PHOTOGRAPHING THE NIGHT SKY

Or how to get started in DSLR astrophotography with equipment you may already own

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- The DSLR camera
- Comparisons between DSLR and CCD cameras
- DSLR astrophotography from the simplest process and least equipment to the more difficult processes and more equipment
  - Nightscapes
  - Wide spectrum solar
  - Lunar
  - Star trails
  - Tracking
  - Guided tracking
  - Image stacking and processing
Digital Single Lens Reflex cameras are the digital version of film single lens reflex cameras.

- Film has been replaced with a CMOS sensor.
- CMOS sensor has very high sensitivity as compared to film.
- Spoiled exposures can be cheaply discarded.
  - Aircraft
  - Bad seeing
  - Bad focus
  - Satellites
CCD vs DSLR

- Charge Coupled Device cameras are up to 50 times more sensitive than standard digital SLRs.
- CCD cameras have a greater dynamic range than digital SLRs, meaning they can more easily capture both faint and bright detail in a single exposure.
- For setups where guiding is required, some CCD cameras have built-in guide chips to make guiding much easier.
DSLR vs CCD

- CCD cameras designed for astrophotography have better H-alpha response
- CCD astrophotography cameras often have internal cooling and fans
- Small chips mean better framing for planets and small deep space objects
DSLRs are much less expensive for a given size chip and number of megapixels

- More pixels means larger prints can be made with native resolution
- Larger chip size means wider fields can be captured in single panel
- A wide range of excellent lenses are available
- DSLRs can be used for other purposes but, mostly, you may already own one
A used Canon T2i can be found on eBay for around $250 – 18.1 megapixels, sensor size 14.9mm x 22.3mm

Astrophotography CCDs start at $420 – less than 1 megapixels 752 x 582 (437,664 total), sensor size 7.40mm x 5.95mm
Upper End CCD Cameras

- **Atik 4000** - $4,044 - 4.2 megapixels, sensor size 16.67 mm x 16.05 mm

- **SBIG STF-8300C** - $1,795 – 8.3 megapixels, sensor size 17.96 mm x 13.52 mm
Hardware You Need to Get Started

- A DSLR
- A tripod
- Lenses
- Shutter release cable
Suitable Lenses

- For star trails and nightscapes, shorter (wider field) is better – 10 to 35 mm with low f/number
- For lunar and solar, a 300 mm to 400 mm camera lens or a telescope is best – solar will require solar filter
- If using a telescope you will need a T-mount and adaptor – typically ~$30
What Can You Do Without Tracking

You can take:

- Nightscapes
- Broad spectrum pictures of the sun
- Pictures of the moon
- Star trails
- Wide field images for stacking
Nightscapes capture constellations or the Milky Way above interesting landscapes.

Single 20 sec exposure, ISO 3200, 16mm – f/2.0 lens.

Fajada Butte at the Chaco Culture Historical Park.
How to shoot nightscapes:

1. Put your camera on a tripod
2. Attach a wide angle, and preferably fast, lens
3. Attach a cable release
4. Open the iris wide
5. Set the shutter speed to maximum for your lens
6. Set the ISO to high
7. Set the lens to manual focus
8. Aim and focus the camera
9. Release the shutter
10. You can use lights to illuminate close objects while shutter is open
Nightscape Shutter Speeds

- For full frame cameras you should use the rule of 500
  - For example using a 16mm lens you can shoot up to about $500/16 = 31.25$ or about 31 sec
  - More than this exposure star trails start to become objectionable

- For cameras with smaller APS-C format chips you should use the rule of 300
  - Using the same 16mm lens you can shoot up to about $300/16 = 18.75$ or about 18 to 19 sec
Nightscape ISO Settings

- Shoot at high ISO setting to provides brightness desired
- Caution: Extremely high ISO settings result in higher noise
- Try various settings to achieve desired result
You can use a broad spectrum solar filter on a camera lens or telescope to take images of the sun during transits, eclipses, and sunspots.

The sun is bright, so fast shutter speeds are required and therefore no tracking is needed.

H-alpha imaging is similar but unmodified DSLR cameras have poor H-alpha response.
The moon is another bright object allowing short shutter speeds.

You can use a camera lens or a small telescope.

NOTE: Close up images of craters using long focal length telescopes will require tracking.
For star trails:

1. Use a tripod
2. Set ISO ~1600
3. Set iris to half to full open
4. Set shutter control to manual or time for exposure of ~30 sec
5. Attach cable release
6. Aim at sky and focus
7. Set drive to multiple exposures
8. Press and lock cable release
9. Processing: Stack images
Star Trail Effects

Variations:
- Shoot aimed at North Celestial Pole
- Shoot near the meridian
- Shoot looking south
- Use relatively short exposures
- Use long exposures
- Have interesting landscapes or objects in foreground
- Use water for reflections
- Zoom lens during image capture
- Use lights to illuminate (“paint” close objects

... Experiment and have fun
More ambitious astrophotography requires tracking.

Tracking uses motors to move the mount to follow the apparent motion of the sky:
- Allows longer exposures
- Allows longer focal lengths
- Opens up ability for deep sky astrophotography

A battery replacer avoids exhausting the DSLR battery during very long imaging sessions.

German equatorial or fork mounts with a wedge allow longer exposures than non-polar aligned altitude/azimuth mounts due to the lack of field rotation.
Field Rotation

Images taken with altitude-azimuth (Alt-Az) Mount

Images taken with Equatorial Mount
Unguided tracking images are best for **short** exposure or **short** focal length imaging.

Images can be stacked to increase signal to noise ratios and allow greater stretching.

90 Stacked 40 sec subs, ISO 800, 24 mm f/4
Guiding used in conjunction with tracking allows long exposures in combination with long focal length optics.

This opens up even more of the universe.

Guiding can be manual or automatic:
- Manual guiding involves the use of a guide scope with a reticule eyepiece – boring and time intensive.
- Auto-guiding involves the use of a guide scope with a guide camera and a computer – the lazy person’s way – about $360 to get started – mount has to have auto-guide port.
Auto Guiding Using a Guide Scope, Camera and Computer

- Image capture can be fully automated with a guide camera attached to the guide scope and a feed to a computer that controls both the mount and the imaging camera.
- Grab a snack, take an nap, or watch TV!
Software is needed in order for the computer to guide the mount.

The most common software used for auto guiding is “Push it Here Dummy” or PHD.

This freeware program has many utilities for aligning and guiding compatible mounts.
It is fairly easy to focus the DSLR camera for wide-field, as well as for the sun and moon, but focusing for high-magnification deep space is difficult.

Auto focus will not work unless there is a large amount of light.

Manual focus looking through the view finder is difficult because objects are small and dim.

There are several techniques that allow for good focusing for deep space.
Many modern DSLRs have “Live View.” This mode displays what the camera is “seeing” on the LCD screen.

1. Find a bright star and center it
2. Set the ISO to the highest setting
3. Zoom the screen view maximum
4. Use the manual focus on the camera lens or the telescope
5. Move to the object of interest without touching the focus ring, set the desired ISO and start imaging
Some software like “Backyard EOS” for Canon cameras and “DSLR Focus” have functions that examine individual stars and analyze the distribution of light dynamically as you focus. Motorized remote controlled focusers can be controlled by focusing software to automatically focus a telescope.
Masks that cover the full aperture with a pattern of openings or slits introduce diffraction into the image.

As you focus the image the diffraction pattern changes.

Inside-of-focus, outside-of-focus, and precise focus each have a predictable pattern.

One of the most popular masks is the Bahtinov mask.
Bahtinov Mask

Just Inside Focus

Just Outside Focus

Good Focus
Software You Will Need to Get Started

- For nightscapes, you really do not need any software but some means to adjust brightness/contrast, saturation, and gamma will be helpful – these may be provided with the camera – or freeware like GIMP

- For star trails use a specialized program like StarStaX

- For lunar and H-alpha solar, it is helpful to have the same image processing capability as for nightscapes but some solar system object stacking capability is also useful – Auto Stakkart does a great job and is also freeware
There are a variety of software packages available for astrophotography image processing.

- Some cost money but there are some capable programs that are free.
- One of the most useful freeware programs is “Deep Sky Stacker” (DSS).
- A highly powerful commercial program is “PixInsight”.
The real power of guided tracking and stacking imaging is what happens after images are captured.

Dim noisy images are stacked to improve signal-to-noise ratio and allow stretching to bring out faint details.

Without stacking, stretching will amplify noise and degrade the image.

Stacking reduces noise in final image by the square root of the number of images stacked.

For example, stacking 25 images reduces the noise by a factor of 5.
“Light frames” are your pictures

Calibration frames:

- **Dark frames** – same exposure time, temperature, and ISO as the light frames but with optics covered (10 to 20)
- **Flat frames** – same ISO as the light frames but short exposures taken with optics in same orientation but focused on flat light background (10 to 20)
- **Dark flat frames** – taken with the same exposure and ISO as the flat frames but with optics covered (10 to 20)
- **Offset/Bias frames** – frames taken as very short exposure and same ISO setting (10 to 20)
Processing a Single Exposure (Not Stacked)

Single 5 Minute Raw Exposure

Single 5 Minute Processed Exposure
Image After Stacking and Final Processing

Stack of 15 Frames With Final Processing
Stacking programs like Deep Sky Stacker (DSS) have some minimal image processing like color saturation and balance.

For final processing, programs such as Adobe Photoshop, Adobe Lightroom, or Corel PaintShop, allow you to tease out the fine details.

The output from DSS is not bad, but it can be improved …
Output of DSS … Not Bad
Output of DSS With Final Processing
Happy Imaging!