photographs may be taken of the one object and then stacked in the appropriate software to produce a single, higher resolution image.

Alternately, the observer can use a *Steadypix* which functions as a connector between the camera lens of your DSLR and an eyepiece of choice and fixes to any eyepiece on the eyepiece holder. Such photography is called eyepiece projection or afocal astrophotography.

If one is using this arrangement, remember to put the camera lens at its lowest f stop (f2.8 or 5.6) and focus it on infinity (by placing it on manual focus rather than automatic!) then the focal ratio must be worked out, which can be done with the following equation:

$$Fr = [(C/E) -1]T$$

Where Fr is the focal ratio, C is the focal length of the camera lens, E is the focal length of the eyepiece and T is the focal ratio of the telescope. To find the focal ratio of your telescope, divide the instrument aperture into the focal length. If you have a 1000mm focal length telescope with an aperture of 200mm, then the focal ratio will be 1000/200 = f5.

In the above configuration a telescope of focal ratio f10 using a 50mm camera lens and a 25mm eyepiece will have the sum 50mm/25mm – 1 = 1. This single unit can then be multiplied by the telescope's focal length (f10) to get the focal ratio of the entire system. With an eyepiece of 15mm focal length, the resultant focal ratio with this telescope will be f23 (50mm/15mm – 1xT) and so on as one uses different eyepieces.

Although occasionally afocal astrophotography enables a relatively large initial image to be obtained, it has drawbacks in that the system must be accurately driven, the contrast of the system will decrease with increasing magnification and some large focal ratios of f40 and above are just giving diminishing returns. Additionally, focusing the system accurately can become very problematic. It is best to attach the camera directly to the telescope with a T-mount and play with the image software later, though many amateurs have gained good results from using Steadypix systems. Again, it is a question of preference. If the observer intends to connect the camera to a telescope, then a T-Mount and an adapter sleeve are essential as can be seen in Fig 4.

Once the camera is fitted in this way then the whole system is one long focal length lens and narrow fields of view and good results can be obtained with some patience and by varying the exposures. Additionally, working with the image in Lightroom or Photoshop will bring out much more detail. We shall examine this later. In the meantime what of other camera systems?

CCD Cameras

There are so many variants of CCD camera available that it is not possible to cover them all in great detail and I would recommend that the observer read the reviews of such online to make the best choice. Many astronomers have CCD cameras such as the various *Atik* cameras, models by the *Santa Barbara Instruments Group* (SBIG) or *Starlight Express*. Many of the models are full colour CCD's others are black and white and require coloured filters such as RGB or BVR to produce a full colour image. Once again, choice is down to observer preference and costs. The advantage of the CCD camera over the DSLR is the smaller field of view and the rapidity of capture and quality of the images, which can be manipulated in various programmes such as *Maxim DL*, *Artemis* and others.

Webcams specifically made for astronomy may also be employed in a similar way to CCD's although the resolution depends on the chip. One of the most popular of such items is the *DMK* camera, which requires a programme entitled *RegiStax* (or similar) to complete the imaging processing. If the observer wishes to use this form of photography, I would refer him to Massey and Quirk's *Deep Sky Video Astronomy,* which covers in depth the video and *Registax* techniques needed to take great pictures.

Resolution of the CCD camera or any DSLR is the most important thing for an amateur astronomer. For the observer equipped or contemplating purchasing a CCD camera, the chip size and pixel numbers on the axis of the chip are very important in obtaining detail and ensuring that a CCD camera and telescope will resolve any astronomical object sufficiently. Thankfully most astronomical bodies are quite large in comparison to the pixel size of a CCD, but to ensure that any camera you consider purchasing will be adequate for your needs then a simple equation will enable the reader to ensure that the CCD camera of their choice is adequate. The relationship is:

$$R'' = [(Ps_m\, 206)/a]/f$$

Where R" is the angular resolution in arc seconds, Ps_m is the pixel size, a (in mm) is the telescope aperture and f is the focal ratio of the telescope. If the camera has pixels of 10µ size and is fitted to a 200mm aperture f5 telescope, then:

$$10 \times 206 = 2060.$$
$$2060 \div 200\ (a) = 10.3$$
$$10.3 \div f5 = 2.06$$

The chip therefore has a resolution of 2.06"

If you then need to know the size of the field of view through such a camera the simple relationship is:

$$S^o = (Pr\ Pn)/3600$$

Where S^o is the size of the frame in degrees, Pr is the pixel resolution, Pn is the number of pixels along the axis of the chip divided by 3600. So for a chip with 1500 pixels along its main axis:

$$1500 \times 2.06 = 3090$$
$$3090 \div 3600 = 0.85^o$$

This is larger than the full Moon and will encompass most astronomical objects but obviously smaller, more distant objects will lose some resolution despite the fact that the image can be enlarged.

No matter what the individual uses, one of the factors essential to any photography is the focus; it must be sharp and free of any obvious defects such as smearing at the edges. It may take time and practise for any astronomer to achieve a good focus, but it is well worth the effort as anything that is out of focus is disappointing when one looks at the pictures. Focusing is a slightly frustrating task when out in the field yet is the most essential component of any photography and getting the focus right deserves time and attention. Many DSLR's have a 'live-view' facility, a consideration to be taken into account when purchasing one, whilst a CCD has the ability to download a picture there and then to judge for focus and quality.

I hope that this precis will give you enough information to make an informed choice about camera equipment and start you on the road to photographing the night sky.