Digital Camera Astrophotography Tips and Techniques

The utilization of Digital Cameras for Astrophotography has become more and more inexpensive and appealing. Since the typical consumer digital camera can be used for regular picture taking as well as astrophotography, the cost is even more justified.

I have always been interested in Astrophotography but thought it was beyond my resources and capabilities. After purchasing a digital camera about a year ago, I was doing some research on the Internet looking for tips on how to use it better when I ran across information on how to use a digital camera with a telescope! Since then I have been obsessed with Digital Astrophotography.

What's so great about using Digital CCD (charge-coupled device) Cameras for Astrophotography? Well, for me it is the instant gratification I can get in seeing my initial results right away versus having to wait for having film developed. This also allows a faster turnaround time for perfecting one's technique. Another nice benefit is that the processing cost is much less than conventional film processing. If you want to have some prints, you can select only the images to be printed thus reducing wasted paper and development cost.

One of drawbacks in using CCD Cameras is that they are very susceptible to "hot pixels" or "noise" when taking longer exposures. Some of the more recent cameras are now incorporating noise reduction technology to help minimize this problem. There are also techniques such as Dark Frame subtraction and stacking that can help get around this problem.

Most CCD cameras that can be used for Astrophotography can be classified in one of the following categories: Consumer Digital Cameras, Digital Video Cameras, CCD Web Cams, and CCD AstroCams. This article mostly covers the Consumer Digital Camera but here are some differences and advantages to other types:

Digital Video Cameras are much like the standard Digital Camera in technology and quality (lower end resolution). However, they typically have fewer and more limited options for single frame picture taking. Images can be acquired and processed either by taking a snap shot (some video cameras have this feature) just like a digital camera or by recording a short video that can be transferred to a computer via a frame grabber or other video transfer methods such as using a firewire. In fact, it may be desirable, with much patience, over the single shot of the Digital Camera in that you can stack tens or hundreds of images into one image to achieve the desired result. This can be done through various software packages some of which I will mention later on. Some good results on lunar, solar, and planetary images can be achieved but DSOs are pretty much out of the question since long exposures are not possible.

The above Photo is used with permission by Johannes Schedler (http://panther-observatory.com/) 11/14/01.

M 45, the Plejades imaged by digicam during good seeing at 10°C, C11 with 40mm Pentax + Nikon CP995 in wide mode,
3 combined exposures of each 60 sec unguided with NR, image size reduced; levels, gaussian blur for background, unsharp mask for stars in Photoshop.

Digital Web Cam Astrophotography is similar to Video Cameras capabilities but require the images to be directly downloaded to a connected PC and resolution is usually limited to 640 x480 or lower. This seems to be a popular method since the cost of getting started is very low. Some Web Cams can also be modified to take extended exposures. For example, I purchased a Phillips Vesta Pro 680 camera for $18 and had it modified at a cost of $60. Finally, I purchased an adapter for $20 to attach it to my telescope using primary focus (without eyepiece). So, for under $100 I now have a CCD camera capable of taking long enough exposures to capture DSO objects. Of course, you still need a PC or a Mac.

CCD AstroCams are the devices used by serious Astrophotgraphers designed specifically for astrophotography. One of the primary differences that distinguish these cameras from the other types is that they are cooled to greatly minimize "hot pixels" or "noise" created from heat within the CCD chip. These types of cameras produce outstanding images of DSOs but much more than a typical general consumer-type Digital Camera. I have seen the costs ranging between $2000 and $45,000 for AstroCams. Decent color AstroCams start at about $4500. A PC is also required but a Mac can be used as well.

Consumer Digital Cameras have become very popular. They allow you to take a digital image afocally and store it onto media that can be transferred to a PC or taken to a Photo Processor for processing.

The camera and accessories you need will depend on the type of objects you want to image. I would suggest that first you decide what you want to be able to do. Lunar and Solar shots* are the easiest to take and process while planetary and DSOs become more difficult.

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The following chart is a collection of my thoughts on what you can expect depending on the targeted object. Note: this is combination of my experiences and results I have had and seen of others and you may find this may vary for you and your equipment.

What is needed?

Cameras – When selecting or using a camera for Astrophotography certain features are beneficial and can be critical.

Important Features - Manual settings such as shutter and aperture control, exposure times (up to 30 seconds or more depending on aperture for DSOs objects), manual/infinity/macro focus selections, ISO settings of 100, 200, 400, or even 800, Optical Zoom of 3x to 10x (recommend disabling digital zoom), contrast / lighting / sharpness, a timer / remote control, flash disabling, output for external monitor, and threaded for lens accessories.

Resolution – Any Mega pixel camera can give you high enough resolution for viewing images on a computer. Many people reduce the resolution down to even 300x200 for displaying on web pages. If you want to print your images, then you may want a camera that can do 2 Mega Pixel or greater.

Accessories – Power pack or at least rechargeable batteries, serial/ USB/Firewire connection to computer, remote shutter control (prevents shaking the telescope).

Memory – The kind and size of memory will depend on what types of formats your camera stores images and whether it is compressed. The resolution of the image will also factor in. Most do JPG compression. Some will allow uncompressed Tiff or BMP files. For example, if you are using a compressed format at 2 Mega Pixel taking shots of

Difficulty vs. Results for Digital Camera Astrophotography

Object Type	Getting the shot	Digital Processing	Image Results
Lunar and Solar*	Easy – Easy to locate and focus. Tracking not necessary. Can be done with or without a telescope.	Fairly Easy – Most software that comes with camera will work. Only minor adjustments to contrast, sharpness, color and light balance are needed.	Can be very good. A lot detail can be obtained even in smaller scopes.
Stars and Constellations	Fairly Easy – Faint stars may require longer exposures and tracking. Light pollution may factor in especially in fainter constellations.	Fairly Easy to Moderate – Depends on magnitude. May have to combine or stack images to obtain good results.	Good depending on magnitude variations and seeing conditions.
Planetary – Large (Jupiter and Saturn)	Easy to Moderate – Tracking capability helps but is not required. Focusing and camera settings get more difficult but can be obtained. Air stability factors in greatly.	Moderate to Tedious – In some cases a single shot may be good enough. Stacking / combining several to many images to produce a composite will greatly enhance the results.	Can be very good. Much detail can be obtained with practice.
Planetary – Small	Moderate to Difficult – Very difficult without tracking. Camera settings and focusing are critical. Air stability factors in greatly.	Moderate and Tedious – Multiple shots stacked / combined are really needed to produce good images and / or detail.	Okay to fair – Some detail on Mars can be obtained.
DSOs	Moderate to Very difficult – but can been done. Must have tracking and a camera that can do long exposures (15 to 60 secs depending on aperture). Light pollution factors in especially in fainter DSOs.	Difficult – Almost always necessary to combine multiple shots. Hot pixels / noise must be subtracted. Balance of contrast and color is critical.	Very Good to poor – With a great amount of effort and practice, mostly on the processing side. Larger apertures have much better results.

**** Warning – never use a camera or telescope for solar viewing or imaging without proper filters in place!***

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Saturn you should get at least 200 to 300 pictures on a 64MB card. In uncompressed mode you may only be able to get 15 to 30 shots.

Popular Cameras Used – The big three I have seen mostly used are the Nikon Coolpix 850/9xx (I have the 990), Olympus 20xx/30xx, and Casio QV xxxx. There are many others but these seem to have most if not all the necessary features most people want for Astrophotography. The costs for these range from about $300 to $750 (*see links below for more info*) and are dropping quickly. They can also be obtained used for less expense.

Telescopes – Just about any type of telescope can be used. Important considerations are:

Telescope mount/tripod/forks – The more stable or sturdy of course the better.

Aperture – Size really does make a difference, especially when imaging fainter objects.

Balance – Smaller telescopes might be more susceptible to balance problems with the weight of the camera attached.

Focusers – Focus is obtained by the telescope, not the camera. Many telescopes tend to shake or vibrate when focused making fine focusing very difficult. Electronic focusers can be added to help with this problem if needed.

Tracking Ability –Tracking becomes critical when attempting to image DSOs and smaller planets. It can also help with larger planets, lunar and solar imaging.

Mounting / Connecting – There are many methods to attaching your camera to a telescope. It can be easier and cheaper if your camera is threaded for accessories. You want your camera lens positioned as close to the eyepiece as possible to help prevent / reduce vignetting. Vignetting is an effect that shows up as a darkened area circling your image much like looking through a tunnel or a tube. A couple methods of connection are:

Attach the camera via thread-on adapters. Obtain a threaded step-up ring for your specific camera thread size to a standard 38mm. Then you can either use a 38mm adapter that clamps / couples onto your eyepiece or a threaded T-Adapter that the eyepiece can be inserted into. I prefer the coupling adapters. (See link below for more information on camera adapters). Another method is by using various "Universal Camera Adapters" that use the camera's tripod threads to attach to a mount that is positioned over your eyepiece. This method may be more universal, but is typically more expensive.

The photo below is used with permission by Johannes Schedler (http://panther-observatory.com/) 10/12/01.

M 42, the Orion nebula imaged by digicam during good seeing at 10°C, C11 with 40mm Pentax + Nikon CP995 in wide mode, single unguided exposure of 60 sec with NR, image size reduced; levels, color balance and gaussian blur in Photoshop

Techniques for taking images

Preparation – Have your telescope cooled down. A large enough temperature difference can cause poor viewing and imaging. Some larger scopes can take several hours to achieve temperature balance especially in the winter months. Check and adjust your collimation if your telescope supports this! This is by far one of the most critical steps for getting sharp images.

Focusing – This is also very critical for taking sharp images. Focusing is done via the telescope. The camera is typically set to infinity or macro mode. For best results focus the telescope with the camera in place. There are several methods for this:

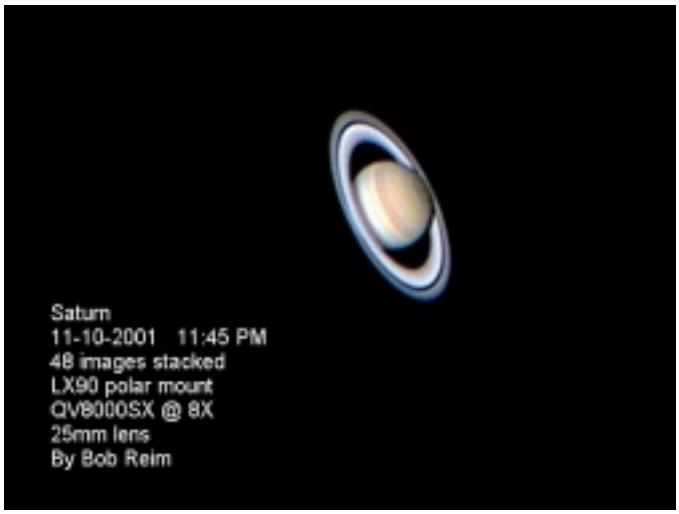
Hartman Mask – This mask allows you to focus on a bright star or planet. You can then remove the mask and target your desired object. (See link on how to build and use. Easy and cheap!) Don't forget to remove the mask prior to imaging! I have made this mistake several times.

Connect a monitor or TV to your camera to give you a larger view than your camera LCD to focus on. This can also be combined with the Hartman Mask.

Zooming – Zooming in on the focus object can also help. You can even use digital zooming for this, but make sure you turn it off prior taking shots of your target.

Camera Settings –

ISO – A balance must be met here. Higher ISO settings mean you can do shorter exposures, which typically equates to sharper images. However, it can also add more general noise and hot pixels due to the higher sensitivity/gain set-



ting of the CCD chip.

Optical Zoom – Zoom is very desirable for planetary imaging. There is currently a big debate over whether it is better to use more zoom of the camera or more power in the telescope. I have not seen any proof for either way yet, but I am currently leaning towards more camera optical zoom may be better based on my observations and theories. Zoom also helps reduce vignetting.

Digital Zoom – Digital zooming is not recommending for taking images. There is no advantage in using this feature since this is basically resizing/cropping the object and can be done later during image processing if necessary.

Light / White Balance – This varies somewhat between cameras. It can affect the resulting color of the object being imaged. Many recommend Black and White for lunar shots.

Exposure – This varies greatly depending on telescope/ camera aperture, viewing conditions, and the object you are imaging.

Resolution – You must experiment to see what works best for your needs. Factors include the target object to image, the amount of available memory, and whether you plan to view these images on the screen or print them in photo quality. It also takes the camera longer to store higher resolution images and it can be more difficult to work with them in some graphics packages. Higher resolution can give you better quality results, though.

Other settings – Flash should be off! Typically, I stay with auto settings on all other settings. Some recommend disabling most settings since you can always adjust things later in software.

Taking a DarkFrame – If your object requires longer exposures than ¼ of a second and your camera does not have an automatic noise reduction feature then you may want to take what is called a Dark Frame shot. This can be used later to subtract out the Hot Pixel and Noise produced by you camera during long exposures. The Dark Frame must be taken for the same duration and camera settings as your imaging session. It is suggested that you take one of these prior to and after a session for each change in exposure time and / or picture setting. You can take these by simply capping off the telescope or by removing the camera from the telescope and covering up the camera lens with the lens cap where no light can get in.

Conditions / Location – Obviously, better seeing conditions are going to yield better results. Planetary, lunar, and solar images are more affected by poor seeing than DSOs and Constellations. On the other hand, Planetary, lunar, and solar images are less affected by light pollution while DSOs and Constellations are. DSOs and Constellations are also affected by bright moon light. The higher in the sky your target image is the better (less atmosphere distortion). Planets should be at least 50 degrees or higher for good results while DSOs are more forgiving

Image Processing

Software – In some cases you may be happy with the raw image straight from the camera. In most cases, at least some tweaking is necessary. Stacking multiple images can also be very effective and can simulate extended exposures. The idea here is that many images of the same size and resolution can be combined to produce an image that has less noise and greater detail in it. You will want to only stack images taken within minutes of each other to help minimize field rotation (for alt/az mounts) and object rotation (Jupiter rotates very fast). Typically, the software that came with your camera will allow you to resize, crop, and adjust contrast and color balance. Other software may be needed to perform stacking, DarkFrame removal, file conversion and other enhancements. There are some nice freebies out there such as IrfranView and DarkFrame. Some of the more popular commercial packages include Paint Shop Pro and Photoshop. Some advanced Astrophotography related software available are AstroStack, AIP4WIN, Cadet, Iris, Gimp, and AstroArt. (See links below for more information about these software packages).

Printing – Inkjet printers can do a nice job at this and some paper and inks are now rated at 10 years or more. You may want to use higher resolution images for better results. Since the background is usually black, you may want to closely crop your image to not waste ink.

Summary

Effect Digital Astrophotography has three distinct skills sets that I have identified so far. First is the astronomy aspect of knowing the sky and using a telescope. Secondly, is learning how to use your digital camera well. Finally, comes the computer processing skills of processing and enhancing the images. It can be a big learning curve for some but can be overcome in time with patience, practice, and perseverance. It can be a very fun, challenging, and rewarding experience.

Digital Camera Astrophotography Tips and Techniques (Continued)

Highly Suggested / Helpful Links Tips and FAQs

Digital Astrophotography Group - http://groups.yahoo.com/group/digital_astro/
Digital Camera Astrophotography FAQ - http://www.erols.com/szykman/Astro/AstroDigiCamFAQ.html
Getting Started Guide to Digital Camera Astrophotography – http://groups.yahoo.com/group/digital_astro/files/GettingStartedGuide.pdf
Imaging Cookbook for Beginners - http://groups.yahoo.com/group/QCUIAG/files/Imaging%20Cookbook%201.0_word6.0.doc by Jay Timmermans

Digital Cameras and Accessories

Cameras and reviews - http://imaging-resource.com/ and http://dpreview.com/
Comprehensive overview of many commercial adapter solutions - http://www.erols.com/szykman/Astro/Adapters.html
Hartman Mask Link - http://www.incessant.com/gap/astrophotography/Coolpix/diyhm/
CCD Article by Eric Meisenzahl, Eastman Kodak Co. -http://www.sensorsmag.com/articles/0198/cc0198/index.htm

Image Processing

Using AstroStack -http://groups.yahoo.com/group/digital_astro/files/AstroStack%20First%20Light.pdf
BlackFrame (removes noise) - http://www.mediachance.com/digicam/blackframe.htm
Image Processing Links -http://groups.yahoo.com/group/digital_astro/links/Image_Processing_Sof_000999519803/
Catching the Light Site by Jerry Lodgriguss (good tips) -http://www.astropix.com/HTML/K_MISC/TOC_SITE.HTM

- **By Bob Shabowski**