Getting Started In Astrophotography With DSLR Cameras

It's Easier Than You Might Think!

By John Moody

Astro-imaging is definitely a hot topic in amateur astronomy these days – everyone enjoys the beautiful images and the camera's ability to reveal far more color and detail than the human eye can see allows us to enjoy and study structure that we cannot observe otherwise. Astro-images are therefore interesting and scientifically useful.

The astro-images we produce ourselves are a fun way to share with family and friends and also great to use in outreach activities as everyone is immediately drawn to astrophotos, especially kids. Plus, you'll have the coolest computer wallpaper and screensavers! Anybody can have a picture of their kids, grandkids, pets, and such, but how many can display an astro-masterpiece that they created themselves? Best of all, with relatively inexpensive equipment, you'll produce images that rival those taken by pros using the best, most expensive equipment not so very long ago – it's a great ego boost.

One of the easiest ways to get started in astrophotography is with a DSLR. These increasingly popular and affordable cameras offer several advantages, not the least of which is that they can also be used for conventional photography. This can help to justify the expense and, if you decide you don't enjoy astrophotography as much as you thought, you will still have a great camera for conventional photos. Plus, if you decide to sell it, the market is larger than that for used astro equipment.

Image 1

Second, DSLRs can be used with a wide variety of lenses as well as telescopes and, since they use the same attachment methods as film SLR cameras have used for years, any required adapters/attachments/accessories tend to be fairly easy to find and somewhat reasonably priced.

Third, although they may cost more than lower-end dedicated astro-cameras, DSLRs (generally) have much larger sensors resulting in a wider field of view and more forgiving image scale. Additionally, depending on models, DSLRs are generally cheaper than dedicated astro-cams with similar chip sizes. Another advantage is that imaging can be performed with DSLRs using a minimum of equipment (no laptop, filter wheels, external power source, etc.), which can be very convenient if you are traveling to dark skies to do your imaging.

Perhaps the biggest advantage though of

Image 2

DSLRs is their flexibility – you can take a hand-held photo of a spectacular sunset, tripod mounted star trails, all-sky shots with a fisheye lens, piggy-back mounted Milky Way panoramas, constellation photos and prime focus shots of deep-sky objects. Finally, since many of us have had some exposure to cameras and conventional photography, DSLRs are familiar tools and may therefore seem less challenging than dedicated astro-cameras.

But DSLRs present disadvantages too. They are generally not to be as sensitive as dedicated astro-cameras and tend to have higher "noise" levels, an aspect that is exaggerated by the inability to control the temperature of DSLR sensors. Images produced with DSLRs must therefore be calibrated with "dark frames" taken at a temperature as close as possible to that at which the image data was captured. Due to these sensitivity and noise issues, processing DSLR images may be more challenging than processing those taken with a dedicated astro-cam. Some DSLRs may also fail to function properly at extremely low temperatures. Also, when not using an AC adapter, it may be necessary to change batteries one or more times during an imaging session. However, in spite of these disadvantages, I feel that imaging with a DSLR is still a great way to get started in astrophotography.

Starting with Fixed-Tripod Images

DSLR astrophotography can at first seem daunting, especially once you start reading, researching and dealing with all of the jargon – guiding, polar alignment, image scale, calibration, lights, darks, flats, bias, histograms, stretching, layer masking, de-convolution, field rotation, and other terminology peculiar to the art can make astrophotography, DSLR or otherwise, seem confusing. In reality though, you needn't know and understand all of this minutia before you can begin taking pictures. Perhaps the simplest way to get started in DSLR astrophotography is by taking some very simple "point and shoot" images of the moon, twilight scenes, planetary conjunctions, and constellations with a setup as simple as the camera mounted on a photo tripod. In fact, this is a great way to learn about the camera and its settings.

I usually shoot such "stationary" photos at an ISO setting of about 800 with a fairly short lens (50 mm or less) at the lowest focal ratio with which the lens is capable of producing decent results in "no flash," "night," or a similar mode. When you are shooting the moon, planets or bright stars (Sirius, Vega, etc) you can often even get autofocus to work, although you may have to get the planet/star/et cetera exactly in one of the Auto Focus (AF) points. If after reviewing some shots on the camera's LCD display I find that I don't like the results, I will switch the camera to manual mode and experiment with different exposure lengths until I get results that look good to me. The biggest limitation to this type of photography is that you're relegated to relatively short exposures before star images start to trail. As long as you are not viewing the photo at full resolution or printing it at an enlarged size, short trails may not become objectionable. Just how long you can expose without noticeable trailing depends primarily on the focal length you are using.

To make wide-angle, stationary images more interesting it helps to include familiar foreground references such as trees, an old barn or building, mountains, or even clouds. Also, shooting fairly low on the western horizon just after sunset or the eastern just before sunrise can add some color and light to make the resulting image even more pleasing. See **Image 1** for an example of a thin crescent moon with earthshine that I took as a single image in "Flash Off" mode with a Canon 300D mounted on a simple photo tripod.

Capturing Star Trails

You can also produce star-trail images with the same simple camera and stationary tripod set up. The best of these tend to be centered near the celestial pole (Polaris in the Northern Hemisphere) and, just as with stationary photos, interesting foregrounds can really make these images stand out. Star trails are as simple as taking many images over a relatively long time with a very short interval in between, then stacking them. In this case you are actually taking advantage of the normal trailing you get when using a fixed mount. See **Image 2** (the horizontal red streak is an airplane) for an example created from 49 frames each 2-minutes long using the free software, *Startrails*, available at www.startrails.de.

Shooting multiple short exposures rather than a single long exposure offers the advantage of retaining the relative darkness of the background sky. *Startrails* simplifies stacking and processing of a final image. It also facilitates creation of time-lapse movies as AVI files. In fact, this feature can be used for creation of time-lapse movies of any subject, not just of star motion.

Piggybacking the DSL

Another fairly simple way to get some nice astro-images and the logical next step after mastering fixed-tripod images and star trails is to either "piggyback" your camera on a driven equatorially (EQ) mounted scope (see **Image 3**), or to simply place the camera on the mount instead of the scope. See **Image 4** for an example of an image of Orion taken with a Canon DSLR and 50-mm lens piggybacked on an EQ mounted Orion 8-inch Newtonian. If you use fairly short lenses (50 mm or so) even a relatively inexpensive mount will provide decent results (long focal lengths require mounts of relatively high accuracy for best results). Some extremely nice images of interesting areas of the Milky Way and large Nebulae can be produced this way.

Image 3

Shooting Longer Exposures – An Overview

Once you start using a driven mount however, you will almost certainly want to take longer and longer exposures to capture ever dimmer objects, and doing so will require taking multiple sub-exposures and calibrating and stacking them to achieve decent results. "Calibrating" simply refers to taking some additional exposures such as "dark," "bias," and "flat" frames and applying them to your sub-exposures using software such as *Deep Sky Stacker*, *Images Plus, IRIS, Nebulosity*, or other similar programs to correct for issues such as vignetting, spots produced by dust on the camera sensor, and to remove sensor "noise," all to make the final image look more pleasing. In my experience, the min-

Image 4

imum calibration necessary to obtaining decent results is dark-frame subtraction. I won't deal specifically with the fine points of calibration and stacking here other than to note that you must shoot images in "RAW" or "sensor" mode to facilitate calibration and that you need to calibrate individual sub-frames with dark frames, and sometimes also flat frames, in order to achieve an optimum final image. We will cover the finer details of stacking, calibration and post-acquisition processing in later installments of this series.

Once you have a stack of calibrated frames you'll need to perform some very basic post image-acquisition processing and there are a number of specialty software programs that assist with this "digital development" of the image. Many of these image processing programs can automate both the calibration and digital development processes – clearly an advantage for those just starting out in astro-imaging. I recommend using software that can automate as much of the process as possible as it will make it easier to quickly get some acceptable results and allows concentration on other aspects of imaging. The astro-imaging learning curve is steep enough as is – there are enough skills to master that there is simply no need to make things any harder than necessary. Besides, it is easier to remain motivated (not to mention more fun!) if you can get some decent pictures quickly. As you develop the desire for ever greater image perfection and want to target ever more difficult targets, you will encounter frustration aplenty, so don't needlessly add any when you are getting started. Just have some fun!

When you master basic dark frame calibration and stacking you can begin working on more advanced techniques such as adding flats, darks and bias frames to your calibration stack and on more advanced processing techniques such as layer masking.

Prime-Focus Astrophotography

As I've already said, once you have taken some pictures using some of the simpler techniques and are comfortable with camera settings and the basics of calibrating and stacking images, you will undoubtedly want to graduate to long-exposure prime-focus photography through a telescope to capture faint objects. At this point it is possible to spend nearly unlimited sums of money and the equipment choices can become overwhelming, but by keeping in mind a few basic but important facts it is possible to choose a combination of equipment that will allow you to produce nice images at a reasonable cost. The things to remember when trying to decide what equipment you will need for prime focus astrophotography are:

1) The most important part of your astrophotography gear is the mount.
2) Increasing focal length generally equates to increasing difficulty, frustration and need for a mount of greater capacity.
3) Even the most capable mounts cannot track perfectly for unlimited periods of time.
4) Fast focal ratios (lower "f" numbers) allow shorter exposure times.
5) A good focuser is very important, as it has to support the weight of a camera, adapter, etc., while allowing the astrophotographer to find and hold critical focus.

Given these considerations, many find that the ideal starter system consists of a relatively small, short focal length scope on the biggest, best EQ mount you can afford, preferably one that can accept autoguider input. This would consist of anything from a 60- to 80-mm Apochromatic refractor between f/6 and f/7.5 to a 6- to 8-inch f/5 Newtonian on a mount such as the Celestron CG-5, Meade LXD75, Orion SkyView Pro, or the SkyWatcher EQ5 Pro, mounts that are capable of handling 20 pounds and more of telescope, DSLR and related imaging gear. Better yet would be mounts of the 30 pound plus payload class of Orion's Sirius/HEQ5 and Atlas/EQ6 mount, or Celestron's new CGEM. If you need to cut cost, do it on the scope, not the mount. This may

Image 5

seem counterintuitive, but even the best under-mounted optics in the world won't produce as pleasing results as capably mounted modest optics. Plus, you can always upgrade to a better scope later and then relegate your "starter" scope to guide-scope status.

When choosing a scope for astrophotography you will need to pay special attention to things you might not consider significant to visual use. For example, a focuser that is capable of carrying the heaviest 1.25-inch eyepieces may not fare as well under the much greater load of a DSLR – the focuser of your imaging scope must be capable of supporting the DSLR without slipping. You may also find that a motor-driven focuser, a feature many would consider overkill for visual work, is very handy for astrophotography. The scope should have at least a two-inch focuser to prevent vignetting of the light received by the relatively large sensors of popular DSLRs.

As mentioned above, you will want a scope with a relatively fast focal ratio to allow shorter exposures, which becomes increasingly important with less capable mounts. Unfortunately, faster scopes are more likely to suffer from various optical aberrations and well-corrected "fast" scopes tend to be relatively expensive. Fortunately, you can keep the cost down and still get a high-quality scope by investing in an instrument of small to modest aperture.

If you choose a Newtonian instead of a refractor, you will want to be sure that the secondary mirror is large enough to fully illuminate the relatively large sensor of your camera, which is one reason I recommend an aperture of at least 6 inches – anything smaller is unlikely to have a large enough secondary mirror to fully illuminate a DSLR sensor. At some point you will want a coma corrector such as the Tele Vue Parracorr so stars nearest the edges of the image field, and especially in the corners, look nice and round rather than like little comets with short, broad tails. Until you invest in a coma corrector, you can simply crop the edges of your images to remove the most obvious evidence of coma, or display the image as a smaller size.

If you decide you prefer a refractor, you should consider investing in an Apo – anything less will produce undesirable false color fringes around brighter stars – and at some point you should consider a field flattener/focal reducer to obtain even illumination across the entire fields of your images and to provide a slightly larger field of view. But again, as with the Newtonian option, you can crop or otherwise display your images in ways that minimize or mask such imperfections. Fortunately, today's market offers an embarrassment of riches in high-quality, competitively-priced small refractors that are wonderful astro-imaging tools as well as great visual instruments.

No matter what scope you use you will need an adapter system that permits mounting the camera directly to the 2-inch (or larger) focuser. The most common method of attachment is a 2-inch to T-thread prime focus camera adapter (see **Image 5**) mated to a T-ring that fits your camera. This is basically a two-inch eyepiece barrel with T-thread on one end. There are lots to choose from, but it is a good idea to choose one that has the lowest possible profile since a common issue (especially with Newtonians) is insufficient in-focus travel to allow a DSLR to reach focus. Scopestuff now offers adapters that combine the T-ring and two-inch adapter. Indeed, it's new "True 2-inch Barrel to Canon EOS Adapter" combines a very low profile with a large unobstructed opening to minimize vignetting of even the largest DSLR sensors, and Orion offers a "2-inch Zero-Profile Prime Focus Camera Adapter" that attaches to any T-ring equipped DSLR.

When you are ready to start imaging through a telescope you will need to master the skill of Polar Alignment of the mount. While the topic is beyond the scope of this article, there are plenty of readily available Internet references with very good instructions on how to perform this procedure. I will simply refer you to the instructions that likely came with your equatorial mount or Internet sites such as http://www.petesastrophotography.com. Suffice to say that accurate polar alignment is necessary to obtaining acceptable long-exposure images. There is a common misconception that guiding/autoguiding can substitute for accurate polar alignment, but this is, sadly, not true. While it is true that you can obtain acceptable images with a less-than-perfect polar alignment, the better the polar alignment the better the images. Once you have learned to polar align your mount you can begin taking photographs like **Image 6**.

Regardless of the quality of the mount and focal length of the scope, you will find that there is a limit to the length of time you can expose an image before you get trailing or other undesirable mount related issues. You can often extend these exposure limits by improving the performance of your mount by performing

Image 6

such procedures as re-lubing it, polishing/lapping gears and other moving parts that are in contact with each other, adjusting clearances, and so on. Since the exact procedures are mount dependant, I cannot provide details here, but, again, there are lots of related resources on the Internet. A good place to start for advice on "tuning" your mount for astrophotography would be the "Mounts" forum on Cloudy Nights (http://www.cloudynights.com).

In addition to "tuning" your mount, another way you can increase the length of time you can expose a single frame is to "guide" the exposure, either manually or automatically using a guide camera and computer program or a self-contained autoguider. Guiding (whether manual or automatic) is basically a matter of correcting for a mount's inevitable tracking errors. Manual guiding is generally performed by using either a second telescope mounted beside or on top of the primary imaging scope with a crosshair reticle eyepiece, or an off-axis guider, a device with a mirror or prism that redirects part of the light 90 degrees through a crosshair reticle eyepiece. You simply keep the crosshair centered on a guide star by making small corrections to the mount's tracking using the buttons of its hand controller.

Autoguiding is more common these days and eliminates the tedium of spending hours staring at crosshairs (risking falling asleep and bumping the scope in the middle of a 4 hour imaging run at 3 a.m!). Autoguiding is performed by installing a second camera in place of the crosshair eyepiece and using a computer program such as *PHD Guiding* or any of the many commercial imaging programs that can automatically control the mount and correct for tracking errors. There are also several self-contained autoguiding units that permit autoguiding without having to have a PC or laptop at the telescope, such as the LVI SmartGuider announced in the November 2008 issue of *ATT*, and the new Orion StarShoot Solitaire AutoGuider announced in this issue.

Autoguiding equipment has become quite reasonably priced and, unless you are really on a tight budget or think you would enjoy manual guiding, it is pretty hard to justify not autoguiding if your mount can support the additional weight. Orion now offers a complete autoguiding package that includes an 80-mm scope, dovetail bar, Starshoot Autoguider camera, and *PHD Guiding* software, all for no more than what a typical guide camera cost only a few years ago. Most autoguiding solutions do require a computer, but it does not need to be particularly powerful one – even an inexpensive, used laptop will suffice. Indeed, I am currently guiding with a computer that I purchased used for only $200. But, if you are not using a computer for other purposes, a self-contained guider is a great option.

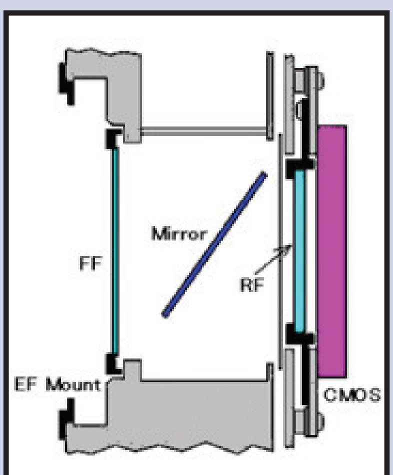
Once you have tuned your mount, sorted out your autoguiding rig, mastered polar alignment and the arcane arts of image processing, and are able to gather hours of flawless data night after night, there is one other thing you may want to consider and that is whether or not to modify your DSLR (or to purchase a professionally modified camera) for enhanced red response to pick up more red nebulosity, specifically the Hydrogen Alpha wavelength. The reason I left this topic until last is that there are plenty of objects to photograph that do not benefit from a modified camera and considering the steep astrophotography learning curve and all the other issues you will deal with in the process of learning to take beautiful images, this just isn't that big a deal unless you are sure you enjoy astrophotography and want to shoot emission nebula. Galaxies, star clusters, and reflection nebula don't benefit at all from a modified DSLR. But, if you eventually find yourself wanting to get the most out of photographs of emission nebula, as do most that get hooked on astrophotography, you'll eventually also find yourself seriously considering this option. For more information on "spectrum-enhanced" DSLR options, please see the accompanying insert.

I know I said DSLR astrophotography doesn't have to be as complicated as many fear and, despite this, you've endured a long-winded article full of statements about things that are "beyond the scope of this article." Nevertheless, DSLR astrophotography is something you can easily master while having a lot of fun in the process. Just follow a step-by-step, building-block approach – start simple and build from there. This approach is also, happily, much less expensive! There is nothing wrong with doing a bit of research on more advanced topics as you work your way along the learning curve, but try to avoid getting ahead of yourself and don't let the lure of long-exposure prime-focus photography sucker you in before you're ready. ATT

Spectrum-Enhanced DSLRs

Spectrum-Enhanced Canon 20D with internal thermometer installed. Shown with and without external readout unit attached.

As Digital SLR cameras become increasingly sophisticated and ever capable with each passing year, the popularity of spectrum-enhanced DSLRs is also increasing. Standard DSLRs are equipped with infrared (IR)-cutoff filters that enhance standard terrestrial images, but that also block some to the red Hydrogen Alpha (Ha) spectrum that is critical to optimum reproduction of astronomical targets such as emission nebula. Modifying a DSLR by removing its IR-cutoff filter, or by replacing it with one that passes more of the Ha spectrum, results in a "spectrum-enhanced" DSLR that more fully takes advantage of the DSLR sensor's capacity to detect the bandwidth critical to imaging some of the night sky's most celebrated targets. Those interested in spectrum-enhanced DSLRs have two basic choices: (1) Modify their DSLRs themselves, or (2) invest in a DSLR that has been professionally modified.



Cutaway view of the front filter and rear filter locations in typical Astro Hutech Spectrum-Enhanced Canon DSLR.

As to ATM modification of DSLRs, we caution that, while it certainly can be done, there are some things better left to the pros. To present an extreme analogy, we know of more than one example of DIY dental root canal procedures. But, although those masochists may have saved themselves a few hundred dollars, we're left to wonder, "Why?" (Actually, we're left to wonder far more than that!) Analogy aside, the fact is that we know of a number of technically proficient astrophotographers who have successfully modified their DSLRs and, if you are absolutely confident in your technical proficiency and don't mind voiding the factory warranty on your camera, conversion filters are available from such sources as Baader Planetarium (www.alpineastro.com).

For those of us who are less adventurous, professionally modified DSLRs are readily available. Astro Hutech offers spectrum-enhanced versions of the DSLR models that are most popular with astrophotographers, including those by Canon, Fuji, Nikon, Panasonic, and Olympus. Astro Hutech installs custom designed filters that exactly match the light path of the factory-installed filters that they replace, thus insuring that the camera's autofocus continues to work properly. Actually, the typical Astro Hutech spectrum-enhanced DSLR uses a two-filter system: a rear filter that replaces the stock IR-cutoff filter and a front filter.

Astro Hutech offers two options for the rear filter: a clear, fully multi-coated filter that passes all bands, including the IR, and an "astronomical" filter that blocks UV and IR, while allowing recording of the astronomically important Ha spectrum. The front filters are mounted in a user accessible holder placed between the camera's lens bayonet and the internal viewing mirror where they can be easily inserted or removed as the user requires to return the camera to standard daylight photography functionality. Or, the user can achieve the same functionality by installing the appropriate conventional in-front-of-the-lens filter instead of a "front" filter. Either arrangement permits the user to enjoy the astrophotography benefits of a spectrum-modified DSLR that still operates as a fully-functional daylight camera as well.

Best yet, Astro Hutech's spectrum-modified DSLRs carry a full one-year warranty from that well-established company. For more information, visit www.astrohutech.com.