

Getting Started Guide to Digital Camera Astrophotography

This guide is designed to begin discussion on this topic and not, yet, as the definitive reference. I hope that by combining all of our experiences, that we might create a document that would help beginners avoid all of the trouble that some of us have endured. This is our group's document and is meant to help people new digital camera astrophotography. You might notice some of your advice in this document. That is because it was good advice!

Familiarize yourself with the manual modes of your digital camera

Try taking pictures in a dark room of LEDs or other small lights. Next, try taking terrestrial pictures at night in your backyard. Make a habit of "bracketing" your exposures.

Bracketing exposures is the practice of taking the same photograph with small modifications in exposure settings. For example, one might set the aperture to a given setting and take pictures using several different exposure times.

Alternatively, one can set an exposure time and take a range of different aperture settings. When set to manual modes, some cameras will indicate which aperture and/or exposure time settings the camera would pick if it had been set to automatic mode. This is useful for providing a good starting point about which to bracket your settings.

Next, take pictures of the night sky using a tripod, or by placing the camera on a table or other sturdy surface. Conjunctions of the planets and/or the Moon are excellent subjects for the digital camera.

If you have a wide-angle lens try photographing constellations, and if you have a fish-eye lens try shooting an all-sky photograph or two.

Remember that you will not be able to see your camera in the dark so getting to know the camera and its settings is an important prerequisite.

Shoot the Moon

The Moon is a lit subject and many have photographed it in Full Auto mode without any special settings, or capabilities. This is a good place to start. Its bright, big and beautiful and you can test many different aspects of your equipment setup on this subject. Many first astrophotography experiences begin with holding the camera up to the eyepiece and shooting pictures of the Moon.

The best time to photograph the Moon is not during a full Moon. Instead, try quarters or even smaller phases, as these will provide stunning details along the area between shadow and light. Experiment using your camera's zoom, try to photograph the Moon completely, and then try to get close-ups of just craters.

Shooting the Sun is also fun and easy, provided you have the specialized filters required to view the Sun. ***Never use a camera or telescope to photograph or view the Sun without the proper filter ***

Shooting the Moon and the Sun are rewarding and have provided the groundwork for most amateurs' interest in digital camera astrophotography. An amateur can produce nice quality images using just a hand-held camera, but when progressing to other smaller or dimmer targets, having a mounted camera can help improve your results.

Connect the camera to the Telescope

Many DCA's (digital camera astrophotographers) have had good luck with a tripod or other bracket that fixes the digital camera on or just above the eyepiece, but most use some sort of digital camera adapter that attaches the camera to the eyepiece.

In our bookmark's section there are many links to sites that have adapters that will allow you to connect your camera to your telescope. A couple of factors should be taken into consideration when deciding on the right connector; namely, the sturdiness of the physical connection and vignette avoidance.

Vignetting causes your photos to look as though they were taken in a tunnel. Try your connection in the daytime and check various zoom settings and note where vignetting begins and ends. In general, the camera lens should be as close to the eyepiece as possible. Also, to minimize vignetting, the aperture should be wide open. When taking astrophotographs, cameras will often open the aperture to the maximum degree due to low light conditions, so this is less of an issue under these circumstances.

However, with bright targets (such as the Moon or the Sun with a solar filter), or when experimenting with manual aperture settings, the aperture may not always be open to its full size. Since vignetting also depends on your equipment and level of magnification, even with a not-fully-opened aperture you may not experience vignetting. But, if it is an issue when your aperture is not fully open, it may be better to modify settings to a more open aperture and shorter exposure times.

Many telescope to digital camera adapters/connections are sensitive to the weight of the camera and this sensitivity causes the subject to fall below the field of view of the camera. This is especially true if you are using a Barlow and/or Diagonal.

The effect of this problem is that the subject will be centered in the eyepiece but when the camera is attached, the subject will fall off the bottom of the field. To test this, first target a bright star or planet and then, attach the camera and make sure that the subject is in a similar location in the camera's LCD screen. If the subject has moved, try moving the subject to the top of the eyepiece, or simply position the object using your camera.

When using a wedge or equatorial system, a diagonal should not be used. It just adds more stuff between the CCD and the subject and may cause field problems described above.

If your telescope is not mounted for astrophotography using a wedge, or equatorial system, be very careful about leaving the camera attached while slewing. You can mangle your camera or other gear by slewing toward the zenith with the camera attached. You may have to use a diagonal when photographing subjects near the zenith.

Find and track your subject

Due to the rotation of the earth, many objects will move out of your field of view before you can shoot. Depending on their location in the celestial sphere, and your camera's exposure setting, you can accidentally blur a shot.

If you are using a telescope with a "Goto" computer or equatorial platform, use them, as this will help with both finding and tracking your subject. If your "Goto" computer has a sync or high precision mode, this can also help.

If you own a star charting or planetary program, use this to determine where your subject will be in the sky and in relation to any obstacles in your viewing area. Note the times when the object will be in the best location based on your site and its light pollution. In highly light polluted sites, subjects are best viewed directly overhead while subjects located between 60° and 80° from the horizon are the easiest to view and photograph.

Focus, Focus, Focus

There are many tricks to getting good focus and the basic rule of thumb is to set your digital camera to manual focus at infinity and use your telescope to focus the image. Many times the LCD display on your camera is less than perfect for this.

Many digital cameras have a separate viewfinder that does not look down the actual lens and therefore it cannot be used. The viewfinder in this case will show you a lovely view of the back of your telescope.

If your digital camera has a video out port, you can attach this to a separate larger video monitor. If your camera will show what it is about to shoot or has just shot through the computer interface, then a laptop or other computer may be helpful to provide a larger image.

Both of these things wreck your night vision and are unpopular at star parties. You can use red rubylith foil to cover the monitor's screen, which will reduce the amount of white light emitted, and this will help in keeping your night vision. A small piece of the rubylith for your camera's LCD might also be in order.

Specialized devices have been created to assist with focusing in traditional and CCD astrophotography and may prove helpful with digital cameras. One trick to focusing bright stars or planets is to use a Hartmann mask.

A Hartmann mask is a disk that fits over the business end of your telescope, like it's dust cap, which has holes cut into it. These are available commercially or can be made from foam core board. Using the mask, a bright star or planet will appear as multiple images, one for each hole, when out of focus and one image when in focus. This is normally much easier to see than the focus of a single image. To focus dimmer subjects try focusing on a bright star in the same constellation.

Most consumer digital cameras have a digital zoom feature that can be the absolute best focusing tool. Simply, center the subject and then zoom in all the way, centering as you go, until a star or planet feature fills your primary viewer. Now, as before, use the telescope to focus image. Once the image is focused back out of the digital zoom before taking the picture. In addition, increasing the ISO setting just during focusing for dim subjects can be very helpful in some cameras.

Noise Reduction

A consumer digital camera uses a charge coupled device or CCD to produce images. An astronomical CCD camera uses similar technology but adds cooling to the CCD to reduce noise. Without the cooling, all long exposure photographs taken with digital cameras will contain noise. Depending on your subject, great care will need to be taken to eliminate this noise. Bright subjects such as The Moon, Sun, and planets may not exhibit noise but dim subjects such as deep space objects will always require intervention.

Put your camera's lens cap on and try taking the longest exposure possible with your camera. Now examine the image. See that it is not black but instead full of tiny star clusters...well almost...it is just noise.

To keep your background black and your stars real, you should take some dark field frames before each camera setting adjustment. Once you have a subject in the field of view and focused, you should take a few "dark" field frames by putting the telescope's cap on and shooting at the same exposure as planned for the subject.

This will only work if your telescopes dust cap is "light tight." If it is not light tight use a dark cloth or simply use your camera's lens cap.

Allow the camera's CCD to cool down before each dark field image and if possible take dark frames and normal frames with the LCD turned off. Write down or otherwise record the subject, exposure, and dark frame file numbers or names. Later on, we will use these to subtract out any hot pixels or other noise caused by the long exposure.

Many different image-processing packages include the ability to remove noise by using image mathematics to subtract the dark frames from the images. Multiple dark frames can be averaged to provide more productive noise reduction and it is good to take more than one dark frame, anyway, in case something happens to one frame you will have a back up.

By examining dark frames from a night's astrophotography session, you should start to see patterns in the noise. Some of these are defects or "hot pixels" and by noticing their location you can try and place subjects in "hot pixel" free zones in future sessions.

If your digital camera has a noise reduction feature built-in to the camera try taking shots with and without the noise reduction on. Those without will need dark frames as suggested above but those with the noise reduction on will already be dark subtracted by the camera. We have found that this noise reduction works for some subjects and cameras very well and for others not as well as doing the dark subtraction manually.

Stacking and integration

Just as a larger aperture telescope collects more light, multiple subsequent photographs, combined, can also collect more light. Because most digital cameras cannot take very long exposures, most are less than 16 seconds and many are less than 60 seconds, combined subsequent images can simulate extended exposures. In addition, stacking brings out details in bright subjects such as planets, in fact, most successful planet photographs contain 20 to 30 images stacked.

Begin by taking multiple exposures with the camera at the same settings. The number of exposures depends on the subject and can vary from two to the maximum possible with your memory card or even multiple memory cards.

Stacking can be done with standard image processing software but is usually easier with software made for astronomical purposes. The main reason for this is that earth is still moving throughout your astrophotography session and the images are not all aligned especially those at the beginning and at the end of session. Astronomical image processing software usually has an alignment or registration function to properly align the images before stacking them.

It is best to shoot each shot within a minute of the next if you are interested in stacking.

Shooting

At this point, you have found your subject, focused the image, and taken your dark frames. You are also prepared to shoot multiple images of the same subject so that they may later be stacked.

To obtain the most detail it is advised to use the finest or maximum non-interpolated resolution available in your camera. Having said this, your memory card will fill very quickly using this resolution and processing of your images will take longer.

To start with, you might want to try using the second best resolution and then, after you have had a chance to familiarize yourself with the process, upgrade to the highest resolution.

It is recommended that you shoot a single subject per session so that the images are not confused and so that you can spend ample time on each subject. Also observing is half the fun and if you spend all of your time in the dark holding your shutter release, you will be missing a very important part of astronomy.

Remember to document each exposure noting the settings and subjects. If your camera automatically documents your photos then you do not need to write everything down. Be sure to put each subject in a separate album or write down which photos go with which subject, if you do happen to shoot more than one subject.

Also, do not forget to turn off the LCD monitor while taking any exposures. It is important to have darks that exactly match the normal images so if you change anything be sure to shoot more darks to match the new settings.

If your computer is close, run in and look at the images, during the middle of your session, and check the images to make sure that all is well. It may be possible to correct the problem and salvage the session or you might see some detail or other area of interest that should be exploited. In either case, a quick peek every so often can never hurt.

Image Processing

We have completed all of our shots and packed up the telescope and all of our various gear. Our astrophotography session is complete...or is it?

Take the camera in the house and look at the pictures. Not a pretty site, are they? The key to good astrophotography of any kind is image processing and the key to almost any astrophotography with digital cameras is image processing.

First, go to bed. It is enough to spend the night in the backyard taking the shots, wait until the next day or even the next cloudy night to begin the image processing of your photographs.

Transfer the images from your camera to your computer under a folder with today's date and organize them so that the dark frames, and normal images of similar exposure, or other settings are grouped together in additional subfolders. Rename the dark frames as dark1, dark2 etc. and normal frames as subject1 thru subject15 i.e. M13-1, M13-2.

Begin by inspecting the images for out of focus or other problem images and move these to a folder named Problems.

Here is an example folder structure:

```
My Astro Photos
  08232001
    Mars
      Dark1.jpg
      Dark2.jpg
      Mars1.jpg
      Mars2.jpg
      Mars3.jpg
      Mars4.jpg
    Problems
      DC23197.JPG
```

The first task is dark subtraction. If you have multiple "dark" frames, then each of these can be averaged (or use median) to create a master dark image.

Next, take your dark or master dark and subtract it from each of your normal images. This process can be found in the image math section of some image processing software or in the calibration or correction section of astronomical image processing programs.

Lets try dark subtraction in Paint Shop Pro 7. We open the dark frame and we open a normal image. We select image menu then Arithmetic and are presented with a dialog box, which has two pull downs for the two images. The operation we are interested in is subtract and PSP7 defines subtract as Image1 – Image2 so we select our dark frame in the image 2 pull down and our normal image in the image 1 pull down. We check the All channels checkbox so that we get a color result, leave the other settings alone, and press ok. A new dark subtracted image pops up in front with a lot less noise! You can leave the dark image and repeat for each normal image.

Now that your images have been dark subtracted, they can be stacked to provide more detail and simulate longer exposures.

Lets try stacking the images in Astrostack. Using PSP (it can do this in bulk) or another program we must convert the JPG or TIF format images to Windows Bitmap (BMP) format before they can be loaded into Astrostack.

In Astrostack, click the BMP button and it prompts you to select the first BMP image and then the last image. This means the files should be numbered as described above as Mars1, Mars2, Mars3, and Mars4 and we would select Mars1 for the First and Mars4 for the last.

Once selected, Astrostack will load the BMPS and stack them. We should also select Align Auto and click GO to register the stacked images. In the result window, we see the stacked image. We can perform a number of other operations from Astrostack but for now, we can click save result and then exit.

We just stacked 4 images of Mars into a single hopefully more detailed image. We could also have automatically dark subtracted the images by clicking the correct button and selecting the dark frame.

Astronomical Image processing is a topic worthy of its own guide and there are many additional processing functions that can help to make your images the best that they can be.

For example, an un-sharp mask, a low pass filter, and convolution/de-convolution algorithms can really bring out the detail and suppress unwanted background or other artifacts.

It might seem obvious, but using paint functions to create features and other fabrication practices are generally frowned upon in the astronomy community.

Finally, share your images with this group and others

That is one of the best parts of this exciting endeavor, sharing images (even bad ones) with the group. You can gain perspective and insight while learning what to do the next time the clouds part for you. Above all, have fun.

Links

[digital_astro] is a yahoo group for people interested in Digital Camera Astrophotography. Be sure to visit the files and bookmarks section.

http://yahogroups.com/group/digital_astro

The Digital Camera Astronomical Imaging FAQ prepared by [Simon Szykman](#) contains frequently asked questions and answers that should be used as a companion to this document.

<http://users.erols.com/szykman/Astro/AstroDigiCamFAQ.html>

Ckcpower is a digital camera and accessories company that specializes in connecting your camera to your telescope.

<http://www.ckcpower.com/>

Digi-T by Scopetronix is a digital camera to telescope adapter. Scopetronix has many other ways to connect your camera to your telescope.

<http://www.scopetronics.com/digitalcam.htm>

TeleVue now has a new line of Digital Camera adapters to fit its excellent line of eyepieces.

<http://www201.pair.com/resource/astro.html/regular/products/tele-vue-optics/digital.camera.to.eyepiece.html>

William Optics has a revolutionary new 1¼ 28mm eyepiece that is threaded and made to connect a Nikon Coolpix camera to your telescope. Rumor has it that additional cameras will be added in the future.

http://www.buytelescopes.com/product_details.asp?pNumber=3940

Mediachance has many different free software programs for digital camera photography and the "blackframe" and "hotpixels" programs are perfect for digital camera astrophotography.

<http://www.mediachance.com/digicam/blackframe.htm>

Paint Shop Pro, an inexpensive but powerful general graphics program with a 30-day trial, which has many advanced features including Arithmetic options, which are perfect for Color dark subtractions of Digital Camera images. Price is \$99US download.

<http://www.jasc.com/products/psp/>

AstroStack, a freeware astronomical image-processing program, will do dark subtraction and stacking and other functions all at once and is a good way to get started with image processing. To use this program the images must first be converted to BMP format and reduced in size by either cropping or resizing.

<http://utopia.ision.nl/users/rjstek/english/software/index.htm>

Cadet, another freeware astronomical image-processing program, is more complex but provides advanced functionality not found in other freeware programs. To use this program images must be also be converted to BMP and then colored images split into their red, green, blue, and optionally luminosity components.

<http://www.terra.es/personal2/oscarcj/introeng.htm>

Iris, also free, is an astronomical image-processing program with a command line interface that can be saved as a script for batch processing. This software is by Christian Buil

<http://www.astrosurf.com/buil/us/iris/iris.htm>

GIMP, freely distributed general public licensed image processing program, has many image processing functions.

<http://www.gimp.org/>

Astronomical Image Processing for Windows is an excellent book by Richard Berry et al that also includes AIP4WIN a powerful astronomical image processing program.

The book is available from Willmann Bell for \$79US.

<http://www.willbell.com/aip/index.htm>

****CAUTION:** Observing the Sun is the one and only thing in astronomy that can be really dangerous. If the filter falls off your scope for some reason, you will instantly damage your eye, which might not be repairable. Always double-check everything before observing the Sun. Especially make sure that the filter cannot fall off your scope, or be blown off by wind. Secure it tightly. Remember to cover any finder on your scope too. Many people have the habit to look thru their finder scope without thinking about it. This can seriously damage your eyes if the scope is directed at Sun. It might be a good idea to find an experienced solar observer near you and let him introduce you to this. Take extra care if kids are around. TAKE CARE ALWAYS.