Astrophotography 101

By: Bettymaya Foott

Where to shoot? Find a Dark Place!

If you are interested in astrophotography, you probably want to capture faint celestial objects like our Milky Way galaxy. This is only possible in an area that is naturally dark and free of **light pollution**. Broadly defined, light pollution is any adverse effect of artificial light at night. It comes in three main forms, **skyglow**: domes of light on the horizon above artificially lit areas, **glare**: the response of the eye to overly bright light (often causing visual discomfort), and **light trespass**: light that extends beyond its property line or intended area of illumination. (Think of your neighbor's porch light coming into your window at night.)

Light pollution can be mitigated simply. **Light only where you need it, when you need it, and in the amount needed.** This means fully shielding the light, using timers or motion sensors to limit the amount of time the light is on, and using the lowest intensity of light needed to accomplish the task. Color of light is also important; select warm/amber fixtures with a low correlated color temperature (CCT).

Light Pollution Solution Postcard, one example of the public outreach materials available free of charge on IDA's website.

Looking for a place to shoot some dark skies? You can find the nearest International Dark Sky Parks, Communities, Sanctuaries, or Reserves with the interactive map available on the darksky.org website!

Photography and Dark Sky Advocacy

Capturing images of our night skies is beneficial for communicating the issue of light pollution. Opening our camera shutters for long periods of time allows faint light to become quite obvious. When capturing images of the night sky, you will also capture the domes of skyglow on the horizon. In most cities today, the light pollution completely obscures our view of the milky way. Two thirds of the world's population cannot see the milky way from where they live[1].

Images of the night sky illustrate the effects of light pollution more effectively than words. The images below show what it looked like in the night sky before and during the 2003 Northeast blackout, a massive power outage that affected 55 million people.

Photos by Todd Carlson

Images of before and after lighting installations can also illustrate the benefits of dark sky friendly lighting. Many lights are more glaring than they are effective, shining light into your eye and decreasing your visual acuity. Many lights are also designed inefficiently, directing the light up into the sky and out into your neighbors windows, as opposed to down onto the ground or task where they are needed.

[1] New world atlas for artificial night sky brightness.

Before image illustrating a glaring porch light. Note illumination on the trees and shadows on the ground.

Lighting after the porch light was replaced with a fully shielded fixture. Note the better yard illumination, elimination of glare, and reduction of illumination on the trees.

Photos: Joyce Harman Photography

Astrophotography Essentials

Exposure - There are three things you need to remember when setting up your exposure, **Shutter Speed, Aperture,** and **ISO**. This is known as the Exposure Triangle.

Shutter Speed - Shutter speeds can range from 15-30 seconds. The focal length of your lens determines how long you can open your shutter without capturing the motion of the earth, evident in star trailing. This can be calculated by the “500 rule” - divide 500 by the focal length of your lens, and you will get the longest time in seconds that you can expose.

For longer shutter speeds - you will need to use a star tracker to compensate for the rotation of the earth. Discussed below.

Aperture - Shoot with a wide aperture, f 2.8 or wider. A wider aperture is reflected by a smaller number. It’s counterintuitive because it’s describing the *ratio* of your lens’s focal length (mm) to the size of the aperture.

ISO - ISO settings for night skies range from 1600 to 6400. ISO refers to your camera’s sensitivity to light. A higher ISO will give you more sensitivity to light. Higher ISO can cause increased digital noise (grain). This can be mitigated with a stacking technique - described later on. Keep in mind higher ISO’s will produce less noise on some cameras than others (newer camera models tend to produce less noise).

My settings - I tend to shoot for 25 seconds. ISO 2000. F 1.8-2.8

Focus - Focus is one of the hardest parts of astrophotography. Autofocus will not work in dark shooting conditions, you must use **manual focus**. To find the correct focus, roughly pre-set your lens to infinity and enable live view (seeing the image on the screen of the camera). Center the brightest celestial object, or something distant and bright. Use the camera display zoom (not on your lens!) to zoom in as far as possible. Adjust your focus until the bright object you selected becomes as small as possible. A good sign that you are approaching focus is if you see dim stars appearing in the viewfinder.

If you do not have live view, pre-set your lens to infinity, take an image, review and adjust the focus and repeat the shot until you achieve a sharp image.

Image Type- Shoot in RAW format for optimal post processing. Shooting in JPEG condenses the image which gives you less information to work with when editing the file. Note that RAW files are larger than JPEGs, you may need an external hard drive to store your files on.

Equipment

Camera - Any DSLR (Digital Single Lens Reflex) camera will capture images of the night skies. A camera with a full frame sensor will enable the most light capture, but it is not necessary for good quality night sky photos. Live view capabilities make focusing much easier!

Lens - For landscape astrophotography, shoot on a wide angle lens (50 - 12 mm) with a wide aperture of f 2.8 or larger (smaller number). A good all around astrophotography lens is the Rokinon 14mm f 2.8.

It's possible to capture images of deep sky objects like nebula and galaxies using a zoom lens mounted on a star tracking device. You can also attach your camera body to a telescope, as long as it's tracking the motion of the earth. The best images taken of these deep sky objects are done via a stacking process to reduce noise, and also a HDR process to capture the range of exposures.

Remote Release - anything that keeps your hand from vibrating the camera will give you sharper, higher quality shots. Although this is not necessary, you can also use the 2 second timer on your camera to release the shutter without touching the body.

Tripod - Absolutely necessary for night sky photography! As much as you may try, you won't be able to hold still for over 20 seconds. You can use natural props, like stones or fences if you don't have a tripod, but the ease of changing the composition of your shot is greatly enhanced with a tripod.

Intervalometer - for more advanced shooting techniques, like timelapses or star trails, an intervalometer is going to be essential to capture rapid fire images one after another.

The Milky Way Galaxy

Basic Info - Earth is located in the outer spiral arm of the spiral galaxy we call home. We can visualize our galaxy shape as a fried egg, basically flat but with a bulge in the center. This egg is 100,000 light years across! Every star you can see with the unaided eye is located within the milky way. The only objects you can see in the sky outside of the Milky Way are the Andromeda Galaxy and Large and Small Magellanic Clouds.

Summer is prime time to capture the Milky Way galactic center. During the summer, earth at night (in the northern hemisphere) is looking toward the center of our galaxy, home to the highest concentration of stars. The combined starlight makes it the most luminous part, too. You can find it in the constellation of Sagittarius, low on the southern horizon (in the northern hemisphere). The brightest stars in the constellation of Sagittarius make a starry teapot; and the milky way rises as steam from the spout.

Summer Milky Way. Goblin Valley State Park, Utah.
Canon 6D Rokinon 24mm 25 seconds, iso 2000, f 1.4

The Winter Milky Way shows us the outside edge of our galaxy. With fewer stars, the wintertime Milky Way will appear more subtle than its summer counterpart. Composition, foreground, and knowledge of some of the brighter constellations (like Orion) will assist in composing a striking image. Winter is also a great time to shoot night skies because the typically dry winter air makes for clearer shots (and you can get out much earlier in the evening!).

Winter Milky Way with Orion at Bryce Canyon National Park, Utah
Canon 6D Rokinon 14 mm 30 seconds, ISO 5000 f 2.8

Galactic Core Visibility

In the northern hemisphere, the Milky Way galactic core will shine in the sky from March to November.
In the spring (March - May), the galactic core will first become visible a few hours before sunrise.
During the summer (June - August) you can view the milky way as soon as the sun sets for most of the night.
By fall (September - November) the Milky Way will be best seen in the early evening.
In winter (November to February) the core will not be visible in the northern hemisphere.

Time of Night

The milky way is most clearly seen during **true night**, after the sun is 18 degrees below the horizon. This is typically an hour after sunset.

A phenomenon called **blue hour** happens just before that, when the sun is sun 12 to 18 degrees below the horizon. Blue hour photos show the stars against a rich blue sky still faintly illuminated by the setting sun. It happens quickly, so you have to plan for it. You can calculate the sun's position using the free desktop app, Stellarium.

Blue hour Milky Way. Dead Horse Point State Park, Utah
Canon 6D Rokinon 24 mm f 1.4 ISO 2000

True night Milky Way. Dead Horse Point State Park, Utah
Canon 6D Rokinon 24 mm f 1.4 ISO 2000

Composition and alignment

The Milky Way core will always be generally south on the horizon (in the northern hemisphere). The orientation of the Milky Way differs throughout the year. In spring, the Milky Way is horizontal, sweeping across the horizon reaching only 35 degrees into the sky. This is the best time of year to capture panoramas.

Early spring Milky Way. Black Canyon of the Gunnison, Colorado
Stitched panorama of 7 shots. Canon 6D Rokinon 24 mm 25 seconds, ISO 2000, f1.4

During the late summer, the Milky Way will be almost completely vertical reaching up to 85 degrees into the sky, almost directly above you.

Late summer milky way. Cataract Canyon, Canyonlands National Park, Utah
Canon 6D Rokinon 24 mm 25 seconds, ISO 2000, f1.4

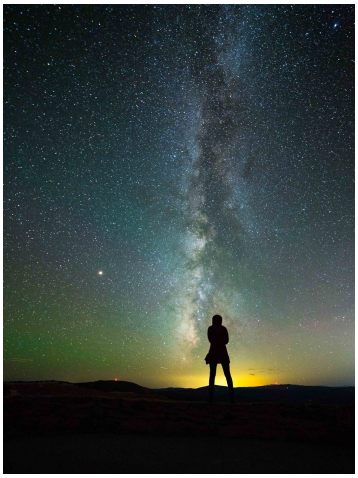
You can use apps to visualize this as well as to plan your shot. Examples of popular apps that help you do this are Photopills and the Photographer's Ephemeris.

Moon Phase

Planning around the moon phase is essential for astrophotography. Light from the moon may seem dim, but it actually can dramatically alter the scene that your camera will capture. During a **full moon**, your image will appear to be a sunny mid-day afternoon, but with stars. Moonlight is bright! (I lovingly refer to this as the “night-sun”.)

Full moon star trails. Vermillion Cliffs, Arizona
Stack of 80 images Canon 6D Rokinon 12 mm fisheye ISO 1000 20 seconds f 2.8

The **new moon** is the best time to capture faint celestial objects that can be washed out by moonlight, like the Milky Way and faint stars. A moonless night is also the best time to capture dark silhouettes against a bright night sky. These shots can also be achieved if the moon has set.



Silhouette against Cedar Breaks National Monument, Utah
Canon 6D Rokinon 14mm 30 seconds ISO 5000 20 seconds f 2.8

My favorite moonphase to shoot is a **thin crescent**, specifically, when the moon is 15% illuminated. This amount of moonlight provides enough light to capture your foreground, but is still dim enough not to overpower faint celestial objects. You can calculate the moon's illumination with a number of online websites. I like this one!

Crescent moon illuminating Canyonlands National Park, Utah.
Canon 6D Rokinon 24 mm 30 seconds, ISO 5000 f1.4

Advanced Techniques

Light painting

Adding light to your your earthly subject matter can add incredible depth and contrast. You will need a light that can be dimmed quite low; a popular option is the Lume Cube. You can diffuse the light with paper towel or other material to soften the light down further. The technique of using very little light to illuminate a scene is called Low Level Lighting, and is good practice for nocturnal habitat health. There are some areas that don't permit light painting, please check on the regulations before you shoot.

Moab Utah Birthing Rock Petroglyph Panel, lit by a Lume Cube
Canon 6D Rokinon 24 mm 25 seconds, ISO 2000, f1.4

Star trails

Layering consecutive night sky images will give you the effect of star trails. I typically shoot 25-30 second shots one after another using an intervalometer, for about an hour. Some people take single long exposures with a lower ISO to achieve the same effect, but I like the method of stacking as it reduces digital noise. A great free program to help you do this is called Star Stax.

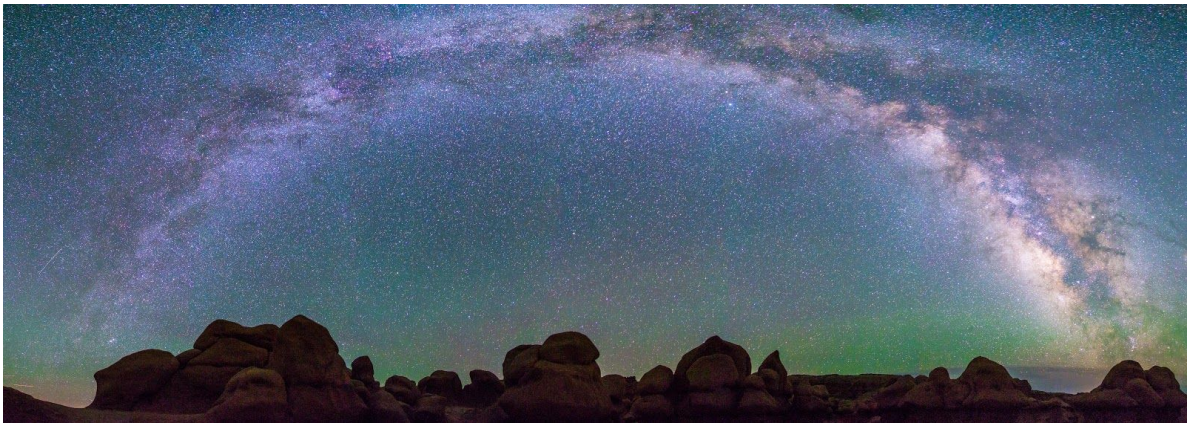
Shooting North, your star trails will create concentric circles around our North Star. Shooting toward other directions will give you large arcs of stars.

Stack of 100 images. Little Dell Reservoir, Utah
Canon 6D Rokinon 24 mm 25 seconds, ISO 2000, f1.4

Panoramas

Panoramas are created by stitching together vertical images to capture more of the scene than you can in a single exposure. Panorama stitching can be done in many programs, I find Lightroom to be simple, easy and effective.

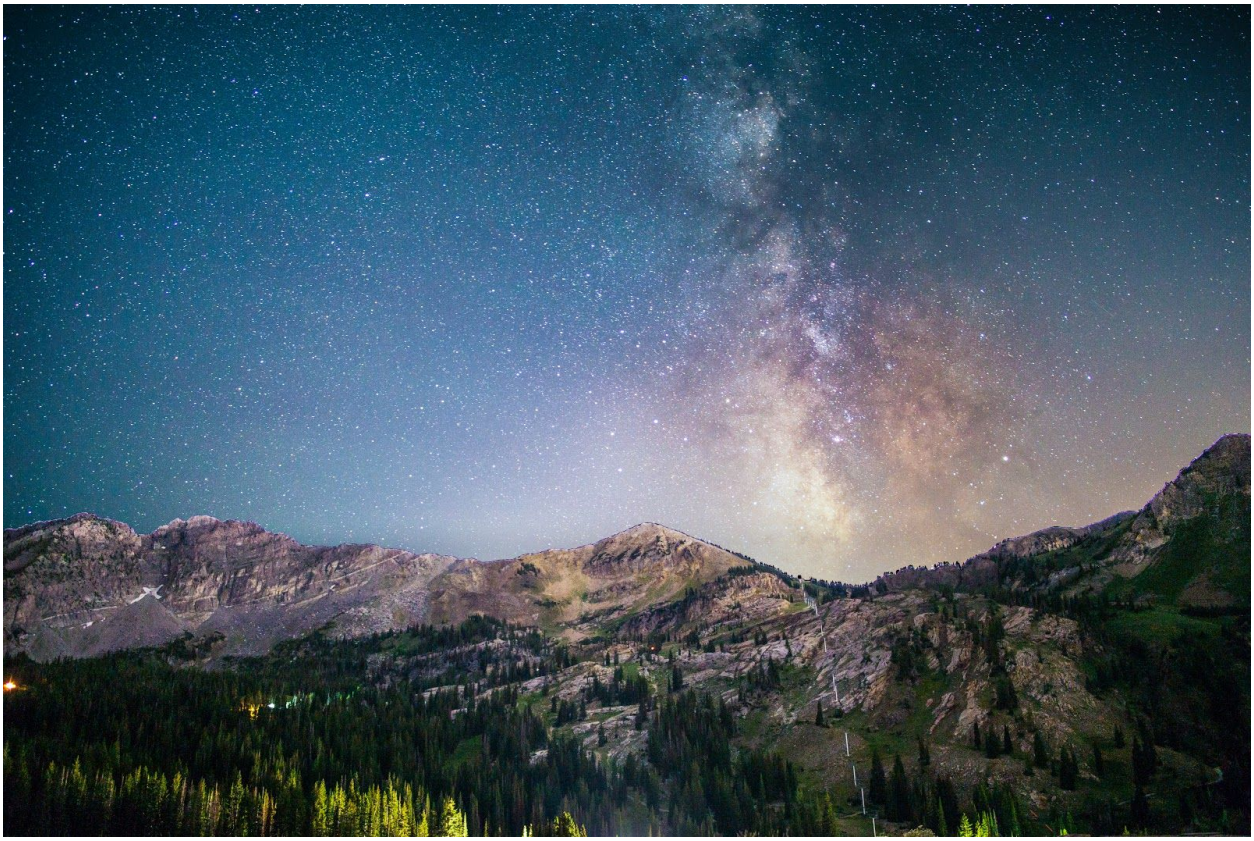
To take a panorama, rotate your camera to shoot a vertical image, you may need a ballhead or L bracket for this. Also make sure that your tripod is level. Take a series of images with a 50% overlap, then use software to merge them. In lightroom, select all of your images in the develop module, right click, and choose photo merge - panorama. So easy! Make sure you edit your panorama after you stitch the images together. It's easier for your software to combine raw image files that have not been altered. Then you can edit the panorama as one photo, not multiple.



Stitched image of 7 exposures. Goblin Valley State Park, Utah
Canon 6D Rokinon 24 mm 25 seconds, ISO 2000, f1.4

Layering Exposures

If you want to capture both the foreground and the night sky, sometimes you have to take two images at different exposures and merge them in Photoshop. To do this, take an image exposing for your night sky, typically 20-30 seconds. Then, without moving the camera or tripod, take another longer exposure to capture your foreground. This can take anywhere from one to two minutes or longer. You may want to take multiple images of your foreground and use software to stack them to reduce digital noise caused by long openings of your shutter.



Albion Basin, Utah. 2 Images merged in Photoshop. Shot on Canon 6D, Rokinon 24 mm
Foreground exposure, 1 minute, ISO 2000, f1.4
Night sky exposure: 20 Seconds, ISO 2000, f1.4

Star Trackers

Our earth rotates at roughly 1,000 miles per hour[2]. In order to capture crisp images of the stars, we have to have a short enough exposure to not capture star trailing caused by the rotation of the earth. (We discussed the 500 rule above) We can counter this and open our exposure for minutes at a time if we use a star tracker, a device that rotates your camera in the opposite direction at the same pace the earth rotates. Star trackers allow us to keep our exposure open for long periods of time and capture detailed, bright images of the milky way. Your foreground will be slightly blurry in a tracked shot, but you can blend it with a still shot of the foreground in photoshop.

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[2] https://www.scientificamerican.com/article/how-fast-is-the-earth-mov/

Stacking for Noise Reduction

Stacking multiple images with software like Photoshop or Starry Landscape Stacker (my personal favorite) will dramatically reduce digital noise (grain and hot pixels) in your night sky images. See below for before and after (not as obvious in these smaller images!)

Before and after stacking for noise reduction. Cataract Canyon, Canyonlands National Park, Utah
Canon 6D Rokinon 24 mm 25 seconds, ISO 2000, f1.4
Above, single image. Below, stack of 10 images combined in Starry Landscape Stacker.

Time Lapses
Time lapses are created using an intervalometer to capture multiple images, one after another, much like the technique used for star trails. Time lapses need at least 24 frames to create one second of video. With such long exposure times, capturing time lapses of the night sky can take a lot of time. When you have your series of images, (I recommend 125-150 for at least 5 seconds of footage), you can create the timelapse many different ways. There's a great program called LR Timelapse that creates the time lapses for you and allows you to adjust your editing throughout different portions of your sequence. You can also use Lightroom's Slideshow module to create your timelapse. For this, you must download a timelapse preset online. Sync your edits across all of your photos, and then use the program to export your video.

Night sky photography best practices

- ★ To preserve your night vision, use red headlamp and turn your camera's LCD display brightness down.
- ★ Bring warm clothes - warm days can be followed by cold nights!
- ★ Tell someone where you are going and when you plan to return.
- ★ Review all regulations about photography on protected lands and access after hours if shooting in a park area.
- ★ Remember to check the weather. Clear Sky Chart provides forecast information relevant to astronomical observing.
- ★ If there are other astro-photographers in the area you are shooting, ask them before you start light painting or using artificial light to see what you are doing. Even small amounts of stray light can be a detriment to an image of the night sky, especially if it's a tracked shot.
- ★ Most importantly, have fun! Let your passion for the night skies inspire others.

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