Shooting the Milky Way

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Shooting

A good baseline exposure for the Milky Way on a full frame sensor with dark skies is 14mm, f/2.8, ISO 4000, 25 seconds, and then tweak your settings from there.

Aperture

Typically as wide open as you can go on a moonless night, but if you have an f/1.4 prime it might have less coma and vignetting stopped down some. Usually you don't want to go as far as f/4 with the Milky Way unless your camera has a very high ISO range, such as a Sony A7S.
3.2) ISO

ISO 2500 to 6400 is a good ISO range for the Milky Way with dark skies. Conventional wisdom would dictate using as low an ISO as possible for less noise, but night photography is very different. Unless you are using a tracker or stacking images for longer exposures, we have to use very high ISOs to capture enough detail of the Milky Way. You'll want to experiment to find the ideal balance between detail and noise with your camera body.

Shutter speed & focal length

Wide angle lenses let you use longer exposures at night without stars streaking. A good rule of thumb is to divide 500 by your focal length for the maximum number of seconds you can use for an exposure and still get acceptably sharp stars. It's a relative figure—stars don't appear to move as fast near the north star, but the further away from Polaris and the closer to the equator you get, the faster the stars appear to move. If you don't have a 35mm full frame sensor, divide again by the crop factor (1.6 for Canon crop sensor DSLRs, 1.5 for Nikon crop sensor DSLRs, and 2 for most mirrorless cameras). 14mm to 35mm on a full frame sensor is best for Milky Way photography. 50mm and higher usually need a tracker to avoid streaking at long enough shutter speeds. Here are some examples:

- 500 ÷ 14mm on a full frame sensor = 35 seconds
- 500 ÷ 24mm = 20 seconds
- 500 ÷ 18mm ÷ 1.6 for a Canon crop sensor = 17 seconds
- 500 ÷ 50mm ÷ 2 for a mirrorless sensor = 5 seconds

I often subtract another 5 to 10 seconds from these estimates to ensure sharp stars when shooting along the horizon, especially when printing large like 24×36 from a high resolution sensor. For timelapses and star trails a small amount of streaking won't matter.

There is a much more complicated and accurate exposure rule for those that are interested. As sensors get denser with more megapixels, or larger such as medium format, the “500 Rule” falls short. This is why I often subtract 5 to 10 seconds from the result. A more accurate formula would be:

(35 x aperture + 30 x pixel pitch) ÷ focal length = shutter speed in seconds

To figure out the pixel pitch of your camera, divide the sensor’s physical width in millimeters by the number of pixels in width, and multiply by 1000 to measure it in microns. For example, a Nikon D810 is 35.9 x 24mm and 7360 x 4912 pixels. 35.9 ÷ 7360 x 1000 = 4.88 µm (rounding up).

Therefore, a 20mm f/1.8 lens on a 36 MP D810 would equal about 10.5 seconds: (35 x 1.8 + 30 x 4.88) ÷ 20 = 10.47 (rounding up)

The 500 Rule would say 500 ÷ 20 = 25 seconds, which has significant streaking in the corners on a 36MP camera if you zoom in or print large. You could probably get away with 15 seconds though and look acceptably sharp.

Don’t forget your “order of operations” from high school math class for the above formula: solve the multiplication before the addition or you won’t get the correct results!

White balance

White balance won’t affect RAW files, just JPEGs, TIFFs, and the preview image on the camera’s rear LCD display. I find a proper white balance is useful when shooting in the field though to get a better preview of my image and exposure, since the histogram won’t be of much use for really dark scenes. A manual white balance of somewhere between 3000° and 4000°K is best for the Milky Way. I’m usually around 3450° or 3570°K on my Nikon. It doesn’t have to be precisely accurate, you can change it in Lightroom or Camera RAW later. If shooting timelapses and editing using LRTimelapse, a manual white balance is preferred over auto white balance for consistency.

LCD brightness

The brightness of the rear LCD on your camera will probably be way too bright for reviewing images at night. It will fool you into thinking your photos are exposed brighter than they really are, and it will annoy others shooting near you! I dial it down until I can barely see the difference in shade between the two darkest colors (black and dark gray) in the sample palette, about -2 to -3 on a Nikon.

Viewfinder cover

It's a good idea to cover your viewfinder or close the curtain to it for long exposures at night. During the day stray light through the viewfinder usually only affects your meter reading and not the image itself, but during long exposures at night it can show up on the edges of your frame, particularly if you have a light source behind you or a headlamp or flashlight hits the back of your camera. Many cameras ship with a little plastic cover (that soon gets misplaced), sometimes on the camera strap. You can also cover your camera with a hat, coat, etc.

RAW vs JPEG

RAW files store much more data than JPEGs, which is important for good post-processing later of night photos. If your camera has a choice between 12 or 14-bit RAW files, go with the highest quality and image size possible for better noise reduction and shadow boosting later.

Noise reduction

There are two types of noise reduction in your camera's menu: high ISO noise reduction and long exposure noise reduction. High ISO noise reduction doesn't apply to RAW files, only JPEGs and the embedded preview image, so I leave it disabled to avoid extra processing time by the camera. Long exposure noise reduction applies to all file types and removes hot pixels from sensor heat during long exposures (typically 8 seconds or more on most cameras). It doubles your exposure time and shoots the second photo with the shutter curtain closed, then removes any exposed pixels it finds in the second shot from the previous one before saving the file.
For a 30 second photo, a minute isn't a long wait, but for a 4 to 8 minute ground exposure, it can feel like eternity! Night photography is a craft that takes a lot of patience to master though, and I usually leave long exposure reduction enabled unless I'm shooting a panorama or timelapse.

If you are shooting a panorama or especially a timelapse for star trails, you can't have a long interval between shots for long exposure noise reduction. Instead, you can shoot a "dark frame" at f/22 with a lens cap on to capture nothing but hot pixels, and then apply it to your light frames later.

Pixel Fixer is a great program for dark frame subtraction if it supports your camera model because it can work on RAW files. Other programs like StarStaX can also use dark frames as TIFFs. More dark frames make for better analyzing, but not every program can do this. I usually shoot somewhere between 10 and 30 dark frames for every shutter/ISO combination that I used during the night, if I'm not using long exposure noise reduction in camera.

Focus

Critical focus is necessary for sharp stars. Infinity is usually not where it is marked on your lens. Autofocus on most cameras will not work on dim stars. The best method is to manually focus on a very bright star using live view on a tripod. If you have good enough eyes, you can roughly center a star in the viewfinder and then switch over to live view. Live view won't see any stars until at least 5x usually, and then you can pan around a bit until you find it and zoom in again to 10x or higher. Don't zoom with your lens, most zoom lenses have "focus breathing" where they shift focus slightly as you zoom. Manually adjust your focus until the star in live view is as small a pixel as you can get it with no soft edges or halos around it. Make a note of where this point is on your depth of field scale and tape your lens down for the night with masking tape or anything that won't leave a sticky residue, unless you are going to do focus stacking later.

Stacking

Often a single exposure of the Milky Way does not have enough depth of field or a long enough shutter speed for ground details. To get around this you have to shoot a longer exposure that is sometimes refocused for a closer object. I often lower my ISO or narrow my aperture by a stop or two and shoot very long exposures of the ground to combine later in Photoshop. The exposure difference varies on light pollution, ground details (woods, snow, grass, water, etc.), and moon light, but sometimes it is 3 or 4 stops more than the exposure of the stars, which can mean a shutter speed of several minutes if I also lowered my ISO for less noise or closed my aperture for more depth of field.

Timelapses

Timelapses are a lengthy discussion and deserve a dedicated article, so this is only a brief introduction with a few resources to check out if you are interested. Timelapses are easy to shoot between astronomic dusk and dawn because the exposure remains constant. Any intervalometer with manual exposure will work. However, shooting sunset into Milky Way or the opposite into sunrise is considered the holy grail of timelapsing due to the complexity. It usually involves some form of exposure ramping or bulb ramping (shifting ISO/exposure in bulb mode).

DslrDashboard is a good app for "easy" holy grail timelapses and worth investigating, especially if your camera has built-in WiFi. There is also a cheap battery powered wireless router that can be used for cameras without WiFi on that website.
LRTimelapse is a powerful program for gradually changing Lightroom/ Camera RAW edits over time (such as white balance or exposure) for both panoramas and timelapses. I use it frequently for timelapses and panoramas.

As mentioned previously, a Promote Control can do timelapses, manual bulb ramping, focus stacking, and a number of other functions.

Ramper Pro is a new, high-end timelapse controller with motion control, interval fairing, light sensor, histogram monitoring, 3D support, and more. This is more complicated than DslrDashboard, but it's an all-in-one box that doesn't require a netbook, tablet, or laptop in the field. It's become my favorite tool for holy grail timelapses.

Dynamic Perception and eMotimo build some very affordable and easy-to-use sliders and motion control robotic heads.

Star trails

Star trails are very closely related to timelapses, in that you capture the images with the same process, but instead of playing them back fast for a video you stack them into a single image to see the star movement. You can also use a single long exposure instead of stacking multiple short exposures. There are merits to both methods. I wrote a longer article on my website detailing why I prefer stacking over a single long exposure.

I find that using the same exposure as you'd use for the Milky Way produces too many stars to look good when stacked. It's better to knock your ISO down 2 or 3 stops. This also means that star trails look good with a little bit of moon light as that also reduces the number of visible stars. I like starting or ending my star trails timelapse during astronomic twilight to get some of the cobalt dark blue color in my skies. I'll let it overexpose at the beginning or end and choose how many frames I want to use later when stacking to get the brightness I like.

A short interval is important to prevent gaps in your star trails. This means disabling long exposure noise reduction.

StarStaX is an excellent free program for stacking stars. It supports dark frames and has features for gap filling, comet trails, reverse trails, and more. Currently it cannot export a 16-bit file, only 8-bit, but it does support TIFFs (both import and export).

Advanced Stacker Plus is a photoshop plugin, and lives up to its name. It's my preferred method of stacking star trails. I recommend taking Steven Christenson's online workshop from his website on how to get the most out of it.

Photoshop's stacking modes can also be used natively, but the two programs mentioned are much faster.

Star Tracer (Windows only) is a great program for extending star trails if you didn't shoot enough frames, and also for gap filling.

Sathya Narayanan has made a couple of Photoshop scripts that are great for creating vortex star trails and creative effects.

More night photography resources

- Antoni Cladera of PhotoPills interviewed several well-known night photographers and put together an excellent resource on shooting the Milky Way
- Another great article on using the PhotoPills app to shoot the Milky Way
- David Kingham has a great eBook on shooting the night sky that I highly recommend
- I keep a list of my favorite apps and websites for iPhones, iPads, Androids, Windows, Mac, etc. on my own website