DSLR Astrophotography Untracked

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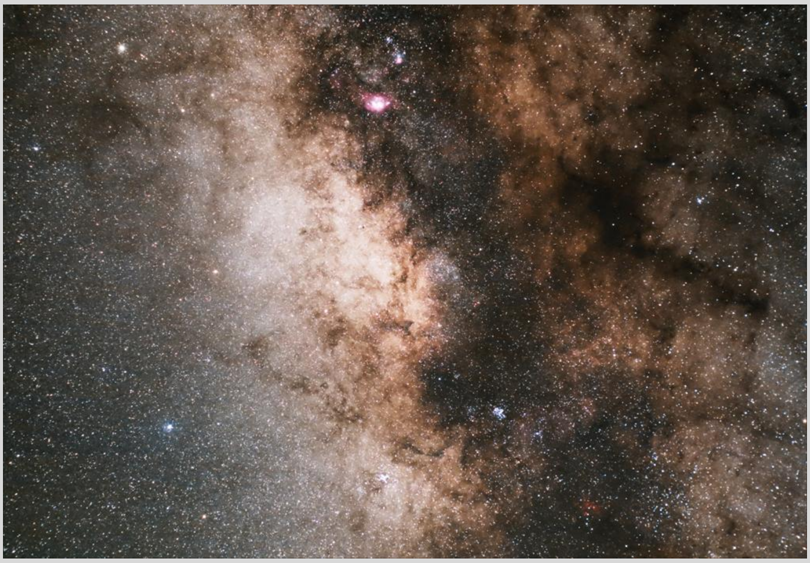
Capture noise-free images of star clusters, nebulae and the Milky Way without any tracking device.

With DSLRs and standard camera lenses astrophotography is on the verge of a new epoch, where tracking is no longer mandatory. When we heard about the technique described in this article, we immediately wanted to give it a try. It allows any stargazer using a modern DSLR to capture colorful, noise-free images of deep-sky objects, without an equatorial mount or tracking device needed. The method has tremendous potential: Capture a binocular comet? Shoot a clean, noise-free image of a star field? Make a well-saturated, colorful picture of a Messier object? No problem anymore, no tracking required.



The Great Sagittarius Star Cloud, imaged with a 50mm lens without tracking. All images were captured under the pristine skies of La Palma island. See text for exposure details.

How it Works

The technique described here was originally brought to our attention by our fellow observer Wolfgang Vollmann, who has been using it for some time to capture comets. His initial results were promising and we decided to give it a closer look and develop it further where possible. After a series of experiments we are now able to present a tried and tested workflow that guarantees great images of star fields. The basic idea of the method is actually quite simple: Shoot a lot of similar exposures at high ISO ratings and keep the single exposures so short that no tracking is needed. The individual frames can then be digitally combined in a stacking program to create a final picture that shows faint details and is free of the noise that comes with the high ISO setting. As the sample images show, the results are quite astounding. For example, with a 135mm lens we captured detailed images of star clusters and nebulae, reaching a limiting magnitude of 14mag. Images shot with a 50mm lens easily captured star clouds and nebulae in the Milky Way with great detail.

Typical setup for untracked astrophotography; instrument requirements are minimal. All you need is a DSLR, a tripod and a remote release timer. You may want to add a lens hood and a right-angle viewfinder.

What You Need

Omega Centauri Cluster, imaged with a 135mm lens without tracking. Limiting magnitude is 14mag, see text for exposure details.

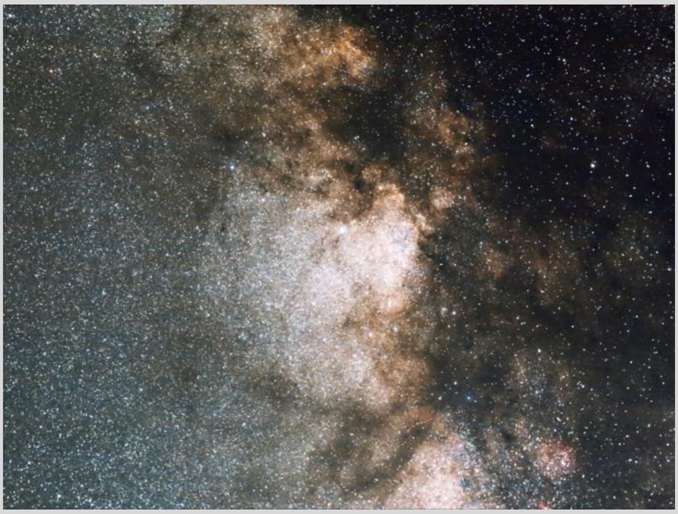
The imaging method is very simple and therefore instrument requirements are minimal. First of all, you will need one of the later DSLR models that allow ISO settings of 6400 or higher. As a lens, any wide angle, standard or tele lens will do, even the typical kit zoom lenses will work. A small but sturdy tripod is required for mounting and pointing the camera. For field work at remote sites we recommend the new, lightweight models (<0.5kg) with a ball head that are available from several manufacturers. The last mandatory item is a remote release timer that allows you to program a series of exposures. As an alternative, many of the newer DSLR models can be remote controlled via a smartphone app. Additionally, you might want to use a right-angle viewfinder and a lens hood. As the shopping list shows, any astrophotographer or nature-interested terrestrial photographer will probably already own most of these items. For this reason the method is ideal for casual astrophotography to capture a comet, a nova or simply to take some pictures of your favorite deep-sky objects during a vacation at a dark site.

How to Shoot

First of all, shoot at the darkest location and under the best skies you have access to. This will guarantee that the individual exposures already show the best contrast possible. After setting up your equipment, set the DSLR's picture mode to RAW, white balance to daylight and sensitivity to ISO 6400 or higher. Turn off any presets for noise reduction, sharpening or color enhancement. Switch your lens to manual focus and use magnified live mode to focus your lens on a brighter star. Finally, step down your lens at least one f-stop from wide open. This will reduce lens aberrations noticeably, especially when using a zoom lens. The next step is to program your remote release timer for a greater number of exposures, 100 is a good value to start with. When you set the exposure time for the individual frames, be aware that it is limited by the focal length of your lens. With a 50mm lens, 3-second exposures are fine, with a

Deneb and the North America Nebula, imaged with a 50mm lens without tracking. See text for exposure details.

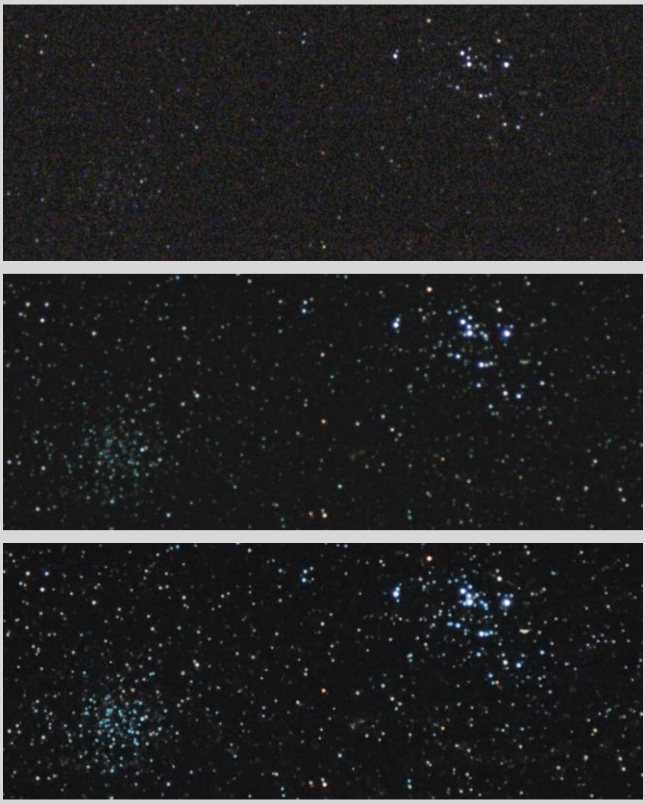
135mm lens exposure time should be around 1 second. To determine the maximum exposure time for your specific DSLR and lens more precisely, use the formula given in the workflow tutorial at the end of this document. If you keep your exposure times within the specified limits, the stars on your pictures will be nice and round without any signs of trailing. As soon as you have completed these steps, your camera is ready and it is time to frame your target. Point your DSLR at the star field, nebula or comet you want to image. Place the object slightly off center in the camera's viewfinder, so it will drift over the center during your exposure series. Start your timer and let your camera record the target. Once the exposure series is finished, cover your lens and shoot at least 10 dark frames with the same exposure settings. To give you an idea which settings work well, the images accompanying this article were shot at rural sites on La Palma Island with a Canon 1100D body set at ISO 6400 with series of 100 exposures each. We used a 50mm lens @f/2.8 and a 135mm lens @f/4 with 3 and 1 second exposures, respectively. Except that our Canon 1100D is modified for optimum H-alpha sensitivity, it is an ordinary, off-the-shelf APS-C sized camera body. Although an unmodified DSLR will record less red nebulosity it will still work very well for the method described.



Scutum Star Cloud, imaged with a 50mm lens without tracking. Short focus lenses work especially well for capturing Milky Way vistas like this one. See text for exposure details.

Processing the Images

Once you return from your imaging trip, star party, vacation or camping hike, it is time to develop the final images. As we mentioned above, the magic unfolds with the stacking of the individual exposures. This



Example of M46/M47, showing how the final image unfolds:

a) Single 1-second untracked exposure with ISO 6400, 135mm @f/4

b) Stack of one hundred 1-second exposures, calibrated with 10 dark frames and stretched but otherwise still unprocessed

c) Final image mildly enhanced with Photoshop. It even shows the 1-arcminute 11.5mag planetary nebula NGC 2438 within the open cluster M46

Orion Nebula M42, imaged with a 135mm lens. The colorful and noise-free picture is the result of a stack of 100 single exposures.

procedure cancels out the noise of the high ISO setting and enhances faint details as well as small stars. For the task of stacking the images there are many different programs available. We recommend the widely used freeware Deep Sky Stacker to start with, but any other stacking software will do the job as well. With the stacking software of your choice, simply import your exposure series as well as the dark frames and let the program register and digitally combine the individual frames. The result is a calibrated stack of your images that is practically noise-free. To get the maximum out of your resulting image you will then have to enhance it using an image processing software such as Photoshop.

Explore the Limits

A compact tutorial of the workflow described can be found in the appendix of this document. We prepared the tutorial for all fellow photographers, because this method opens a whole new world of astrophotography. With DSLR cameras getting more and more sensitive, tracking is no longer an absolute requirement for stunning star field images. On many occasions this can be a tremendous benefit. For example, when you want to travel light to a dark observing site, when the observing window is very short or simply in all situations when you don't want to hassle with the complexity that comes with the use of an equatorial mount or tracking device. And our experiments made it pretty clear that the potential of this new method is really great. Who wants to give it a try?

*The authors **Karoline Mrazek** and **Erwin Matys** are founding members of the astrophotography group project nightflight. Check out their images, projects and tools at **www.project-nightflight.net***

For the workflow tutorial go to the next page.

Workflow Tutorial:
DSLR Astrophotography Untracked

1. Basic Principle

The basic idea of untracked DSLR astrophotography is actually quite simple: Shoot a lot of similar exposures at very high ISO ratings and keep the single exposures so short that no tracking is needed. In a stacking program the individual frames then are digitally combined to create a final picture that shows faint details and is free of the noise that comes with the high ISO setting.

2. Camera Settings

Picture Mode – RAW
White Balance – Daylight
Sensitivity – ISO 6400 or higher
Aperture – Stop down lens at least one f/stop from wide open
Focus – Manual
Presets for noise reduction, sharpening or color enhancement – Off

3. Exposure Time

The imaging lens' focal length, the DSLR's pixel size and the object's declination determine how long a single shot of a star field can be exposed without showing star trails. The maximum exposure time can be calculated with the following formula:

$$t \sim \frac{27\,000 \times \Delta}{f \times \cos\delta}$$

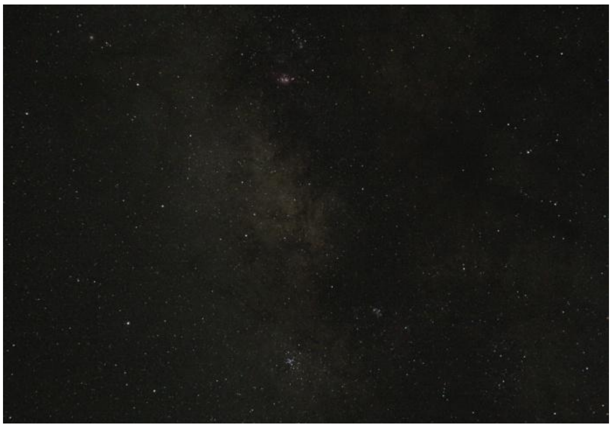
t = maximum exposure time in [s]
δ = object declination
Δ = pixel size of DSLR chip in [mm]
f = focal length of lens in [mm]

Using this formula, the resulting star trails will have a length of 2 pixels on the image, which is unnoticeable for all practical purposes. Example: With a 50mm lens on a DSLR with a pixel size of Δ=0.005mm the constellation Cassiopeia (δ=60°) can be exposed for 5 seconds without showing trails.

4. Shooting

Switch your lens to manual focus and use magnified live mode to focus your lens on a brighter star. Point your DSLR at the star field, nebula or comet you want to image. Place it slightly off center in the camera's viewfinder, so it will drift over the center during your exposure series. Start your timer and let your camera record at least 100 single images of the target. Once the exposure series is finished, cover your lens and shoot at least 10 dark frames with the same exposure settings.

One single image of the exposure series will look like this:



5. Stacking with Deep Sky Stacker

For the task of stacking the images there are many different programs available. We recommend the widely used freeware Deep Sky Stacker to start with, but any other stacking software will do the job as well. Simply import your exposure series as well as the dark frames and let the program register and digitally combine the individual frames.

The following parameter settings for Deep Sky Stacker work well:

RAW Settings
Bayer Matrix Transformation – AHD
White Balance – Use Camera White Balance
Colors Adjustment – Brightness 5, Red 1, Blue 1
(You may need to vary the brightness value)

Stacking Parameters
Result – Intersection Mode
Light – Median, No Background Calibration
Dark – Median
Alignment – Automatic

When registering and stacking is done and the final stack is displayed, save it as a TIF image and check the box “Embed adjustments in the saved image but do not apply them”

6. Further Processing

The final stack you saved is a linear, non-stretched image. If you open it with an image processing software such as Photoshop, it will be rather dark:

At first, do a non-linear stretch to brighten the image:

Finally, process the image to your likings: