Prescott Camera Club
2021 Night Sky Workshop

Learn how to capture the Milky Way, use low-level landscape lighting, and create star trails, with this one night workshop presented by the Prescott Camera Club.

Date: Tuesday, June 29
Alternate date in case of inclement weather: Tuesday, July 6
Location: Meet at the dirt parking lot next to the Iron Springs Cafe at 7:30pm and we will car pool to the site (20 minute drive). We will likely be out until approx. 11:30 or 12:.

Original content in these notes by Bill Zombeck and Rob Redford, major rewrite in 2021 by Dan Lenardon.

Workshop Exercises

1. Photographing the Milky Way with foreground elements
    1.1. Focusing on stars at night
    1.2. Low-level LED lighting for foreground
    1.3. Photo for single image
    1.4. Photos for stacking
    1.5. Dark slides
2. Star Trails
    2.1. Pre-visualizing the star trails
    2.2. Multiple exposures for combining

Equipment Recommendations

1. Camera
2. Fully charged camera batteries (bring extra batteries)
3. Extra memory cards (erased)
4. Wide angle lens (f/2.8 or f/4)
5. Sturdy tripod and weights
6. Cable release or electronic remote
7. Intervalometer or timer if not built into your camera (see section below)
8. Optional: Night Sky Light Pollution Filter (see section below)
9. Optional: Bahtinov Mask Focusing Aid for night stars (see section below)
10. Flashlight and/or headlamp (walking trails at night and settings), preferably with a red filter
11. LED light panels (variable output) optional with warming filter *(workshop leaders will bring these for this workshop, but put this on your personal list)*
12. Snacks and water
13. Smart phone with night sky and compass apps
14. Insect repellent
15. Hiking shoes
16. Compass (an "old school" magnetic one)
17. Folding chair

Pre-workshop Preparation

1. Review the equipment list and pack up your gear.
2. Head lamp with red light (to preserve night vision) is recommended for "hands-free" lighting while setting up the camera and tripod in the dark and when making adjustments while we are shooting. Alternatively, you can put a red filter on your flashlight. Note: If you are shooting with other photographers, please check that no one is shooting before you turn on your head lamp.
3. Camera (and Photographer!) Preparation

   Most of these are fixed settings we will not likely change during the workshop, so please set them in advance so you are not trying to do this in the dark.

   1. Turn off Image Stabilization/Vibration Reduction (on a tripod).
   2. Turn off auto-focus.
   3. Set exposure mode to "Manual."
   4. Turn off Long Exposure Noise Reduction (doubles the time of each shot & dark slide handles it).
   5. Turn off High ISO Noise Reduction (softens the image & you can do better in post-production).
   6. Turn off the automatic display of the image (Image Review) after a picture is taken. This is recommended to avoid shining light in other photographers images and to conserve the camera's battery, especially during multi-shot sequences.
   7. Review how to set or change your LCD monitor brightness. You will likely want it set to Manual, but you might need to set it brighter than normal to aid in focusing on stars. However, this will give a false sense of brightness when playing back your images, so you may need to move it up or down during the workshop.
   8. For DSLRs, set shutter control to Mirror Lockup (unless you are using “live view” or electronic shutter). This is to reduce vibration.
   9. Set the file mode to RAW (or RAW+JPG). RAW files give you the best ability to recover details in dark areas of the image.
   10. Consider removing any filters from your lens, unless you are using a “Light Pollution” filter specifically designed for night photography. Sometimes even a clear protection filter might cause some distortion or fuzziness of the sharpest stars.
   11. Learn how to use Live View (if available) and how to zoom into different areas of the image while in Live View. This will be needed to “fine-tune” your focus on stars.
   12. Find where Infinity focus is located on your lens. Most lenses will not focus at infinity at the Infinity mark on the lens. The easiest way to do this is to mount your camera on a tripod and zoom in on the LCD monitor while manually focusing on a high contrast object far away. This is much easier to do in the daytime than during the night! Once the infinity focal point is determined, remember and/or mark this point so you can easily find it in the dark. You may even want to tape the focusing ring to the lens barrel with gaffer's tape to ensure it is not disturbed during the shoot. However, the focus point may shift a little as the temperature changes, which is why we will fine-tune the focus during the workshop.
   13. Look up your maximum shutter speed to obtain pin-point stars
      - The old “rule of thumb” was to use a formula of 500/focal length (with focal length corrected for crop sensors as below) = max shutter speed. This old formula doesn’t work well with modern cameras and will result in point stars looking like dashes. A better simple rule is to use 300/Focal Length, where the dashes or elongated stars may not be as noticeable in normal sized prints.
         - Simple Rule: 300/Focal Length)
           Example: 300/14mm lens = 21.4 sec max exposure
         - For DSLR crop sensor cameras an adjustment to the formula is required:
         - For a Nikon crop (DX) sensor, multiple focal length by 1.5
         - For a Canon crop (APS-C) sensor, multiple focal length by 1.6
         - Example: 300/(14mm lens*1.5) = 14 sec max exposure

- For really sharp, pin point stars use the more complicated NPF rule to determine maximum shutter time. This formula takes into account your camera's pixel size and other factors. Look up the value using either PhotoPills (phone app) or a website such as https://www.lonelyspeck.com/advanced-astrophotography-shutter-time-calculator/. This method produces results with very sharp stars even with today's high-megapixel cameras, but the shorter exposure time than the 300 rule above will result in a darker image (at the same ISO setting) and can mean more noise in an individual image. Stacking of images (described later) can reduce or eliminate most of this noise and brighten the image, so the NPF rule is best used in combination with stacking. If you are only taking a single image of the Milky Way, using the 300 rule or a shutter time in between the two will produce a brighter image that is easier to process.

14. Cover any LED indicator lights on your camera body with gaffer's tape. These small lights may be visible in yours or other photographers' images. Common LEDs to cover are: an LED that indicates writing the file to card; an LED that's on while making long exposures; the LED focus assist light that beams out a bright red light towards the front; any color LEDs on your remote control or intervalometer that blink during exposure or are always on.
15. Review how well your camera works with high ISO settings. This topic is not that simple, but if interested, here is a good article: https://www.lonelyspeck.com/how-to-find-the-best-iso-for-astrophotography-dynamic-range-and-noise/#more-84388 . If you are using stacking technique described below, you may be able to use a higher ISO setting than expected.
16. Review your camera manual for any settings or procedures you are unfamiliar with.

On Location: Shooting the Milky Way - Camera Settings and Process

1. Ensure you have made all the settings and calculations in the **Camera Preparation** section on the previous page.
2. Initial setting (our starting point. We will experiment with different values of these settings depending on conditions and creativity).
   - Widest focal length (e.g. 14 or 16mm) if you are using a zoom lens
   - Widest aperture (e.g., f/2.8) or 1/3 stop down from widest aperture.
   - ISO 1600 to 3200 (depending on light). Use the histogram to assess exposure and possibly increase ISO to 6400 or 12800 depending on camera.
   - Exposure time at the maximum shutter speed determined above by the NPF Rule
   - White Balance: While the white balance can be changed in post, it is recommended to set either daylight, which will show the background sky as black, or 3800K (or Tungsten if you don't have the Kelvin temperature option on your camera), which will show the background as blueish (creative choice).
   - Use your remote or intervalometer to trigger your camera. If you don't have one, at least use the 2-second or 10-second timer so that you are not shaking the camera with a shutter press.
3. For DSLRs, cover the optical viewfinder when not in use to prevent extraneous light from hitting the sensor on our long exposures. You could do this ahead of time if always using Live View.
4. In order to utilize night sky stacking software in post production to significantly reduce noise, you must have a number of shots at the same settings. Plan to take 10 to 20 identical shots using your intervalometer or with your remote control. If using an intervalometer, set it to 2 seconds greater than your shutter time. This is usually needed to allow the camera to finish processing and writing the image to disk before triggering the next shot.
5. It is also recommended to take 5-10 dark slides which will be used by the stacking software to reduce noise. Put your lens cap on and take a several shots with the same settings as the

images used for stacking. This should be done just after taking the stacking shots before the camera/sensor cools down too much.
6. Optional: If there is no wind or moving trees, you could capture an image with much lower ISO and much longer exposure time. While the stars will be long streaks, you may have a nice low-noise image of the foreground which could be composited with your sharp star image(s).
7. Do not rely on a visual observation of the brightness on your LCD to check exposure. Instead, review the histogram and look for two things. First, the very low tail on the right side must not touch the far right side or bright stars will be clipped and you may loose much of the color in any stars. Second, you would like the main peak in the histogram to extend a ways from the left. Often, at the settings recommended above, the histogram will not even extend to ¼ of the way. If it's way to the left, you may need to increase the ISO to increase exposure.

On Location: Settings for shooting Star Trails

1. Star trails are most commonly taken with the North Star (Polaris) in the image frame which produces circular tracks around Polaris. However, shooting in other directions can also be interesting with different shaped streaks.
2. Since we are intending to capture the star streaks caused by the earth's motion, we do not need to limit our exposure time to the maximum described above. One method for producing a star trail image is to use settings closer to a daylight image and expose for 30 minutes to an hour using the bulb timer or a remote that locks the shutter button down. However, it's harder to get the correct exposure and all of the tracks from airplanes flying by will be mixed in with the star trails and harder to edit out.
3. A better way to take star trails utilizes lots of shorter exposures stacked with software specifically for star trails. Each exposure could be taken with the same settings as for the Milky Way above, or you could increase exposure up to 30 seconds, the maximum shutter speed without using bulb mode, and reduce the ISO setting if each image is too bright. In order to get an interesting star trail composite, you will need to stack images captures over a time period of from 15 minutes to one hour. For the workshop, we'll recommend shooting for 20-30 minutes.
4. You may want to put your fingers in front of the lens before and after the sequence to help "mark" the beginning and end of the images to stack.

Intervalometer for different cameras

Many camera bodies have an intervalometer built into the menu system. If you're not sure, you can check on your camera at the following web site: https://www.lonelyspeck.com/list-of-large-sensor-cameras-with-built-in-intervalometers/. Note that many of the Canon DSLRs on the list that have an asterisk (*) require the add-on "Magic Lantern" software. That topic is not covered here nor in this workshop. There are also external intervalometers that serve multiple purposes: remote shutter release, intervalometer, and bulb timer. For this workshop, we will always be taking multiple shots one right after the other, unlike what one might do for time-lapse photography. This means that just holding down the button on your remote, or using a remote release that has a "lock" will work fine. You just need to estimate the length of time to get the desired number of shots.

Night Sky Photography Apps for your Phone (or desktop)

1. PhotoPills – Great app with sections for planning all types of night sky photography and includes a pre-visualization mode. https://www.photopills.com/
2. The Photographers Ephemeris (TPE) – good for planning sunrise/sunset/moon rise/moon set and angles.
3. Stellarium – Pre-visualize sun, moon, planets, Milky Way, constellations.

4. Light Pollution Map – Will you have dark skies at your location? Where might you drive to get darker skies? https://photographersarsenal.com/mobile-apps-android-ios-iphone-ipad/light-pollution-map/
5. Clear Outside – Will it be dark, will there be clouds (short term forecast)
6. Sky Map – Look around to see where planets, constellations, etc. are right now. http://sky-map-team.github.io/stardroid/
7. Compass apps (many available).

Night Sky Light Pollution Filters (Optional)

A light pollution filter (LPF) is very specific in filtering out or reducing the pollution from sodium lights and often mercury lamps, too. These are more complex filters that take out just certain frequencies of light. While there are many techniques to try to reduce the light pollution from city lights in post production, they are difficult and may not be able to achieve the same benefit as a light pollution filter. Adjusting color balance doesn't really do the same thing. However, LPFs are expensive, especially if one needs a special holder for the 100mm or 150mm square filters for use with may ultra-wide lenses.

Focusing with a Bahtinov mask (Optional)

If you need "help" with focusing at night to obtain pinpoint stars, a recent star focusing tool that some photographers are beginning to use is the "Bahtinov Mask." It has been used by astronomers for years to help focus their telescopes on distant stars and planets. It consists of a "filter" composed of grids that create a diffraction spike ("star spikes") when perfectly focused on a bright star or planet. It works best on mid to telephoto lens. However, newer "Batinov mask" designs (although on the expensive side) work on the wide angle lenses as well. They range in price from $15 (B&H Photo) to over a hundred plus dollars (Focus On Stars - HIGH PRECISION focusing tool for astrophotography). Note: the simple plastic $15 item will likely not work with the very-wide-angle lens we typically use for a Milky Way image with foreground.

Post-Processing

While we are planning a separate Zoom Workshop on Night Sky Post Processing to show basic techniques and allow Q&A, we'll include some basic information here for post-processing your workshop images.

Post Processing Milky Way Images

For single images, use all of your normal processing ideas.

1. You will likely need to apply some noise reduction. Good options for this include plug-ins from Topaz and Nik in addition to the normal options in Lightroom or CameraRaw. You might want to consider applying noise reduction to the sky areas and not to foreground rocks or other elements.
2. The Dehaze slider in Lightroom and CameraRaw can be very effective in increasing contract while brightening stars.
3. White balance can be adjusted to get the sky color and overall "look" that you desire.
4. Consider using an adjustment brush to brighten portions of the Milky Way nebula clouds.

Stacking for the Milky Way

1. Using a program to stack 20-30 images with pin-point stars is highly recommended. You'll want a program that automatically aligns the stars, since they appear to move, while keeping the foreground fixed. On a PC, you can use Sequator (https://sites.google.com/site/sequatorglobal/) or on a Mac use Starry Landscape Stacker (https://sites.google.com/site/starrylandscapestacker/home). Both programs will stack the stars and foreground separately with noise reductions in both. Both programs can take advantage of dark frames / noise images as well as flat-field frames / vignette images, but will

work without them. It is usually recommended to utilize your RAW images without other processing. You would then edit the resulting stacked image with your normal edits as above. The one possible exception is that for images taken with a lens with significant or complex distortion, such as the original Rokinon 14mm F2.8 lens, you might try only applying the lens profile corrections before stacking. Sometimes this results in less distorted stars around the periphery of the image. When using Sequator, make sure you select the "Freeze Ground" option and use the brush to select most of the sky region. I think Starry Landscape Stacker has something similar.

Post-Processing, Star Trails

1. Presuming that you are creating your star trails image using a sequence of stacked images, you'll need an application to do just that. The Sequator app described above has an option to stack for star trails and also does a good job, and is one of the few that will accept RAW images as input. I would also recommend StarStaX (https://markus-enzweiler.de/software/starstax/), available for both PC and Mac. It is fast, and has a nice option to fill in the gaps in trails caused by the seconds between images. However, you will have to export/save your images in TIFF format since it doesn't accept RAW images.
2. Star trail images usually don't look very good with tracks from airplanes. They usually have colored lights and cut across the star trails. If you have several in your image (very typical), you may want to edit the airplane tracks out of the original images before stacking for star trails. If this case you'll likely be exporting/saving the edited images as TIFF files, so that makes it easy to use StarStaX. The stacking process for star trails also significantly reduces noise, so you shouldn't have to apply noise reduction before stacking. As with the Milky Way stacked process, do your editing on the resulting star trails stacked image.

Resources

Planning for a night shoot is absolutely critical. You need a clear night, no moon (unless you want to do moonscapes), and you need to know where in the night sky your subject will be on the night of your shoot.
Probably the best app for planning is PhotoPills (link above). The free desktop app Stellarium is also excellent for visualization or pre-planning. A good basic tutorial on shooting the Milky Way, although a little dated is: https://digital-photography-school.com/how-to-do-milky-way-photography-a-comprehensive-tutorial/. The PhotoPills web site also have great tutorials and cover how to use the app, but also many aspects of night sky photography. Another highly recommended site is: https://www.lonelyspeck.com/. They have articles on many aspects of night sky photography.