Imaging Basics

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Introduction

When you perform a search on the Internet for “Deep Sky Images”, you will find hundreds of images and sites with images on them. Some of these pictures are literally stunning. When I first saw these images, I remember thinking, “wow, I want to take pictures like those”. These same Internet sites also tell you that this form of photography is both very difficult and also very expensive. This article attempts to show you how you can take images of deep sky objects without having to spend huge sums of money.

Equipment Requirements

You can take deep sky images with almost any type of telescope, despite what most Internet sites will tell you. It all depends on what you wish to take pictures of.

As an example, I have taken the image below of the M57 the Ring Nebulae with a Canon EOS450D camera and a Meade ETX125PE telescope. These are not expensive items of astronomy equipment. The telescope is a 127mm Maksutov Casegrain GOTO telescope on an Alt-Az mount.

This M57 image comprised of a stack of 75 exposures taken with a Canon EOS 450D camera through a Meade 125 telescope each at ISO 1600 and each exposure taken for 5 seconds duration. These were then stacked in DeepSky Stacker.

The Meade telescope is not geared for photography, it's motors tend to jump around and if you were to take long exposure photos, you would see a huge amount of star trailing. Having said that, taking short exposures can still work since most of the short exposures will not show the star trailing.

If you know your way around the night sky, then you do not even need a GOTO telescope. You do not even need a motorized telescope. (you will need to re-center the image on the sensor every now and again which will increase the effort required and the time it takes to collect all the pictures)

With these types of low cost telescope, you are limited to taking exposures of up to a maximum of 10 seconds. For example when I took the M57 image, I took 105 exposures, each at ISO 1600 and 5 seconds duration. I could only use 75 of these exposures due to star trailing or other factors that ruined the image, but I still managed to get a reasonable picture as you can see. Admittedly, it's not of the high quality seen by some photographers, but I took it myself and as such are very proud of my achievement.

However, with the above setup, you are unfortunately limited to the brighter Deep Sky objects. You can not take photos of the fainter or larger objects without having a significantly better equipment setup that can track the stars accurately or better still capable guiding. I realized this the hard way, after firstly purchasing the Meade, then after 9 months, I opted to purchase a more costly setup that comprised of a Celestron CGEM mount, a Skywatcher SkyMax 180 Pro Maksutov Casegrain telescope and a Skywatcher EvoStar DS 80 ED Pro Refractor telescope. This imaging setup is not cheep, but it is still within my limited budget and is no where near the prices of some imaging setups.

From my limited experience, the ideal equipment that you will require for Astro Imaging is therefore as follows...

Essential Equipment

The following is a list of the essential equipment that you must have for Astro Imaging.

Mount

This is the tripod and electronics that drive the telescope to ensure it is always pointing to the correct location in space. This is by far the most important part of any imaging setup. Do not cut corners here. Slightly inferior optics can be partially corrected during image processing, but you need good images to begin with.

There are two types of mount, the Alt-Az mount and the Equatorial mount. In order to take long exposure images, your mount needs to be equatorialy mounted. You can achieve this with an Alt-Az setup by bolting it onto a wedge (see another article on telescope mounts), alternatively, you could get a true EQ mount.

The mount needs to be motorized to enable it to track the stars accurately.

The issue with EQ mounts is that they have to be aligned accurately to the polar star. This means that in the northern hemisphere, you need to point your telescope to Polaris which is not a particularly bright star and you have to wait for it to become pitch black before you can setup your telescope. I have attempted to overcome this issue by choosing the Celestron CGEM mount, which has an All Star Polar alignment function which theoretically means you do not need to see Polaris to obtain an accurate polar alignment. It is still early days with this mount, so exactly how good this All Star Polar alignment actually is remains to be seen.

Telescope

This is obviously the next thing that would be useful to have. I have another article that covers the various types of telescope. But basically, choose an telescope that can be EQ aligned and is ideally suited for imaging. The most common ones being the Refractor, Schmitt Cassegrain or Maksutov Cassegrain types of telescope.

As with most things, you generally get what you pay for. Choose a telescope that you can afford. They can range from a few hundred pounds up to many thousands of pounds.

The telescopes that I purchased for my imaging experience were the Skywatcher Maksutov 180 PRO and the Skywatcher Refractor Evostar DS 80 ED. These to me were reasonably priced optics, from a known manufacturer and had some good reviews on the Internet forums. There are many other telescopes out there, it pays to do lots of research on the ones that you like to see what other photographers are using.

Camera

You will need a camera to capture the images of your chosen Deep Sky Objects. This is where you can really start to rack up some serious spend. This item can be a dedicated Astro Camera costing anywhere from many hundreds of pounds to many thousands of pounds. Alternatively, this can be a multi-use Digital SLR camera which although still costs a few hundred pounds, can be used for family snaps and holidays, thus you get the maximum use out of it.

I have opted for a Canon EOS 450D camera. This is an entry level DSLR camera again with some good reviews in the Astro forums and is a nice family camera with full auto capability. There are other cameras that are equally as good, it all depends upon your own preferences. Again do your research here, what are other photographers using?

Camera to Telescope Adapter

You will need a a way to connect your chosen camera to your telescope. On a DSLR, this comes as a T-Adapter.

I use a T-Adapter and a 1.25” noise piece adapter that attaches to the camera. The camera is then inserted into where the eyepiece would normally fit.

Optional Equipment

The following is a list of the optional equipment that can make Astro Imaging easier.

Computer

A Computer that you can use in the field is a useful accessory. This can be used for displaying a star chart or planetarium (there are numerous different software packages for this). It can also be used for controlling a GOTO telescope and for controlling the imaging camera, Guiding camera as well as for processing your images.

I use an Acer Aspire One Notepad running Microsoft Windows XP. This only gives me 1 hour of operation on battery, so I have to use mains power for this. I use this machine for camera control, telescope control and will be using it for Guiding once I get that far. The Notepad is considered to be expendable and it does not matter to me that it gets a hard life. All of my imaging processing is performed on a higher specification machine that is protected from the harsh environment of outdoor use.

Guiding Camera

If you want to perform really long exposures (5 mins or more), then you need to have a guiding system. This is basically a separate camera that is looking at a star and moving the mount to ensure the star remains exactly in the same position on the sensor.

There are all sorts of guiding cameras covering many price ranges. The main thing to look for is a sensitive camera that can see faint stars. This camera will most likely connect to your Computer which will then send commands to your Mount. An alternative is for the Computer to send commands back to camera which will in turn connects to the Mount via what is called an ST-4 port.

Image Flattener

It is recommended to have an image flattener to correct some of the optical problems encountered in telescopes. From what I can work out, a telescope optics would work ideally if the camera sensor was a curve, something to do with the mirrors being curves, hence light is focused perfectly on to a curved surface. However, CCD sensors are flat, hence there is some distortion towards the edges of the sensor. It is this distortion that is removed or reduced by using an Image Flattener.

I have not opted for one of these as yet. If I find that I require one of these items, then I will update this article to reflect my findings.

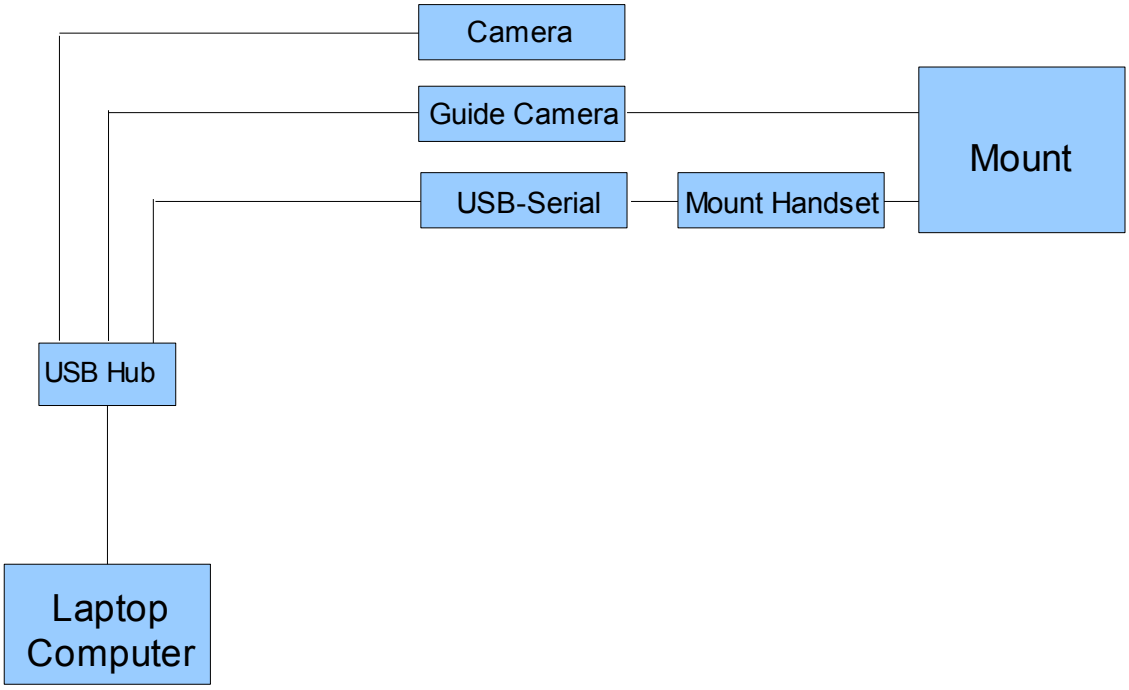
Focal Reducer

A Focal Reducer effectively reduces the focal length of your telescope. As a consequence of this, the images on the camera sensor become smaller, but brighter.

I have a 1.25” Antares 0.5x Focal Reducer, this item simply screws onto the front of my Camera nose piece. I use it for two reasons. Firstly to assist me in making sure the telescope is pointed at the Object I have chosen (the object may be smaller, but it is also brighter so easier to see on some test images). The second reason is to reduce the telescope focal length to enable me to reduce the exposure time for particularly faint images.

Connecting The Equipment

The equipment mentioned in the above section all needs to be connected together. The diagram below shows how this is achieved.



The above diagram shows how I connect my equipment together. The USB Hub is located at the telescope. I use an Active USB extender cable from the Laptop to this USB Hub.

My USB Hub has 4 ports on it, I only ever use 3 of these ports at any one time. I have labeled these ports to ensure I only plug one item into each of the ports.

My USB HUB ports are allocated as shown in the table below...

Port Number	Label	Description
1	NexImage	Planetary Imager (Web Cam)
2	Serial	USB to serial adapter for telescope control
3	DSLR	Canon EOS 450D camera
4	Guide	Guide Camera

I do not swap devices between different ports, each time you do this, windows will load a new driver and associate it with the USB port, this could cause the laptop to slow down over a period of time and I need all the power and speed I can get out of the computer.

I only use the DSLR or the NexImage cameras, never both together. Also, I would not use the Guide camera and the NexImage together. This ensures that I have sufficient capacity in the USB link for streaming the video images from either the NexImage or the Guide Camera to the laptop without dropping any frames.

The Mount that I have can be controlled from a computer via a serial port, however, my netbook does not have any serial ports so I have to resort to a USB to serial adapter to provide this connectivity.

The Guide Camera connects to the computer via a USB cable, but it connects to the Mount via an ST-4 connector (a special cable that is supplied with the camera). The Mount accepts this type of connection, If you intend to operate a Guiding camera, you do need to check the capabilities of your Mount and how it will all connect.

Software

There are a huge number of different software applications that are available for astronomy, some of these are free, others are commercial products.

Since I have spent a reasonable amount of money on the hardware elements of my setup, I like to save money in other areas, one area I can save money on is in the software area. A trawl through the Internet and the various forums can reveal some very good free software.

I admit that the free software may not have all the bells and whistles of the commercial products, they do have the basic functionality needed for the beginner. Also, do not forget the free software that came with the various hardware that you will have purchased anyway, these can also be useful.

Much of the commercial software provide full automation of your imaging sessions. If you are prepared to put a little manual effort into your imaging sessions, then multiple different applications of the free variety can be equally as effective.

The following is the list of software that I use. There may well be other software available that I have either chosen not to use, or that I am not even aware of. If you do know of other free software that I have not listed here, feel free to drop me an e-mail with the details.

Software Name	**Description**	**Notes**
Canon EOS Utility	Canon camera control	Software provided with my Canon EOS camera. This allows me to fully control the Canon camera from my notepad. I can use the Liveview window for focusing and there is a nice feature which allows me to automate the exposures of any length, the software will also download the images and save them to a directory on the notepad's harddrive.
NexRemote	Celestron mount control	Software provided with the Celestron CGEM mount. This provides complete telescope control from the notepad as if you were using the handset that is connected to the mount it'self.
AmCap	NexImage capture software	Software provided with the NexImage webcam. This allows full control of the webcam settings and control of taking the AVI files of any duration.
Registax	AVI image processing software	This is free software available from http://www.astronomie.be/registax/index.html This software takes an AVI file recorded by the Webcam and will stack the various frames to reduce noise and to enhance the image. From what I have seen, Registax works extreemly well with AVI files, but tends to struggle a little with digital still images from my canon DSLR. I use this software exclusively for processing the AVI planetary images.
DeepSky Stacker	DSLR processing software	This is free software available from http://deepskystacker.free.fr/english/index.html This software will take RAW images taken with many DSLR cameras, it will identify any stars in the image, align the images and stack them to reduce noise and enhance the image. Dark frame subtraction is also performed as well as many other image enhancement features are available. I use this software exclusivley for stacking deep sky exposures taken with my Canon DSLR.
DeepSky Stacker Live	Real-Time DSLR processing software	This is free software also available from http://deepskystacker.free.fr/english/index.html This software is a cut down version of the main Deepskystacker software. The difference is that you can use it in real time to show you your

		results whilst you are capturing your exposures. I use this one on my notepad, it will process your exposures and will count the number of stars it can find in your image, the more stars it can see the better your exposure. I use this feature alone to determine the best settings for the DSLR.
C2A	Planetarium software	This is free software available from http://www.astrosurf.com/c2a/english/index.htm There are may different planetarium software available, I stumbled across this one and found it to be relatively easy to use (even if the help file is only available in French). It works well and also runs fine on my notepad.
Stellarium	Planetarium software	This is free software available from http://www.stellarium.org/ I only use this software on my main PC. It provides a very smooth graphical display which is very pretty. This software however does lack many of the features available on C2A. However, Stellarium does have a very useful feature in that it displays the ground, trees and houses etc (you can define the outlook from your observing location) and if you look for an object, you can identify immediately if you will be able to see the object or not. I have often used stellarium to check if an object is visible only to find that it is currently located looking thought the ground.
Photoshop Elements	Photo editing software	This is a cut down version of Photoshop at a cut down price. This is very often supplied with new PC's or is a reasonable price if not. I use this software to tweek any images that I can not finish properly when using Registax or Deepskystacker. Mostly I use it to finish off the deepsky images. The only down sides to Elements are that it does not fully support 16 bit colour images (only 8 bit images) hence you loose definition, it does not have a curves feature (See later in this table for a solution to this one) and it does not have a macro recording feature. However as a beginner, it is a start. Once I become confident with all the other aspects of astrophotography, then I may choose to spend the money on the full version of Photoshop.
Smart Curve	Curves plugin for photoshop elements.	This is a free plug in available from http://free.pages.at/easyfilter/curves.html This plug-in provides the missing curves feature in photoshop elements.

Open Office	Office application suite.	This is a free application available at http://www.openoffice.org This is not so much an astronomy software suite, but is a Office application suite comprising of spreadsheet, word processor, draw package and presentation package. I use this software exclusively on my laptop for any office type work needed.
PHD Guiding	Guiding Software	This is free software available from http://www.stark-labs.com/phdguiding.html This software provides the guiding needed for long exposure photography. At the time of writing, I have not actually used this software as yet, since I am still working towards getting to grips with the other elements of this hobby.
IRIS	Image processing Software	This is free software available from http://www.astrosurf.com/buil/us/iris/iris.htm This software will take RAW images taken with many DSLR cameras, it can process the images in numerous ways. I have used this software only once so far with limited results, but I think my issues were down to bad RAW images rather than the software. This software appears to be very powerful and full of features.

As you can see from the list above, most of the software that I use for astronomy is freely available software, that either comes with the hardware, or is available for download from the Internet.

Taking and Processing your Images

To complete this article, the steps below cover the basic steps that I use when taking and processing deep sky photographs.

- Setup the telescope
- Align the telescope to the stars
- Move the telescope to a bright star close to your chosen imaging object.
- Attach the imaging camera
- Setup the computer
- Focus the camera on the star
- Slew the telescope to the chosen object.
- Take your photos
- Transfer your photos to the post processing computer
- Stack your photos.
- Tweek your photos using the photo editing software.