

Astrophotography Without a Telescope – Summary Notes

by Mary McIntyre

If you are new to photographing the night sky, it's worth downloading Stellarium on your computer, tablet or phone. It is a planetarium software and once you've selected your location, you can enter a date and time and it will show you where things are in the sky. You can turn on constellation lines and labels to help you to find the constellations and it will show you where the Moon and planets are and where the band of the Milky Way is. It's free and easy to use and it will help you to plan your photography sessions.

Basic equipment you need:

- Camera
- Tripod
- Remote shutter cable
- Intervalometer
- For long imaging sessions, pocket hand warmers & an old sock!
- A mains power cable is helpful if you're shooting for very long periods

Get familiar with your camera! Read the manual. Then:

- Practice changing settings in the dark or with your eyes closed
- Practice removing & re-attaching the camera to the tripod
- Practice getting the focus right

Settings:

- Lowest f number possible to let in the most light. If you have a lens that can go down to very low f/numbers, be aware that it can introduce noise with budget cameras. When I use the 50mm lens I don't go below f/2.2
- ISO setting appropriate for local conditions, allowing for light pollution, moonlight, humidity, etc. With budget cameras an ISO higher than 1600 may introduce more noise. Remember that pushing up your ISO will capture more of you don't want as well as what you, so do your test shots. Almost everything I do is at ISO-800 or 1600.
- If using a static tripod, shutter speed depends on focal length

For a rough guide, use the "Rule of 500s":

$$500/\text{focal length} = \text{length of time in seconds before trailing (for a full frame camera)}$$

Eg 1: If you are using a focal length of 10mm:

$$500/10 = 50 \text{ seconds exposure}$$

Eg 2: If you are using a length of 50mm:

$$500/50 = 10 \text{ seconds exposure}$$

Eg 3: If you are using a 300mm lens:

$$500/300 = 1.6 \text{ seconds}$$

This figure is a starting point for your test shots but remember that stars closer to the north celestial pole move less distance in a given time than the stars near to the celestial equator. For us in the UK, that means if you're pointing your camera south you'll need to keep your exposures shorter than if you're pointing north. Additionally if your camera has a cropped sensor, you will need to reduce the exposure time. Unless you're trying to capture star trails, you need to keep the exposures short enough that you don't have trailing stars in your photos, so always do test shots first and zoom in to check for trailing.

The table below shows some examples of shutter speeds that should work for some example focal lengths, but still always review your test shots.

Focal length	Cropped Sensor	Full Frame
10mm	25 seconds	37.5 seconds
18mm	20 seconds	32 seconds
50mm	10 seconds	12 seconds

If you have a tracking mount you can do much longer exposures but from many parts of the UK light pollution makes longer exposures difficult.

Shooting the Photos:

- Camera should be set to RAW for most astrophotography, but there are times when highest quality jpeg is fine
- Use remote shutter cable or intervalometer to prevent camera shake
- If you can't use a shutter cable, then utilize the timer delay function to allow the camera to stop shaking before the shutter opens
- Take lots of test shots first and review to check for position & star trailing, etc
- If you're imaging for a long time, prevent dew from forming on the lens using the sock and hand warmers. This is a low tech option that is lightweight and needs no batteries, but long term it's worth investing in a dew heater

Shooting Star Trails:

- Star trails are one of the easiest things to produce because it's the one time you actually want to get trailing stars!
- Decide on your framing; if you want concentric rings you need to have Polaris in frame. This star is located 52 degrees above the northern horizon and the two stars on the outer edge of the bowl of The Plough point at it
- Shooting one long exposure on bulb setting at low ISO is not ideal because it gives a very washed out result
- It's better to take lots of 30 second exposures (or 15 seconds if that's your camera's maximum) on continuous shooting then use free software such as StarStax or Sequator to stack them together
- If you save the cumulative files in StarStax, you can make a timelapse video. I made a You Tube video on this
 - <https://youtu.be/yrzNp6flb8E?si=VI7sDuX2ij1FV2i4>

Shooting Constellation and conjunctions:

- Some constellations are only visible at certain times of the year, others are visible all year round but their position will be different from season to season. Use Stellarium to check the position of the constellations and any objects in conjunction with them

- Most constellations are best photographed using a short focal length, so use anything from 10mm to 55mm but if you are photographing a close conjunction where two objects are really close together, you can use a zoom lens
- Use highest ISO setting to do your test shots & get framing correct
- Select best ISO for your light levels. Go lower if there is a lot of light pollution or a Full Moon, higher if dark sky site. If your camera suffers from a lot of noise, avoid going above ISO-1600. If you want to preserve star colour, try a lower ISO such as ISO-800
- Select shutter speed according to focal length and position of constellation; remember – you can shoot for longer if you’re pointing towards the north celestial pole – ie the Pole Star, but shorter if you’re pointing south
- Review photos to check for star trailing
- If the Moon is part of the conjunction, use shorter exposures if you want to keep the detail on the Moon’s surface. If you have a crescent moon you can do longer exposures to get earthshine

Shooting the Milky Way:

- The region of Milky Way towards the galactic core is only visible low in the southern sky during July/August. Whilst this part is beautiful, other parts of the Milky Way are visible all year round and are still lovely to photograph
- For best results, you need as dark a sky as possible with no moonlight to interfere
- Using a “fast” lens which lets you get down to a lower f/number will vastly improve your results. The fixed 50mm lenses are excellent as they go down to f/1.8 but they only photograph a small region of the Milky Way. A wide angled lens will let you capture more of it
- To fit in the entire arch of the Milky Way you can take overlapping photos and stitch them together – I use Microsoft ICE. When stitching I get better results if I shoot with a 10mm lens and the capture in portrait orientation, overlapping by about a third, then apply a lens distortion correction in Lightroom before stitching. This removes vignetting and helps to prevent shadows where the images overlap
- Long exposures are better but aren’t always possible due to light pollution, but you can take several identical shots and stack them to give a longer total exposure time that will not only help to bring out more detail but will also reduce noise. Sequator is the free stacking software I use for Milky Way stacking and I love the results it gives. I made a You Tube video explaining how I do it: <https://youtu.be/KPeyi4hZgfg?si=LCFuacD3OiewO4QZ>
- A tracking mount allows you to shoot longer exposures, but be aware that you may also capture more light pollution in longer exposures, so unless you live somewhere very dark, don’t worry about investing in a tracking mount. Also a long exposure will blur your foreground!
- Good processing techniques will help to make the best of your shots. Basic levels and curves adjustments bring out the detail and the Lightroom adjustment brush is excellent for selecting only the Milky Way part of your image and then process just those parts without destroying your background sky. If you’ve been shooting from a dark sky location just levels and curves adjustments will do the job. I use Fast Stone Image Viewer for this – it’s free of charge and very easy to use
- Remember that some regions of the Milky Way are not visible from the UK so we cannot replicate some of the images we see online

Shooting Meteors:

- Meteors are random, and may occur at any time
- Best chance of photographing them is during a meteor shower. The showers are named after the constellation that the shower radiant lies; this is a patch of sky that all meteors belonging to that shower appear to originate from but the meteors may appear anywhere in the sky

- Point camera 45 degrees up, at least 45 degrees away from the radiant because meteors have longer, brighter trails further away from the radiant. Stellarium has all the main shower radiants marked on the sky map
- Keep ISO as high as light conditions will allow, shoot continuous 8 - 10 second exposures. If you capture a bright meteor keep shooting because you may catch the ionisation cloud left behind!
- Try to record times of meteors you see to assist you later
- If you keep the camera pointing in the same direction taking photos for a long period of time, you can also use the images to create timelapses, star trails and other things. I made a video about things you can do with your meteor shower photos here:
 - <https://youtu.be/y0c4uLyZxd8?si=DJLbD6FpVPrVd2o9>

Principle Annual Meteor Showers (there are many other minor showers too!):

- Quadrantids January 1st – 6th
- Perseids July 17th – Aug 24th
- Orionids October 14th – 31st
- Geminids December 7th – 16th

Shooting Aurora:

- Faint aurora displays happen quite often from mid-latitudes, especially when we're at the maximum point of the Sun's activity cycle
- Download an aurora notifier app for your phone I use the Glendale App which you can get from their website – details are with the list of download links at the end. You can also monitor www.spaceweather.com
- Point your camera north, and shoot around ISO-800 or 1600 for between 5 and 15 seconds depending on how bright the aurora display is. Remember that aurora is not static so during very active displays you will get better results doing shorter exposures. If you shoot a sequence of photos it will make a fantastic timelapse video!
- Leave your camera and let eyes become dark adapted so you can see the faint aurora as well as shooting it. To the naked eye aurora has very little colour so don't expect to see dayglow fireworks!

Shooting With a Zoom Lens:

- All the principles are the same, except you need to reduce your shutter speed accordingly (remember your rule of 500s!). With a static tripod you may only be able to take 1.6 second exposures but that's enough for bright star clusters, brighter nebulae such as M42 the Orion Nebula, conjunctions of the Moon + a planet, a planet + star cluster, the Moon + star cluster, etc.
- You can easily photograph detail on the Moon with short exposures, capture aircraft transits of the Moon, lunar occultations of a star or planet (when the Moon passes in front of the star or planet). You can also photograph the four brightest moons in orbit around Jupiter with a Zoom lens
- If you have a tracking mount you can then push your exposures up to capture fainter objects but if you don't have that you can take lots of identical images and stack them to give a longer total exposure time. This will increase detail and reduce noise

Shooting With a Bridge Camera:

- Features will vary from camera to camera but there are some useful presets
- Very good for doing wide field night sky shots & daytime optical phenomenon
- Can utilize the optical and digital zoom for excellent close up Moon photos
- Not as much manual control over the settings
- When choosing a camera, beware that a larger zoom doesn't necessarily mean a bigger picture; it also depends on chip size

- Friends of mine have used Nikon Coolpix, Canon SX50 and Lumix bridge cameras and have achieved great results

Image Stacking:

Once you have got comfortable with taking single shots, you can improve your Milky Way and Moon photos by image stacking. Stacking involves taking lots of identical photos then using software to digitally bring them together. It increases the signal to noise ratio, which means more detail on your object with less background noise.

- For the Moon I use Autostacker! 3 – raw files need to be converted into TIFFs
- For the Milky Way I use Sequator. This software has many excellent features, including a foreground freezing option and light pollution removal. I cover this in the You Tube tutorial I linked above.
- For star trails I use Sequator or StarStaX
- It's better to stack fewer, high quality images. If you put junk in, you'll get junk out!

Calibration Frames:

- If your camera is older, even with image stacking you can encounter noise on your Milky Way and star trails photos. One way to help reduce this is to shoot dark frames which capture a photo of the dark signal noise from your camera. Noise is random from image to image, so the software will take an average and subtract it from your photos. Noise will vary with temperature so it's good practice to shoot 10-15 dark frames at the end of each imaging session, otherwise you may remove too much or too little from your images. In addition to removing noise it helps to reduce hot/cold/dead pixels
- They are easy to do; simply put the lens cap on and make sure the view-finder is covered, then take some photos with the same camera settings
- When you stack, you add the dark frames and the software will create a "master dark" which is basically an average noise frame that is then subtracted from each of your photos, and that will make them smoother
- In most astronomy stacking software your photographs are called "lights" and dark calibration frames are called "darks". However, in Sequator the lights are called "star images" and darks are called "noise images"

Basic Processing:

- Processing of astronomy photos is just as important as taking the photos. At a glance it may not look like there is much in your photograph, especially in the output file after stacking, but the data is in there waiting to be pulled out
- Fast Stone Image Viewer is free and easy to use but has some amazing features. It's denoise function is brilliant, it has levels and curves, colour corrections, sharpening and much more.
- Lightroom is great, especially for batch processing because you can make adjustments to one image then paste those settings to all the other images in the set. This allows you to remove light pollution or remove noise from the entire set of images in seconds. The adjustment brush is also helpful to pull out Milky Way detail from images taken in light polluted areas
- Photoshop and Affinity are great for advanced processing, but for basic photography taken with just cameras and lenses, the free software is usually all you need

Basic Processing; What Do I Need To Do?

- Adjust the contrast to darken the sky
- Adjust the highlights to enhance stars
- Adjust the white balance to correct for light pollution
- A bit of sharpening and/or de-noising if needed
- Lunar Processing
 - Adjust the contrast to darken the maria regions

- Adjust the highlights to enhance craters & highland areas
- Adjust the colour saturation to enhance the colour differences in the basalt regions

Remember that less is more; over-processed images look unnatural, so make changes in small steps. When doing levels and curves adjustments it is better to make small changes and repeat the process 15 times than to do one big adjustment to the graphs.

Making changes to the graphs is called “stretching” the image. When you first open levels you will see a graph with a peak; this peak is where all of your data is and the first step is to drag the sliders across so that the peak is spread across the whole graph; do this via multiple small adjustments rather than one big one.

Levels before adjusting:



The goal is to move the black point and white point so that they straddle the peak of the graph:



Then move on to curves adjustments. Your data is represented by a the levels graph with a straight line graph on top. The black point at the bottom left and white point at the top right. You can drag parts of this line to anchor the bright points and dark points, then brighten only the mids to produce a sigmoid curve. Experiment with which parts of your image need to be brightened to pull out that faint detail. As with levels it's better to make small adjustments, exit the tab, and when you go back in the data will once again be a straight line. Repeat this step several times until you have pulled out the detail you need.

Curves before adjustment:



Curves after adjustment:



You can then do any additional processing such as denoising or colour correction to finish.

Hopefully these notes were helpful but feel free to contact me if you have specific questions. The software downloads are on the next page.

Mary

Software downloads:

Stellarium: <https://stellarium.org/>

StarStaX: <https://markus-enzweiler.de/software/starstax/>

PIPP: <https://web.archive.org/web/20230531163522/https://sites.google.com/site/astropipp/downloads>

Autostakkert! 3: <https://www.autostakkert.com/>

Sequator: <http://bit.ly/3sNafdt>

Fast Stone Image Viewer: <https://www.faststone.org/download.htm>

Glendale aurora alerts: <https://aurora-alerts.uk/>

iPhone users - you will find the Night Cap app is really helpful.

My friend Dave Eagle has self-published several astrophotography processing guides for different processing software. They include how to use Photoshop, Affinity Photo or Pixinsight and they're presented in an easy to understand and easy to follow format. You can find those here:

<https://www.star-gazing.co.uk/WebPage/shop/>

Email me: spiceyspiney@gmail.com

Visit my website and online shop: www.marymcintyreastrology.co.uk

Follow me on Facebook: www.facebook.com/marymcintyreastrology

Follow me on Twitter: @spicey_spiney

Follow me on Mastodon: <https://astrodon.social/@MaryMcIntyreAstro>

Follow me on Blue Sky: <https://bsky.app/profile/marymcintyreastro.bsky.social>

Follow me on Instagram: <https://www.instagram.com/spiceyspiney/>

Follow me on Flickr: https://www.flickr.com/photos/spicey_spiney/

You Tube: <https://www.youtube.com/user/Spiceyspiney>

Astronomy blogs/articles: <http://marysastronomyblogs.blogspot.com>