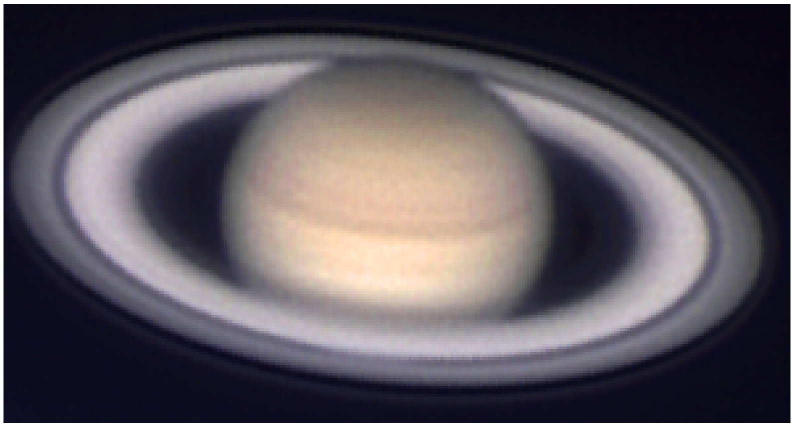


Planetary and Lunar Imaging

by Mark Estes, Digitec Optical
[click to email author]

Editors Note :Mark and Wendy Estes own and run Digitec Optical - a reseller of both astrophotograpy equipment and telescopes.

For those who are new to planetary and lunar imaging, we hope that the following article will assist you in getting started in this highly rewarding hobby. Only modest equipment is needed to get excellent images. Given the short exposure times required to image these bright targets, it is more technique and practice that gets results instead of expensive equipment. Listed are a few tips to avoid some common pitfalls that have newbies ripping their hair out in frustration. We will delve into some detail here, but it can be summed up with a few simple words:

COLLIMATION, FOCUS, EXPOSURE, PROPER SAMPLING and PROCESSING.

What Type of Camera and Telescope Combination is Best for Planetary Imaging?

The most important feature of a planetary camera is small pixel size. This is the physical size of each individual pixel, usually measured in microns, and not the size of the array. A good range is 5-10 microns. This will allow small details planet to cover more pixels, thereby allowing you to record the small details more accurately. This is known in the astrophotography world as proper sampling.

Without a doubt, any camera capable of recording AVI movies on your laptop is best for reasons we'll get into later. SAC imagers, like the SAC7 series, webcams and even video taped images can be used.

Meade's new LPI (Lunar Planetary Imager) is a very cost effective way to break into this hobby. Astrophotographers are getting really good results with this very basic camera.

You can also shoot still frames from either the SAC, webcam, LPI or digital camera and process the images manually. Many astrophotographers have done stunning work with modest digital cameras. If you go that route, we recommend that you use Scopetronix's Digi-T adaptor to connect your camera to the eyepiece. This adaptor will work with most common eyepieces and get your camera as close as possible to the eyepiece to reduce vignetting effects. The SAC camera comes with a 1.25" nosepiece adaptor so it'll plug straight into your telescope. Adaptors can be purchased from Scopetronix and other companies to allow you place a 1.25" nosepiece on your web cams. If you are a do-it-yourselfer, you can make a webcam adaptor using a plastic 35mm film canister. As it turns out, the diameter of that canister is 1.25 inches. Just make sure that the canister is square to the ccd chip when it is mounted.

As far as the telescope is concerned, the larger the aperture the better. This will give you more light to resolve a highly magnified image. The combination of large aperture telescope will a small pixel size camera is a formidable weapon for this type of imaging. Typically, a telescope of eight inches or larger is best, but smaller ones can be used quite successfully.

Stack Your Images

Those great planetary and lunar images you see everywhere are not single shot images. They usually consist of many images that are mathematically averaged (stacked) together. This is done for two reasons; noise reduction and detail enhancement. Lets talk about noise reduction first. The CCD sensor in your camera generates a certain amount of electrical noise. In your images, it takes the appearance of a graininess, or snowiness. This noise chews into your image and obscures details. The amount of noise that a camera generates is directly related to the temperature that the camera is operating at. The warmer the temperature, the more noise it will produce. When you mathematically average two images together you increase its signal to noise ratio (SNR). In other words the signal (detail) increases and the noise decreases. The more images that you average together the higher the SNR will become. It is not uncommon to average hundreds of images together to get superior results. Luckily, there are free software packages that will perform this averaging function but we will get to that in a minute.

The main problem with averaging images is that the pictures must be perfectly aligned (or registered) in order for the process to work. Manually aligning planetary images is a difficult and tedious process. Even the auto alignment functions of the leading image processing programs have difficulty registering planetary images accurately. Enter Registax! Registax is a free program available on the Internet that will automatically align, average (stack) and process your raw images your images. You can download it for free at the link indicated near the end of this article.

Shoot Movies Instead of Still Images

Given the fact that you must use a high number of raw images in your stack, it is highly feasible to shoot movies instead of single images. Movies? Yes! Some cameras, like the SAC imagers or web cams can record short movies and store them on your hard drive in AVI format. A standard video recorder and some sort of video capture device on your computer can also be used to record AVI movies. An AVI movie is nothing more than a series of still frames shown to you in rapid succession. If you could split up the movie into still frames, that would be ideal. Well, Registax will do exactly that. It will take a raw AVI movie, split it into individual frames, rearrange the frames in order of quality, automatically drop the frames that are below a certain quality, align the remaining frames, stack them and then drop you into a screen for final processing. It couldn't possibly get easier.

Shooting movies has another significant advantage. When you look at a planet visually, you know that for brief times the image will snap into a sharp focus and then back out as seeing conditions fluctuate. Recording movies allows you to capture those moments of great seeing, and Registax will automatically pick those images out for you.

How do I Configure the Basic Setup?

I recommend a prime focus setup, where the eyepiece is removed and a camera used in its place. It is less complicated and will give you better initial results than if you used eyepiece projection. Planetary and high resolution lunar images require that you cast a large image of the planet across the CCD chip. This can be thought of as being highly magnified, but in reality there is no magnification in the camera. You are simply casting an image across the chip. I have coined the phrase "apparent magnification" to help describe this. Generally, focal ratios of f20 and beyond are required for high resolution imaging. If you use a standard SCT. already at f10, you can increase it to f20 by simply inserting a 2X barlow in front of the camera. For f30, use a 3X barlow. If you are using a Newtonian which is typically at f5, you can also use a barlow, or stacked barlows to achieve the same effect. The limit of "apparent magnification" you can achieve is determined by a number of factors, not the least of which is your current seeing conditions. I generally record my first movies of the evening at f10, and then progressively step up to the limit, first a 2X, then 3X barlow and beyond. Higher f ratios will require that your mount is polar aligned and tracking properly. If not you will spend most of your time chasing the target instead of gathering data.

Some Tips for Getting Great Images

Seeing Conditions

You will be limited by the current seeing conditions at your location. You can get a general feel for it by looking straight up to see how much the stars are twinkling. Stars do not twinkle, they are solid point sources of light. Any twinkling you see is due to atmospheric disturbance.

Collimation

The collimation (the alignment of your optics) is critical at high f ratios. It will be impossible to get any substantial detail with an un-collimated scope. There are many articles on the Internet dealing with this subject and it is beyond the scope of this article. Suffice it to say that a six inch reflector that is in collimation will easily out perform a ten inch that is out of collimation.

Temperature Equalization

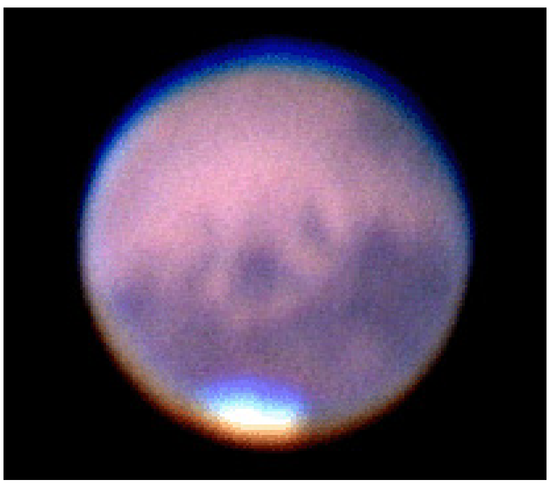
Allow your telescope, camera and all other optics sufficient time to cool to equalization. For a ten inch telescope this could be over an hour, especially when the temperature shift is greater than forty degrees. Collimation of optics should only be performed on an equalized telescope.

Timing and Target Location

If at all possible, wait several hours after sunset before you start imaging. During the first few hours, the Earth radiates most of the heat it has built up during the day. This is true in both summer and winter. This radiation of heat will give you a shimmering effect. The same thing can happen if you shoot over a heated dwelling or large body of water. A laptop computer sitting in front of, and below the telescope can also cause this. No kidding! Also, refrain from using dew heaters whenever possible.

Targets are best imaged when they are sixty degrees above the horizon or higher. Ideally the target should be straight up. When you shoot straight up you are only shooting through the height of the atmosphere. When targets are down low, as Mars was last August, you are shooting diagonally through it and are subject to much more atmospheric dispersion and turbulence.

Atmospheric dispersion is common when targets are at low angles. The atmosphere acts like a lens and diffracts light at different angles depending on the color. You can notice it easily if you see a blue halo being projected from the top of your target and a red one below (or vice-versa depending on the setup). The atmosphere splits up the light like a prism. The only way to get around this is wait for the target to get higher. It can also be corrected for, in a large degree, during processing. You can use Photoshop or another program to split up the RGB image, realign the primary colors and then recombine them into a color image. The blue part of the image will be slightly larger because it is slightly out of focus, so the process isn't 100% effective. With more work on the blue frame you can get better results. Luckily, the new version of Registax will perform this function automatically and is quite effective.



The effects of atmospheric dispersion is evident in this raw Mars image. Notice the top blue, and bottom red halos. It can also be easily seen on the polar cap. This was common on most Mars photos during its opposition of August 2003 as it was at a low angle, especially at the upper latitudes.

Focus is Critical

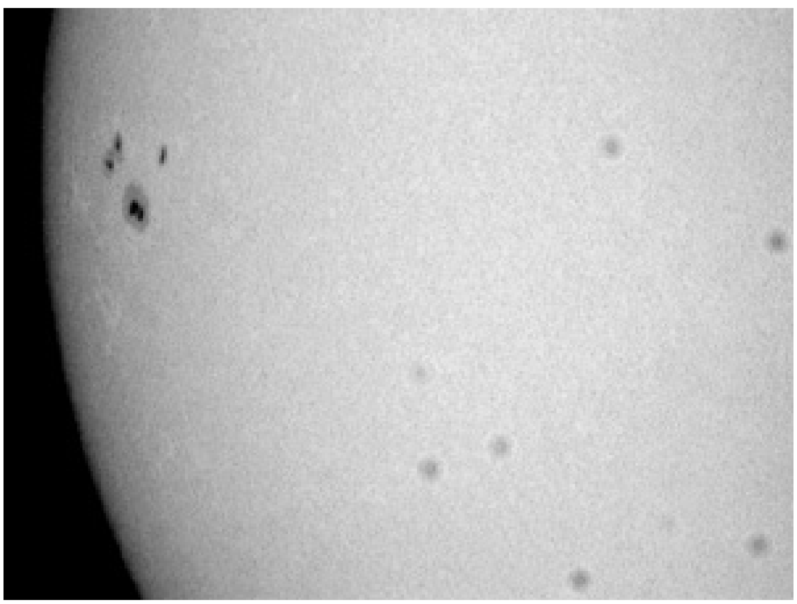
The human eye is a remarkable device that is capable of focusing in real time. It will adjust, to a certain degree, to compensate for an unfocused image at the eyepiece. The CCD is completely unforgiving and must be exactly focused. There are no image processing tricks that can repair an unfocused image, although many try to cover it up with unsharp masking and other techniques. This only introduces processing artifacts into your image making them look unnatural. Focus is critical. Use an electronic focuser whenever possible. If you are shooting movies, most software will allow you to focus and position on a live image. This is a significant advantage in both time savings and frustration.

Dirty Optics

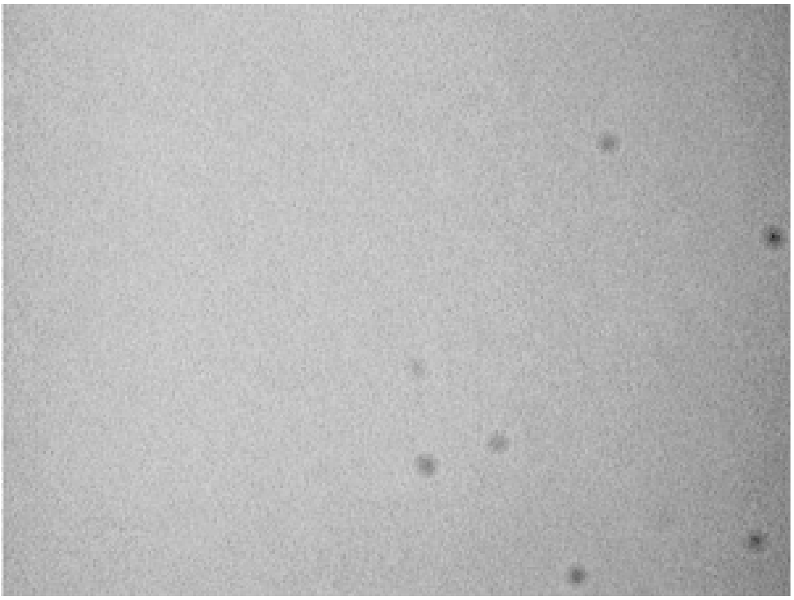
When specks of dirt or other debris are on the optics they will most certainly show up in your images as dust motes. They have a donut like appearance and their size depends on how far they are away from the camera. Any dust or dirt on the secondary mirror, and especially the CCD itself will produce these nasty dust motes in your pictures. The closer to the CCD they are the more they affect your photographs. On the CCD itself is the worst place to have them. If they are located on your corrector plate, objective lens or meniscus then they are generally so far out of focus that you wont see them. Anything close to the camera has to be really clean. This includes diagonal mirrors, barlows or powermates, filters, prisms etc.

The way to remove dust motes from you images are to shoot "flat fields". A flat field is a picture of an evenly illuminated surface. When you examine the picture you will see the effects of dirty optics and uneven sensitivity in both the camera and optics. When you correct your image using the flat field all of these effects disappear.

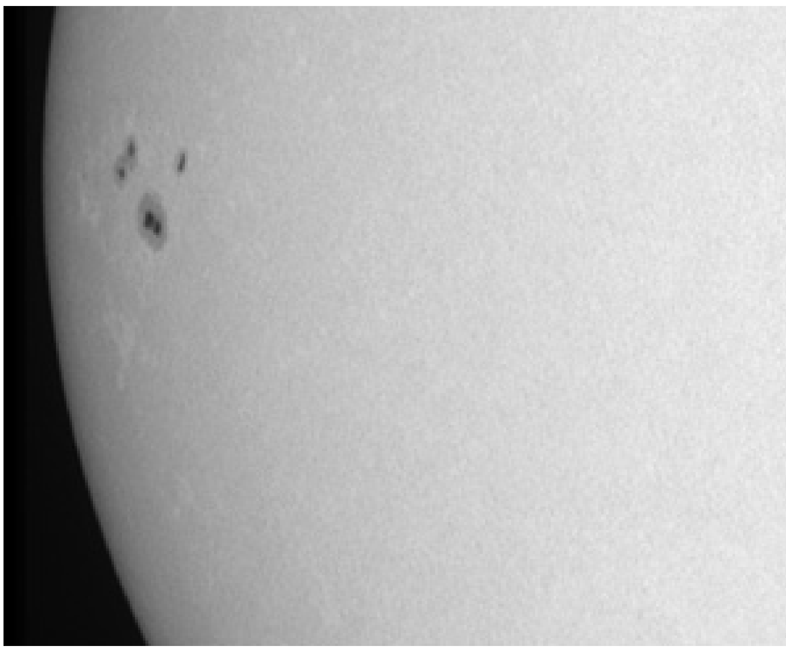
If you have never experienced "dust motes" in any of your night time pictures, you will certainly be beaten over the head with them during any solar shoot. Your optics need to be especially clean. Below are some pictures taken during a solar shoot where the dust motes ruined the image, and then were corrected out.



Raw solar picture of a basic bare sun with a group of sunspots on the left side. The dust motes in this case were located on the barlow lens and can be seen on the right half of the photo.



This is a flat field frame taken on a clear area of the sun. Only the dust motes can be seen.



Here is the raw image corrected with the flat field.

Image Processing

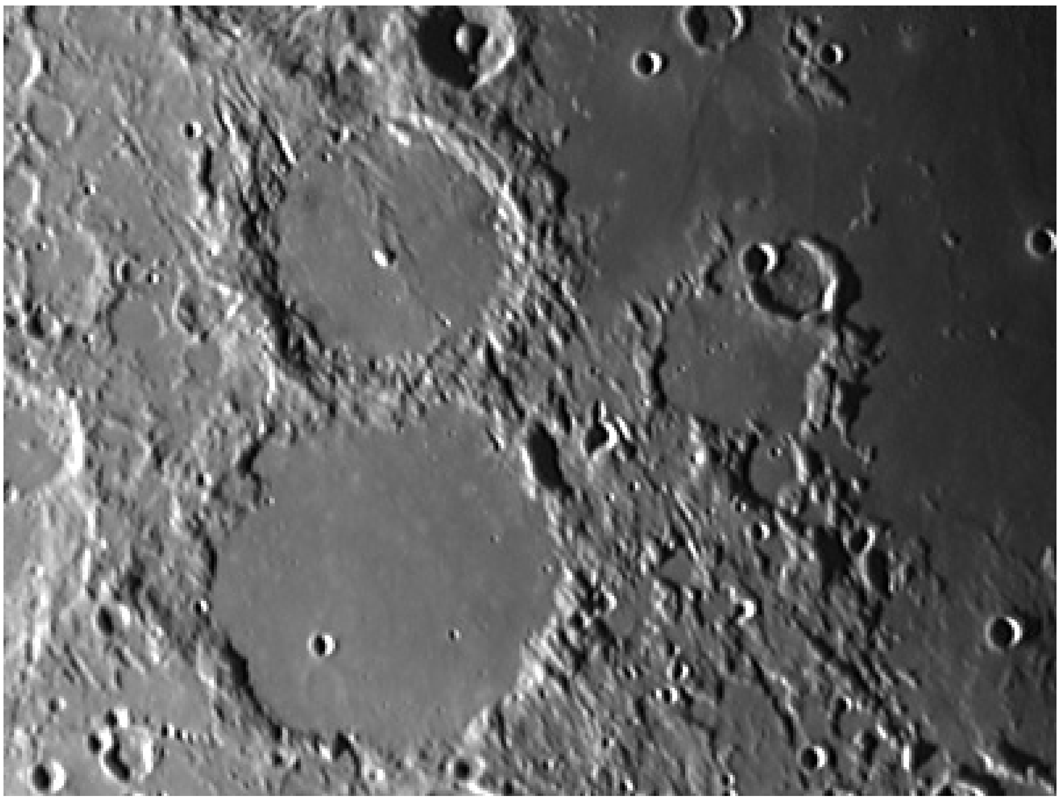
The processing of lunar and planetary images are simple compared to deep space targets like globular clusters, nebulae and galaxies. This is because most of the work is done while taking the pictures; collimation, temperature equalization and razor sharp focus. Here is a list of the basic steps used when processing a list of still images.

- Weed out all pictures that are not razor sharp.
- Use your dark frames and flat fields (if any) to calibrate your remaining images.
- Align (register) the images exactly.
- Stack (average) the images together to bring out detail and reduce noise.
- Set the brightness and contrast levels for the best looking result.
- Adjust the color balance (if color) to a natural hue and level.
- Apply sharpening for the final image.

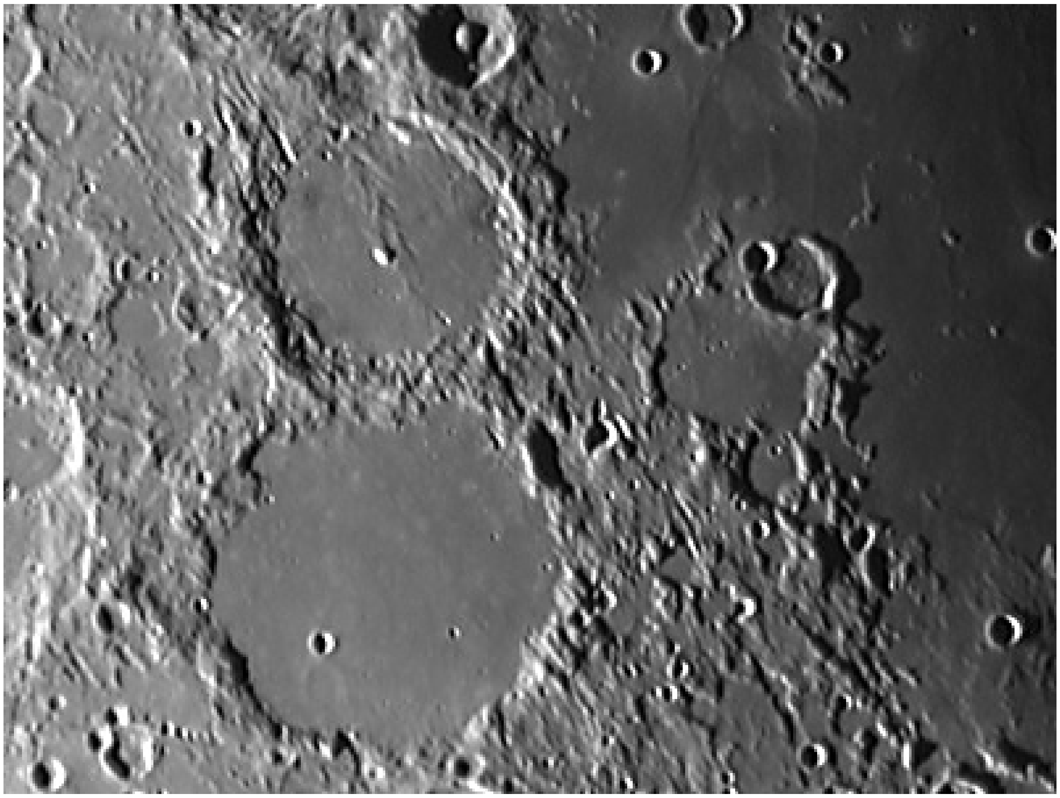
If you are processing from a movie, then simply use Registax. Registax will automatically do all of the steps listed above.

Sharpening Lunar and Planetary Images

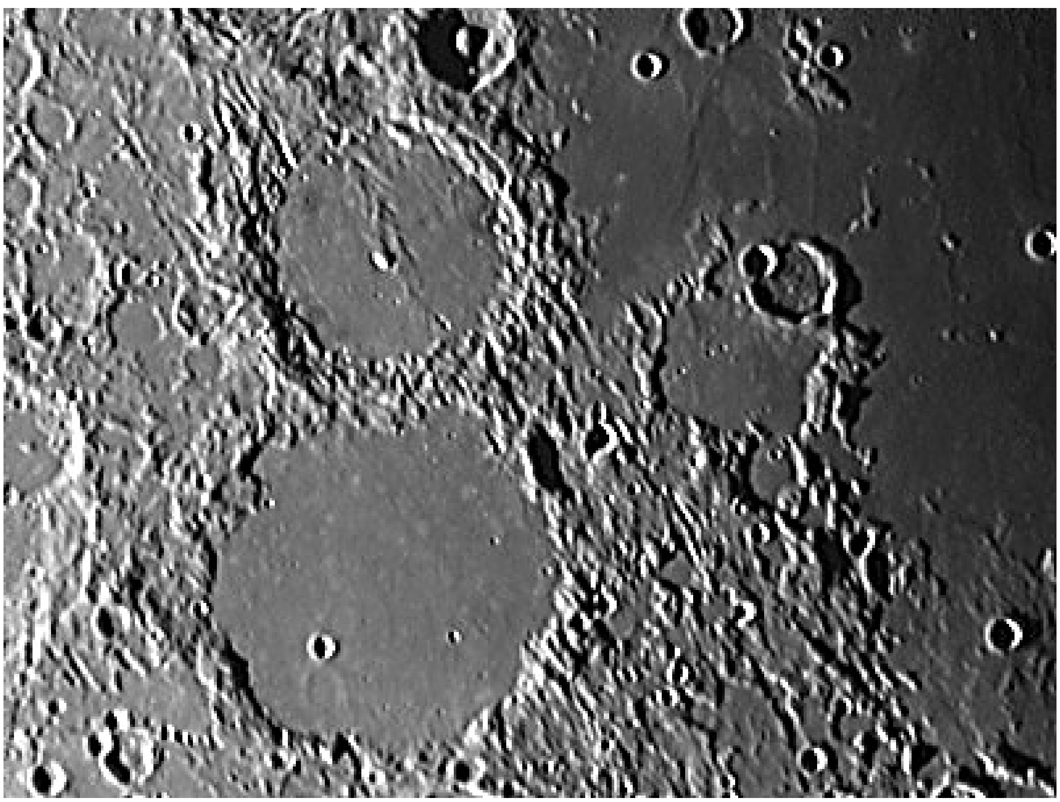
As stated above, sharpening images using an unsharp mask filter, is usually the final step for processing your image. Many imagers will use unsharp mask to help correct images with poor focus. It will improve it slightly, but there is no substitute for sharp focus. It is unfortunate that many imagers get a little heavy with the unsharp mask as the pictures do not look natural. Here are some examples.



Unsharpened, raw stacked shot. Not the greatest image, but definitely in focus.



Just a touch of sharpening added



Woahhh Baby!
This is what happens when you get a little heavy with the sharpening. It looks very unnatural.

Good Image Processing Programs

If shooting movies, use Registax. It has everything you need including sharpening filters. For still images, Registax will still work but consider some other titles if you also plan on doing deep space stuff. You can download it for free by clicking on this link.

http://aberrator.astronomy.net/registax/html/download.html

Maxim DL is a full featured package but is a little pricey.

AstroArt is also a full featured package but priced more reasonably.

Adobe Photoshop is the program nearly everyone uses to finish up astronomical images of all types. Cropping, level adjustments (brightness and contrast) and sharpening are all easy to lean and use. Photoshop can be used for other steps too, like alignment and stacking of images but is a lot more difficult to use than AstroArt or Maxim.

Conclusion

The Moon, Saturn and Jupiter should be your first targets. When shooting lunar targets, shoot along the terminator between day and night on the moon. You will image shadows being cast of for miles and targets look three dimensional. The worst time to image the moon is when it is full, unless you are specifically trying for full moon shots. To reduce the excessive light, try using stacked dark green and dark blue standard Wratten filters. Red and green work well too. This usually gives better results than standard moon filters. Variable polarizers work well too.

Good imaging, of any type, requires technique and practice. Don't be turned off by poor images, even after several attempts. Enlist the help of others by joining and reading Yahoo groups and doing research on the Internet. Most imagers are completely free with their time and advice. Make use of them

Please remember one important thing.... have fun!