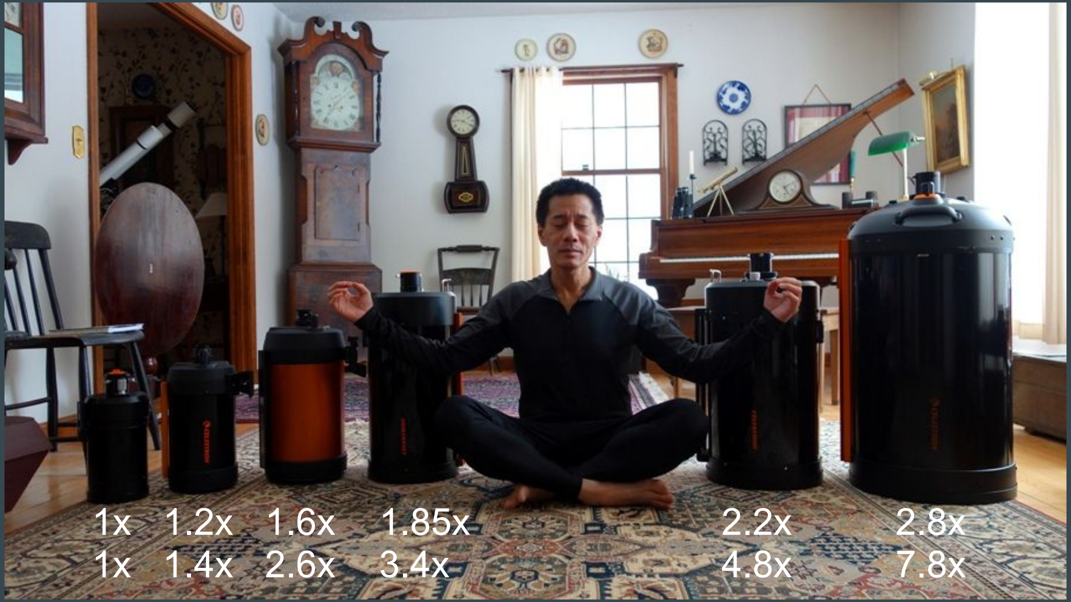
Beginner Astrophotography

A guide to your first astrophoto

Jon Dolan www.jondolan.io/astro

It’s all about the light

All the expensive gear and fancy techniques all boil down to one goal: collecting more light



https://www.scopereviews.com/CSCTs.html

So how do we collect more light?

Get a larger telescope?

- Creating refractors doesn't scale well
  - 80mm for $760
  - 100mm for $875
  - 120mm for $1,780
  - 140mm for good luck...

So how do we collect more light?

Get a larger telescope?

- We can make giant reflectors, but carrying them doesn’t scale well
  - 4lbs for $630
  - 11lbs for $500
  - 30lbs for $1,000
  - 40lbs for $1,300
  - 55lbs for $2,300
  - $2,700 for the pier for a larger mount

So how do we collect more light?

- Rule of thumb for imaging - use at most 70% of your mount's advertised payload capacity
  - So, to image on an 8 inch Orion reflector (17.lbs), you would need at least a Celestron AVX or Orion Sirius (30lbs payload)

So how do we collect more light?

Look at the target for longer?

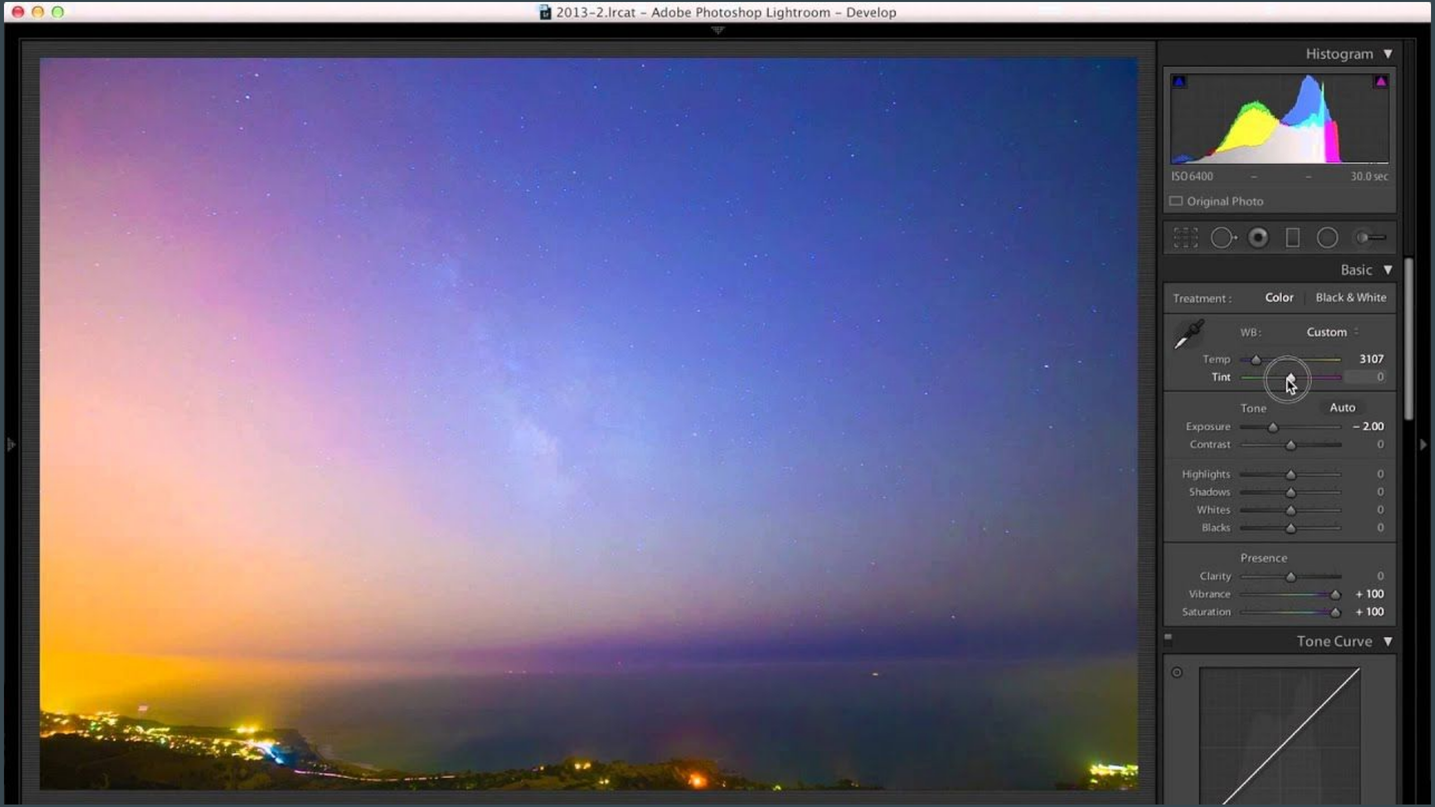
- Long exposure photography
  - Keep the camera shutter open for longer allowing the sensor to collect more light
- What limits how long we can take a picture for?
  - Mount tracking capability - for DSO imaging with pinpoint stars, super accurate alignment and good tracking are required (more on this in a later presentation?)
  - **The Earth's rotation**
  - **Light pollution**
  - Chances of random events ruining your frame (and a proportionally higher amount of effort wasted for each ruined frame)

So how do we collect more light?

Use a more sensitive camera or a higher sensitivity setting?

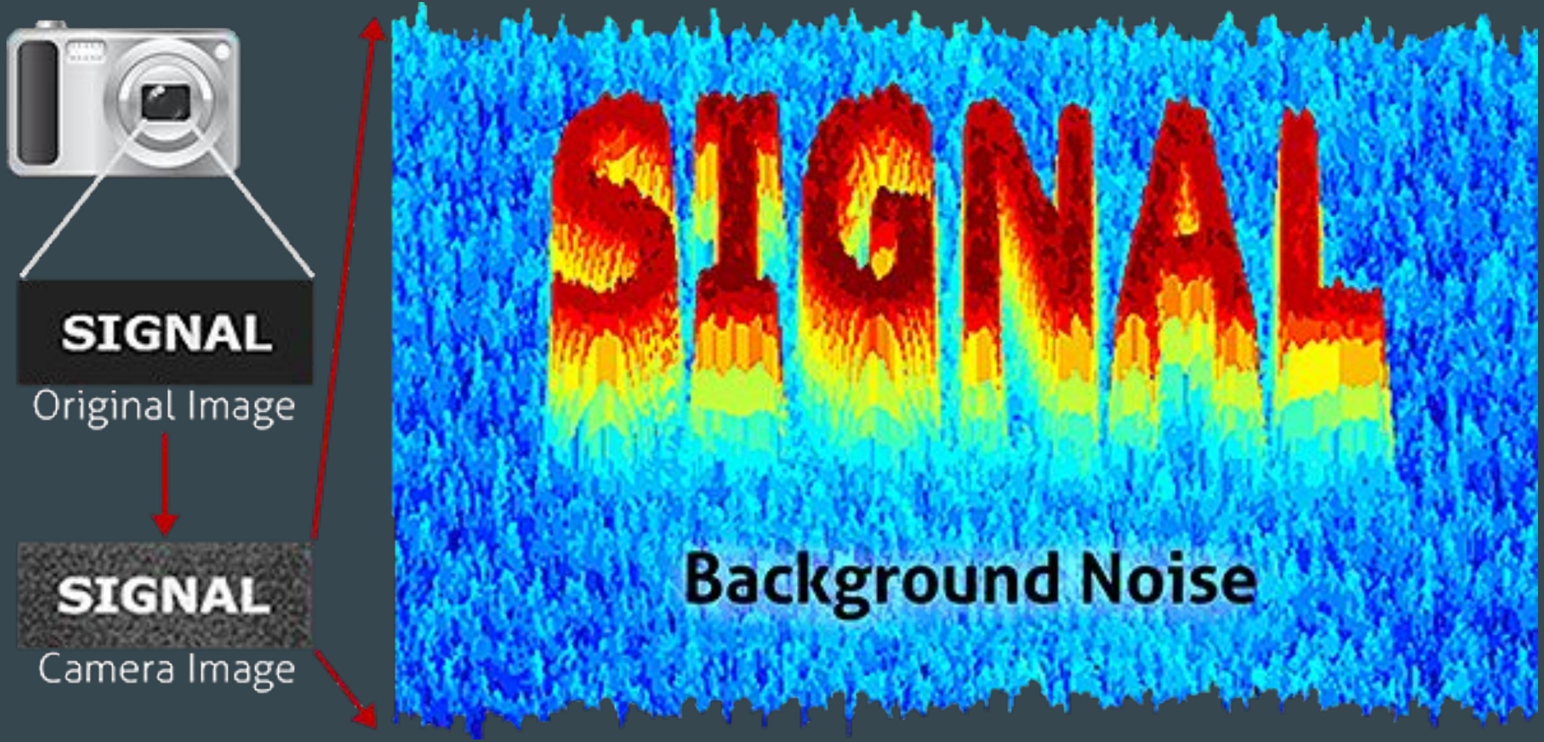
- First, we need to introduce the concept of **noise**, **SNR**, and **dynamic range**

Is all light we collect good?



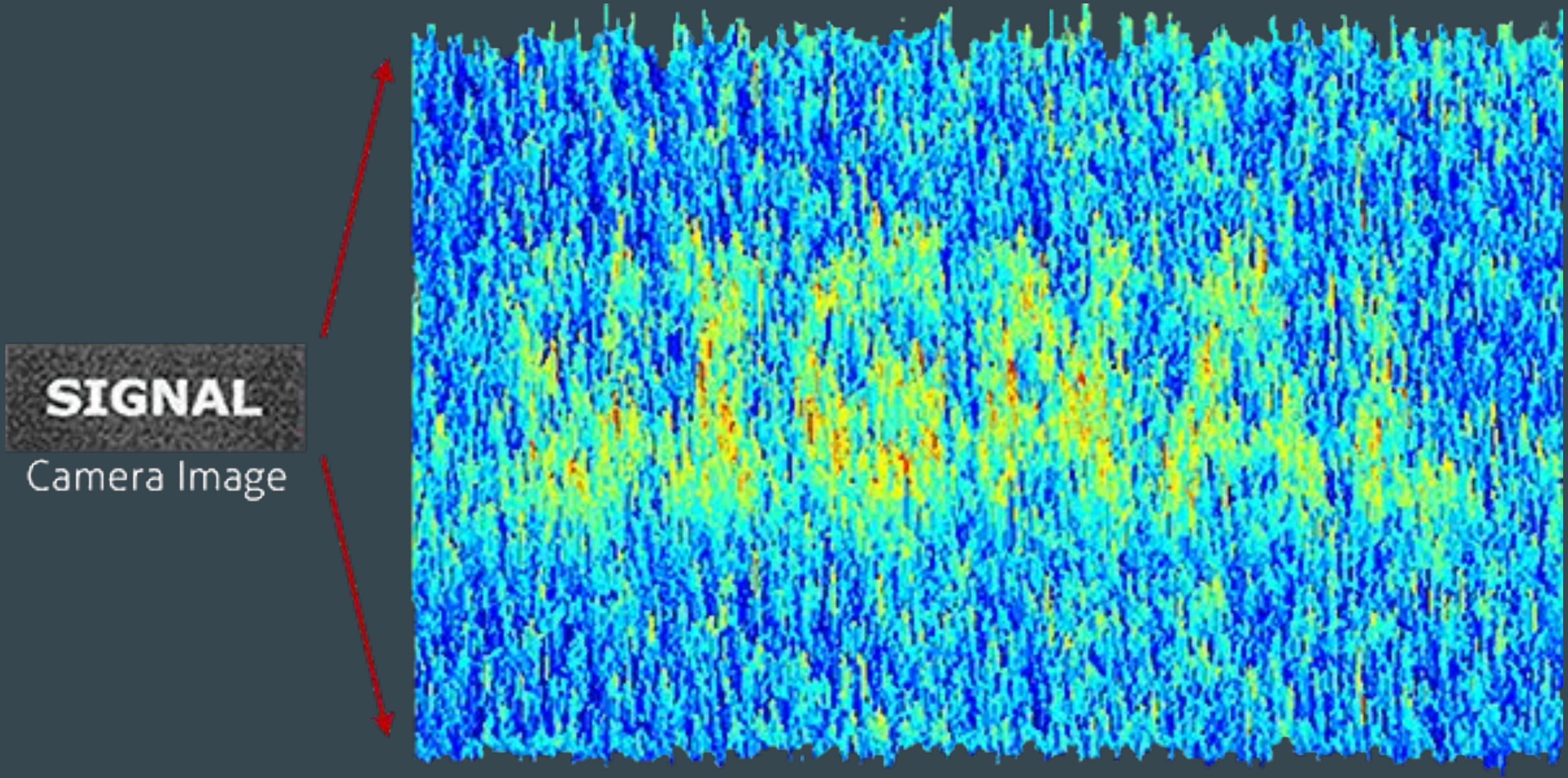
https://www.youtube.com/watch?v=J1Kfr8RG3zM

What is noise?



https://www.cambridgeincolour.com/tutorials/image-noise.htm

Low SNR



https://www.cambridgeincolour.com/tutorials/image-noise.htm

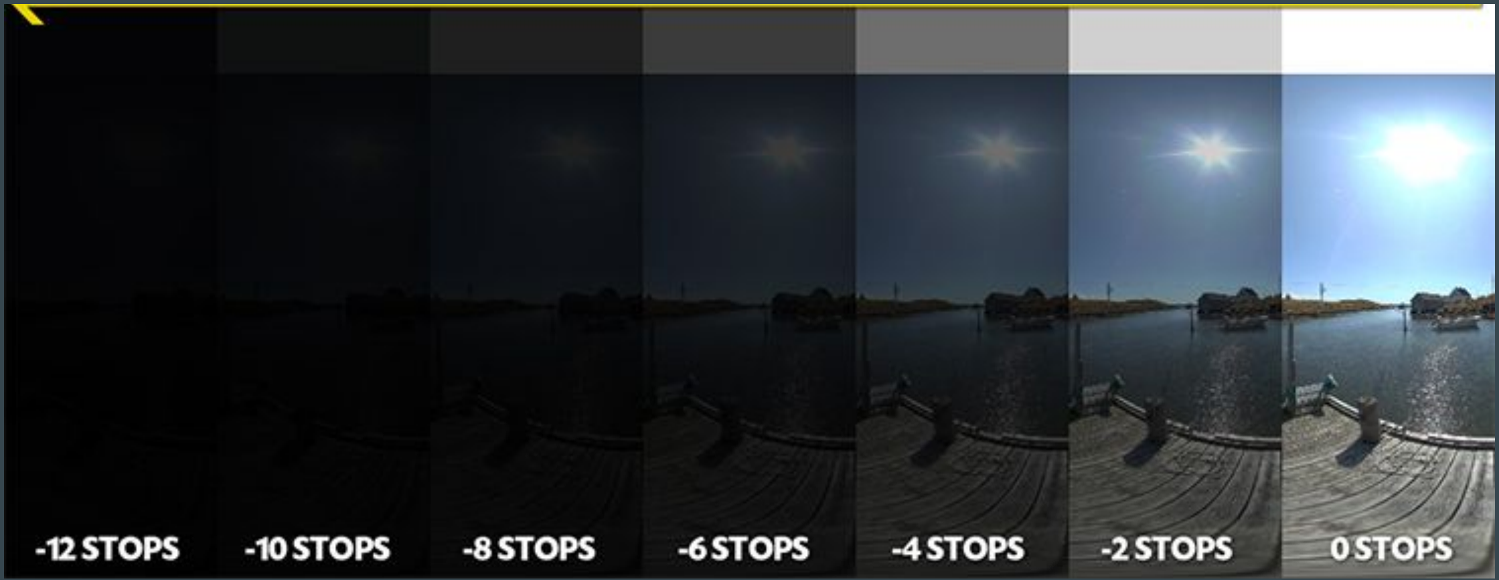
https://www.slrlounge.com/iphone-5-vs-iphone-4s-low-light-comparison-and-review-by-austin-mann/

What causes noise?

- The imperfections of the camera
  - Read noise
  - Bias
  - Hot pixels
- The physical properties of photons and electrons
  - Shot noise, see also
- Your camera and ambient temperature
  - Thermal noise
- Cosmic radiation
- Air glow
- Light pollution

Dynamic Range

“The range in which a camera can capture the brightest and darkest spots of an image without loss of detail” (source)



So how do we collect more light?

Use a more sensitive camera or a higher sensitivity setting?

- Misconception: higher ISO does not mean more noise in your photo!
  - ISO is an amplification applied by the camera after data collection - the sensor itself is not changing to become more or less sensitive!
  - Increasing ISO increases SNR up until a point, after which the read noise added by more ISO amplification decreases your SNR
    - This change is small compared to how other settings affect SNR
- **For astrophotography, you must select your ISO to maximize your dynamic range**
- We also take more photos and combine them to improve SNR (sqrt(N))

Read more

Recap

Collect more light and have a higher signal-to-noise (SNR) ratio

Recap

Collect more light and have a higher signal-to-noise ratio (SNR)

So how do we actually do that?

First, you have to gather some light.

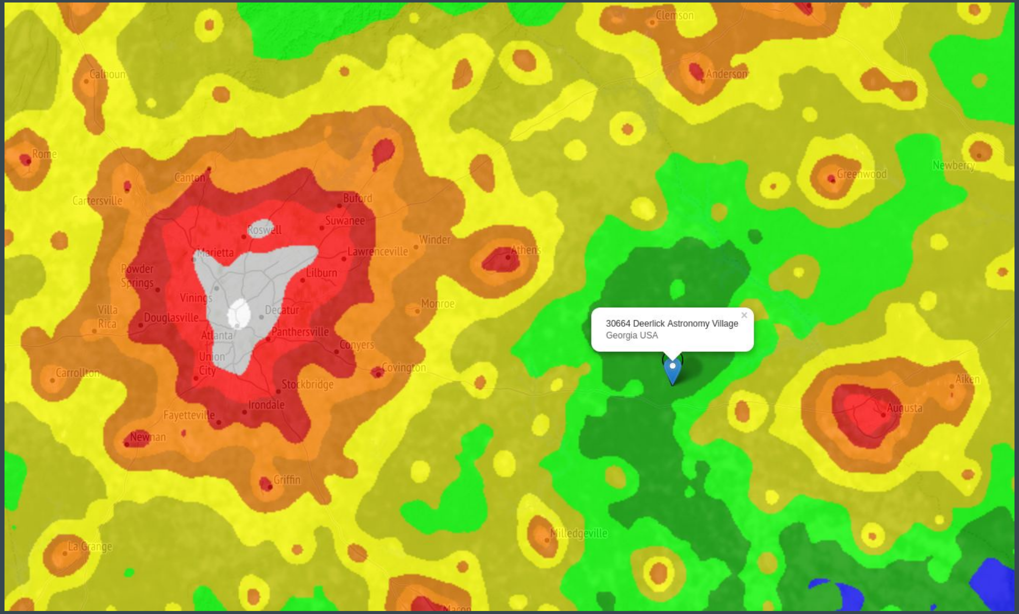
These tips apply to every method of capturing night sky photos

- Get a camera that allows you to modify the settings
- Use a sturdy tripod
- Remote shutters are important, headphones work just fine for phones

Going to a dark site

To avoid light pollution (a form of noise), head to a dark site

- Use a map to find a dark location near you (aim for green and better)
  - Be familiar with the Bortle Scale
- Check the weather
  - ClearDarkSky
  - National Weather Service
  - Weather.com, AccuWeather
  - Windy.com for seeing conditions
  - Meteoblue
- Deerlick Astronomy Village!



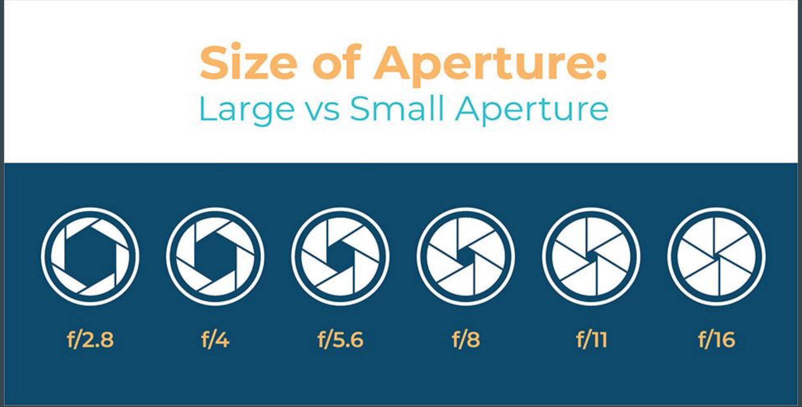
Planning your targets

Traveling to a dark site isn't helpful if you go during a full moon, or when your target isn't visible in the night sky

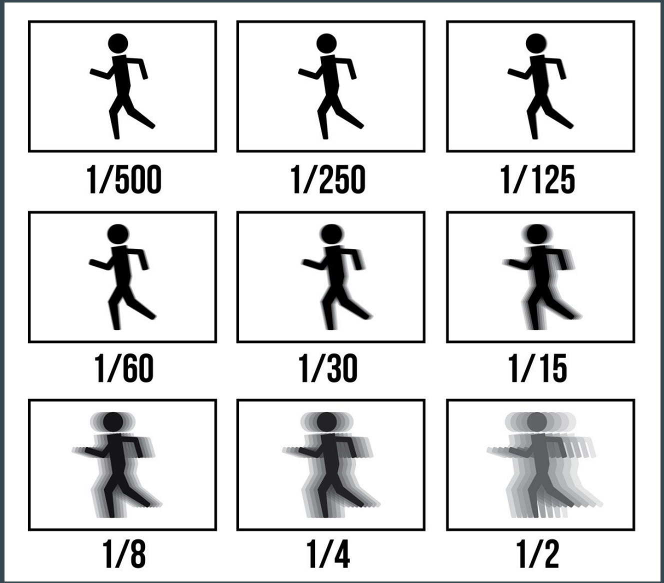
- Milky Way season is the late spring, summer, and early fall
- Planets are low right now, and primarily near the Milky Way (Saturn, Jupiter)
- Lunar Calendar
- Astronomical Twilight information and map
- Stellarium - your free, open source personal planetarium
- Phone apps - SkySafari, StarWalk, etc.

Determine your camera settings

- Settings can vary significantly between devices, but there are some general rules
- Aperture - how open your lens is
- Shutter speed - how long your lens is open for
- ISO - post capture gain applied to your image



https://photographylife.com/what-is-aperture-in-photography



https://www.creativelive.com/photography-guides/what-is-shutter-speed

How long can you expose for (shutter speed)?

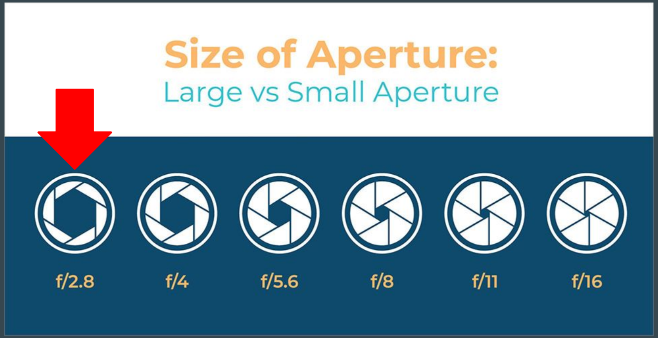
- With a regular tripod, you are limited by the movement the of the stars across the night sky
  - **You want pinpoint stars**
  - 500 rule for full frame sensors: (500/focal length) seconds of exposure
  - 300 rule for APS-C crop sensors (entry level DSLRs): (300/focal length) seconds
  - Generally, it’s 500/(focal length)/(crop factor) seconds, try this calculator

- Typically, 30 seconds <= exposure time <= 10 seconds
  - Anything with a long enough focal length to require 10 second exposures you probably want to consider tracking, and lenses with short enough focal lengths for >30 seconds are prohibitively expensive
- If you’re unsure, try 20 seconds and see if your stars have trails!

What aperture?

All the way open, you want the most light possible to enter through the lens. The widest aperture is the lowest number (f/1.8 collects more light than f/3.5)

The only exception is a "fast" lens (such as a f/1.8 35mm Nikkor) - stopping down your lens can achieve better focus, limit spherical aberration, and lessen vignetting and you're already collecting light fast enough, even at f/2.0



https://photographylife.com/what-is-aperture-in-photography

What ISO?

As mentioned earlier, we are searching for an ISO to **maximize dynamic range**

- Consult a chart (linked at the top of the page) for your camera
- When in doubt, ISO 1600 or even up to ISO 3200 is a good bet for most DSLRs and will provide a nice Milky Way picture out of the camera
- For other cameras, like cell phones, it is harder to say
    - I would go with something like ISO 800 to start

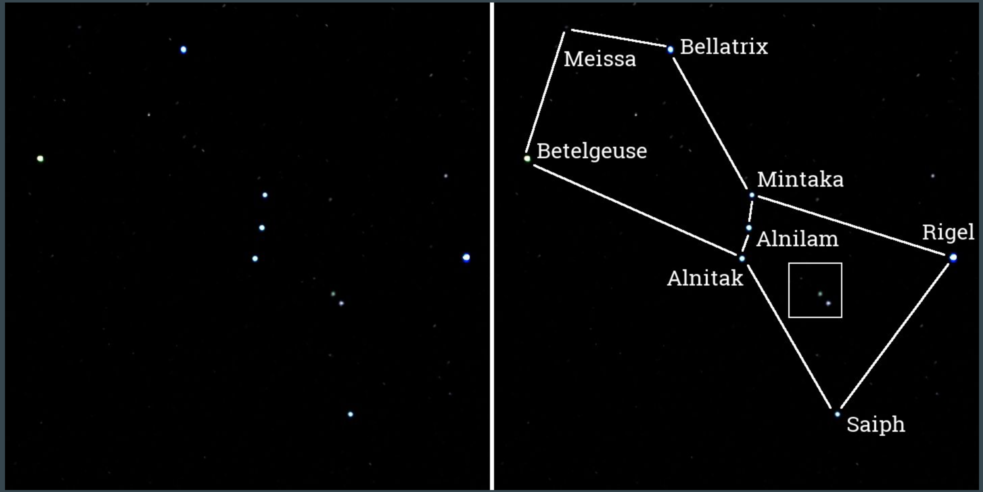
Obtaining focus

An often overlooked but arguably the most important part of night sky photography, and not easy either

- Use a bright star to focus in **manual focus mode**
    - **Do not assume your focus is at infinity**! It is a good starting place, but it's not infinity!
- Use your camera's live view, zoom all the way in and rotate your focus back and forth to look for the best, most sharp version of your star
- If you do not have live view, get close to focus with the viewfinder then take a picture and keep trying to get better focus
    - This will take some patience, but it is **extremely** important - bad focus will completely ruin your shot and there's nothing you can do about it in post processing!

What gear can you use?

What gear can you use?



What gear can you use?

What gear can you use?

What gear can you use?

What gear can you use?

What gear can you use?

??

Phone cameras

- Find your camera's manual mode or get an app (or any of these) to do it
- Expect lots of hot pixels and lots of noise!

Handheld on a Pixel 3 with night sight

Tripod mounted iPhone 5 with SlowShutter

Compact camera, GoPros, etc

- Same premise, except with a little more freedom (potentially)
  - How long the shutter can stay open could be limited by firmware
- An old compact camera on a tripod can get you a lot further than you think, especially with some post-production editing

DSLRs

Get a sturdy tripod, a remote shutter, and your 18-55mm kit lens

- Set it to 18mm, f/3.5, 20 second exposure, ISO 1600 and fire away!

https://www.dpreview.com/products/nikon/slrs/nikon_d5500

So how do we actually do that?

Then, you have to work with your data to improve SNR.

- When you can't take longer exposures, you take more of them
- SNR increases linearly with exposure time and sqrt(N) with N number of pictures taken
  - Ensure you're maxing out exposure time first, then take a bunch of pictures!
  - Stacking reduces **random noise**

Stacking

To combine all those images you took, we need to stack them

- Stacking is essentially an average
  - Images have random noise and pattern/repeatable noise
    - Reduce pattern/repeatable noises with dark frames and other types of calibration frames
    - Reduce random noise by taking more pictures
  - Any pixel that is randomly noisy in one frame will likely be not randomly noisy in another, so it's value becomes an outlier and will be averaged out
- For basic night sky photography, you only have to worry about stacking
  - Forget about calibration frames for now, that's a discussion for a future presentation
  - This works good enough for Milky Way photos and star trails, since the targets are bright and so the SNR is already high

Stacking

There are many tutorials

- Lonely Speck: Milky Way stacking (manually doing it in Photoshop is not advisable, see 2nd slide vs 3rd slide picture)
- DeepSkyStacker: a basic how-to
- AstroBackyard introduction to astrophotography
- PetaPixel: stacking Milky Way using Starry Landscape Stacker
- Sequator (I have not tested this but I have heard good things)

This requires a lot of trial and error, and we can cover a workflow example at a later date if there is interest. But first, go out and capture some data!

Stretching

This is the first in the process of turning a basic astrophoto into a finished masterpiece

Resources - SNR

- Types of noise

References - Stacking

References - Milky Way Photography

References - Generally good sources of information