How to Shoot Stars and the Milky Way - Astrophotography

Whenever you're shooting stars there's a question you have to immediately ask yourself and that's whether you want to render your stars as point stars or star trails. There isn't really a good middle ground between the two of these things because a slightly trailed star just comes across looking like a slightly blurry point star. In other words, it looks like you made a mistake when you were shooting it. Of course, this can cause a few problems because the inherent lack of light in your night-time location means that you require a pretty lengthy exposure time. What's more, when people first starting shooting at night they are often very surprised to see just how short an exposure time can start to produce trailing on their stars from the rotation of the earth.

Minimum Requirements

Tripod: For any type of night sky photography, a sturdy, well-built tripod is one of the most important pieces of equipment.

A cheaply build tripod will shake / move slightly over the long exposure time required for night sky photography, causing blurry images.

Camera with Manual Mode Functionality: Manual Mode means you can independently and manually adjust the ISO, Aperture, and Exposure time by hand.

Full Frame / 35 mm Camera: A full frame sensor provides a larger surface area to "capture" the light of the stars and Milky way. Using a full frame camera will help to reduce the amount of noise in high ISO images, in turn providing higher quality RAW files.

A Wide-Angle Lens: An f/2.8 minimum aperture. In short, the smaller the number shown under the "f", the wider the lens can open. This wide opening will allow your camera's sensor to pick up as much light as possible in the shortest amount of time.

- For full frame cameras, wide angle lenses between 14mm and 20mm (widest focal length) are recommended.
- For crop sensor cameras, wide angle lenses between 10mm and 17mm (widest focal length) are recommended. **Apertures of f/2.8 – f/4 are required.**

Camera Timer / Intervalometer: Most cameras will take up to a 30 second exposure without a timer. If you would like to capture long exposure images of the night sky, longer than 30 seconds, you'll need a timer. (Amazon has a wide range of timers for all types of cameras.)

Tip: Remove the camera strap if you have one! (It will flap about in any breeze!)

Set the focus to manual at infinity ∞

Location, Location, Location

Now, it's not enough to just get all the gear, you need to find the right places to photograph the night sky as well. Light pollution is a serious problem for astrophotography and if you're anywhere near a large city you're going to have to travel at least an hour to get away from the lights.

However, as seen in this image, even a town of only about 30,000 people and over ten miles away can still result in some obstructive light pollution.

One thing to do to try and minimize the light pollution is to find out where it is in a timely manner. To do this I typically will fire off successive shots all around the horizon using an absurdly high ISO (typically the highest my camera will go) simply to limit the time it takes for each shot to expose. These shots won't be used in the final process, but they are valuable in letting me know which parts of the horizon are off-limits.

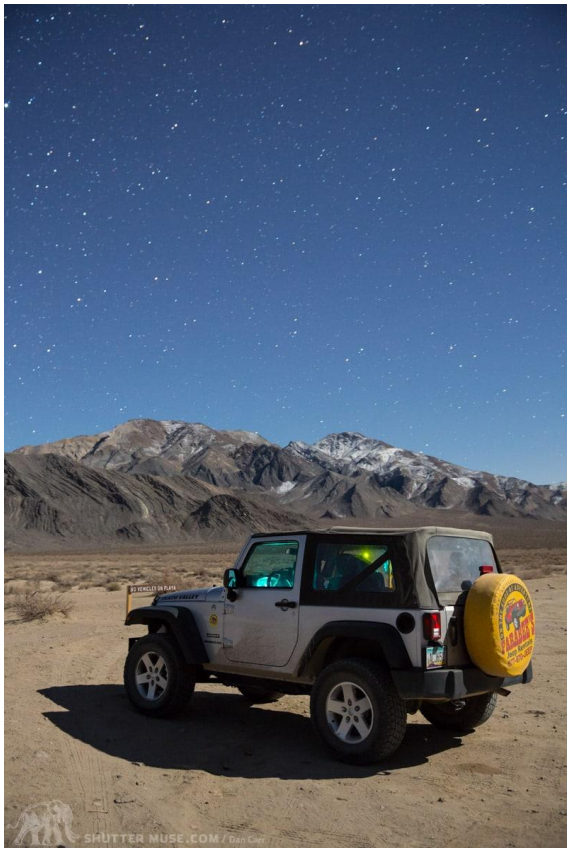
The exact length of exposure that you can get away with depends on a few variations. Firstly, you need to know the focal length of your lens and the wider it is, the longer you can expose for without the stars becoming visibly blurred. Secondly, and very much related to the first point, you also need to know the crop factor of your camera's sensor because this has an effect on your equivalent focal length. A full frame camera has a crop factor of 1x, but APS-C sensors have either 1.5x or 1.6x depending on the manufacturer.

When deciding on what your maximum exposure time should be for point stars, you might also take into account how you will be viewing your final image. For example, if you were only showing your images in small resolutions on the web, you could get away with a small amount of trailing without it being noticeable. On the other hand, if you make large prints of your work, or they are featured as full-page shots in a magazine, then these would definitely have less tolerance. It's fair to say though that most people will want to get the best possible results, but if you are struggling with your particular gear setup then it might be that you can have a little leniency and nobody will really notice.

The '500 Rule'

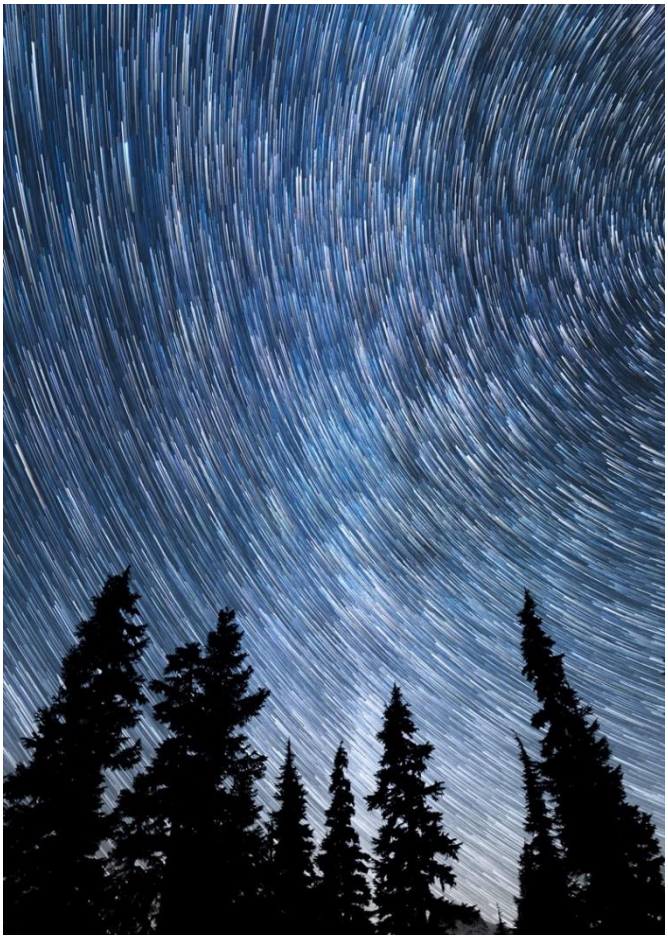
The '500 Rule' is a definitely more of a guideline than a rule because really there are *no* rules in photography. What this says though is that the maximum exposure time you can have before your stars start to become blurred is equal to **500 divided by (your focal length in 35mm equivalent)**.

EXAMPLE: IF I HAD A 24MM LENS ON 1.5X CROP CAMERA MY MAXIMUM EXPOSURE TIME WOULD BE 500 / (24×1.5) = 14 SECONDS.



Now the shortness of this exposure time can catch people by surprise. If you have a crop sensor camera with a kit zoom lens on it that only has a max aperture of f3.5 or something like that, you're going to be pushing your ISO up pretty high to get your exposure time down to 14 seconds. It's therefore easier to shoot with wider lenses, and also a good reason for a full frame camera which will allow the full field of view of a lens and also have a better high ISO performance.

In this shot (left) an exposure time of 31 seconds was used, but the lens was set at 35mm on a full-frame camera. The 500 rule would say that I shouldn't have my exposure longer than 500/35=14 seconds. As you can see from the 100% crop of the image below, the stars have indeed begun to trail quite visibly in the photo. Not ideal! Hey, we all make mistakes…… that's how we learn. In fact, the focus of this image is more on the vehicle than the night sky so in this instance you could say the photographer "got away with it". Had this been a shot entirely of the sky though, focussed on the intention of just showing the stars, this would have looked a lot worse.



As beautiful as star trails can be, sometimes it's not what we want.

THE '500 RULE' CHART

For easy reference (and because nobody really likes to do math), here's a handy chart that you can refer to. Below the chart you'll also find a download link to get a PDF version of the chart that you can keep with you on your mobile device or print out and keep in your camera bag. The chart features a large variety of focal length, as well as three different sensor sizes. Full frame 35mm as well as 1.5x and 1.6x crop factors to cover Canon, Nikon and Sony.

FULL FRAME, 1.5X AND 1.6X CROP

Full Frame Focal Length (35mm)	Max Exposure Time	Crop Sensor (1.5x) Equivalent (mm)	Max Exposure Time	Crop Sensor (1.6x) Equivalent (mm)	Max Exposure Time
8	63	12	42	13	39
9	56	14	37	14	35
10	50	15	33	16	31
11	45	17	30	18	28
12	42	18	28	19	26
13	38	20	26	21	24
14	36	21	24	22	22
15	33	23	22	24	21
16	31	24	21	26	20
17	29	26	20	27	18
18	28	27	19	29	17
19	26	29	18	30	16
20	25	30	17	32	16
21	24	32	16	34	15
22	23	33	15	35	14
23	22	35	14	37	14
24	21	36	14	38	13
25	20	38	13	40	13
26	19	39	13	42	12
27	19	41	12	43	12
28	18	42	12	45	11
29	17	44	11	46	11
30	17	45	11	48	10
31	16	47	11	50	10
32	16	48	10	51	10
33	15	50	10	53	9
34	15	51	10	54	9
35	14	53	10	56	9
40	13	60	8	64	8
50	10	75	7	80	6
60	8	90	6	96	5
70	7	105	5	112	4
80	6	120	4	128	4
90	6	135	4	144	3
100	5	150	3	160	3
120	4	180	3	192	3
150	3	225	2	240	2
175	3	263	2	280	2
200	3	300	2	320	2

ISO Settings – Star Photography

Now that we have narrowed down all of the other star and Milky Way photography camera settings, the only one left is ISO. This is the only destructive / noise inducing setting for long exposure, night photography. This is why you should select exposure time and aperture prior to selecting an ISO setting for Milky Way or star photos.

There is no reason to degrade picture quality by increasing ISO (to obtain a brighter image) when you can keep the same picture quality and increase the brightness using a longer exposure or a wider aperture, given your photo is not exhibiting star trails.

Follow the next steps to select an acceptable ISO setting for your photo. All of your other settings should still be the same, as calculated above:

Step 1: Adjust your camera to ISO800 and take a practice shot. This practice shot will most likely be dark. If it is, move on to step 2.

Step 2: Increase your ISO one stop, or to the next larger value, such as ISO1200. Take another practice shot. Most likely this shot will still be very dark. If it is, move to step 3.

Step 3: Continue to increase your ISO until you start to see the Milky Way very visibly in your photos.

TIP: There is no need to over-expose your star photos. They can be fairly dark just like the night sky that surrounds you. The best method is to match the brightness of your photos to the landscape and stars you're looking at. The camera picks up much more data than is actually displayed on the preview screen. This data can be brought out in post processing.

Step 4: Once the Milky Way is clearly visible in your photos, you have found an ISO setting that works well for the given composition and situation.

Depending on the camera make and model, you may notice a lot of noise in your photo. You may also notice that you have increased your ISO to the maximum setting and the photo is still not bright enough.

Other than adjustments in post processing, there is nothing else that can be done about maxing out your ISO prior to having a bright enough photo. This is where it truly helps to have a full frame camera.

Shooting Star Trails

If you would like to shoot star trails, select your composition and try an exposure time of 3-4 minutes with an ISO of 600-800 and take a picture.

If your picture is too dark, increase the exposure time. If your trails aren't long enough, increase the exposure time. This is all personal preference.

Increase and decrease the ISO as required if there is too much noise in the photo.

This is all about trial and error, finding which settings work best and which don't. Eventually you will start to see photos you like!