

Astrophotography

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Introduction

A brief introduction to the night sky – how does the sky move?

Techniques;

Cameras, focussing and exposures

Fixed tripod exposures

Equatorial (specialist) clock driven mount

Post Processing;

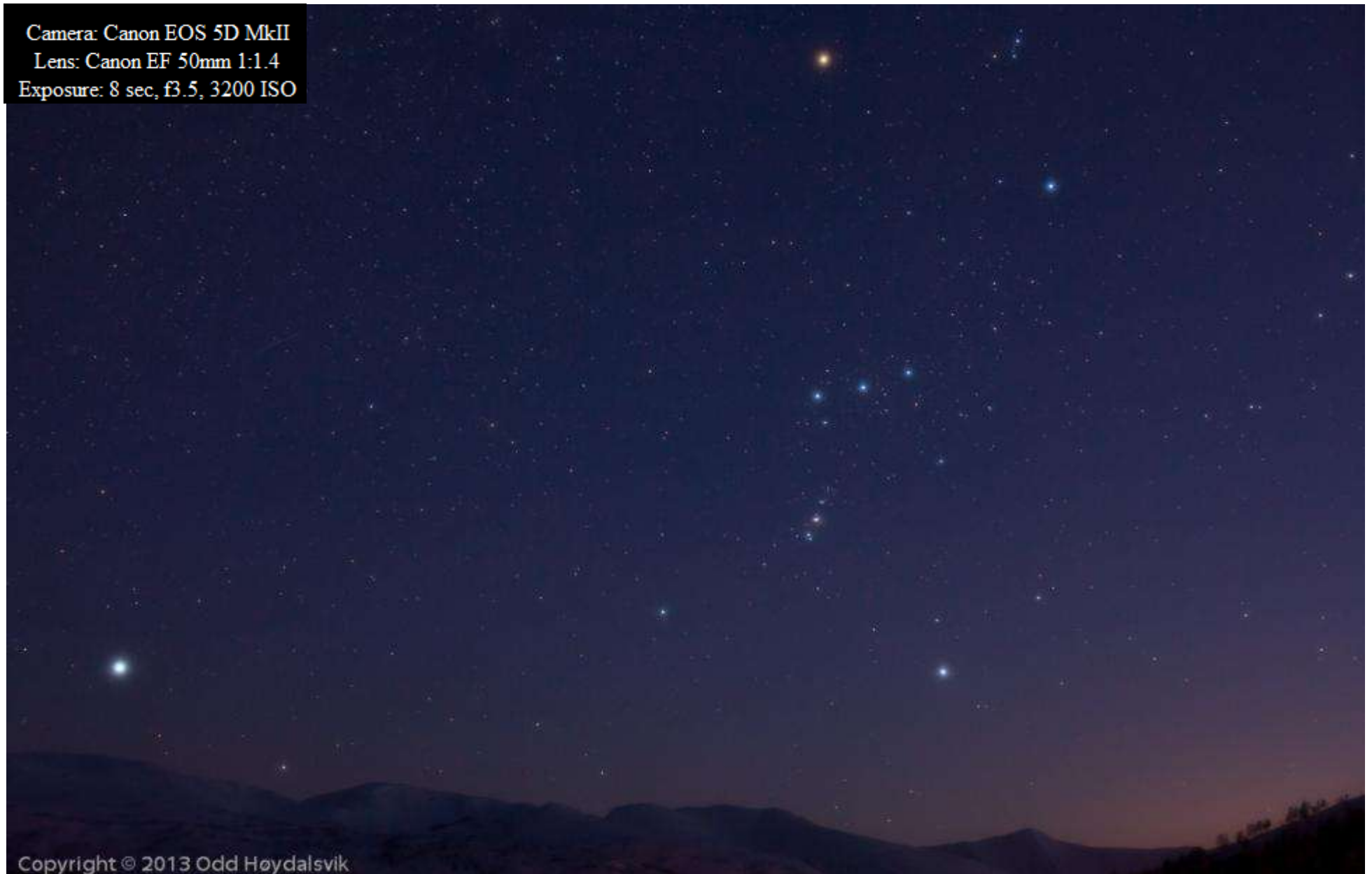
Stacking, dark fields, flat fields, bias, software/freeware!

Specials – videos/webcams for planets, Slideshow of examples

Golden Age of Amateur Astrophotography

1. DSLRs – fantastic, far better than film
2. Computerised or efficient electronic mounts
3. Easy post processing after the exposures, especially 'Stacking' of multiple digital images.

Do you recognise the constellation Orion?





Prolonged exposure (actually adding/stacking many short exposure images)



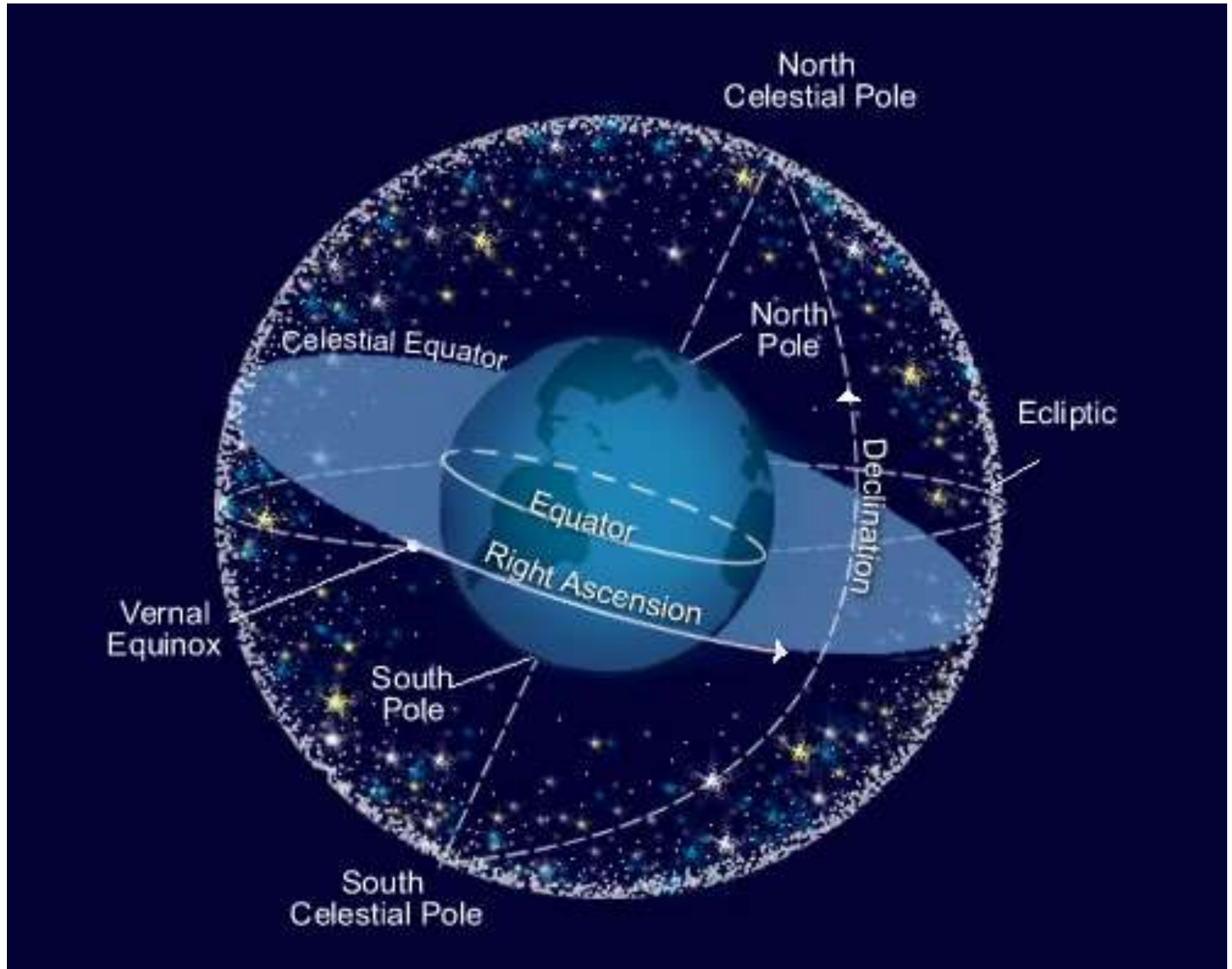
Ultralong Exposure – 200hours!!

Much Astrophotography is about collecting light from faint objects – long exposures

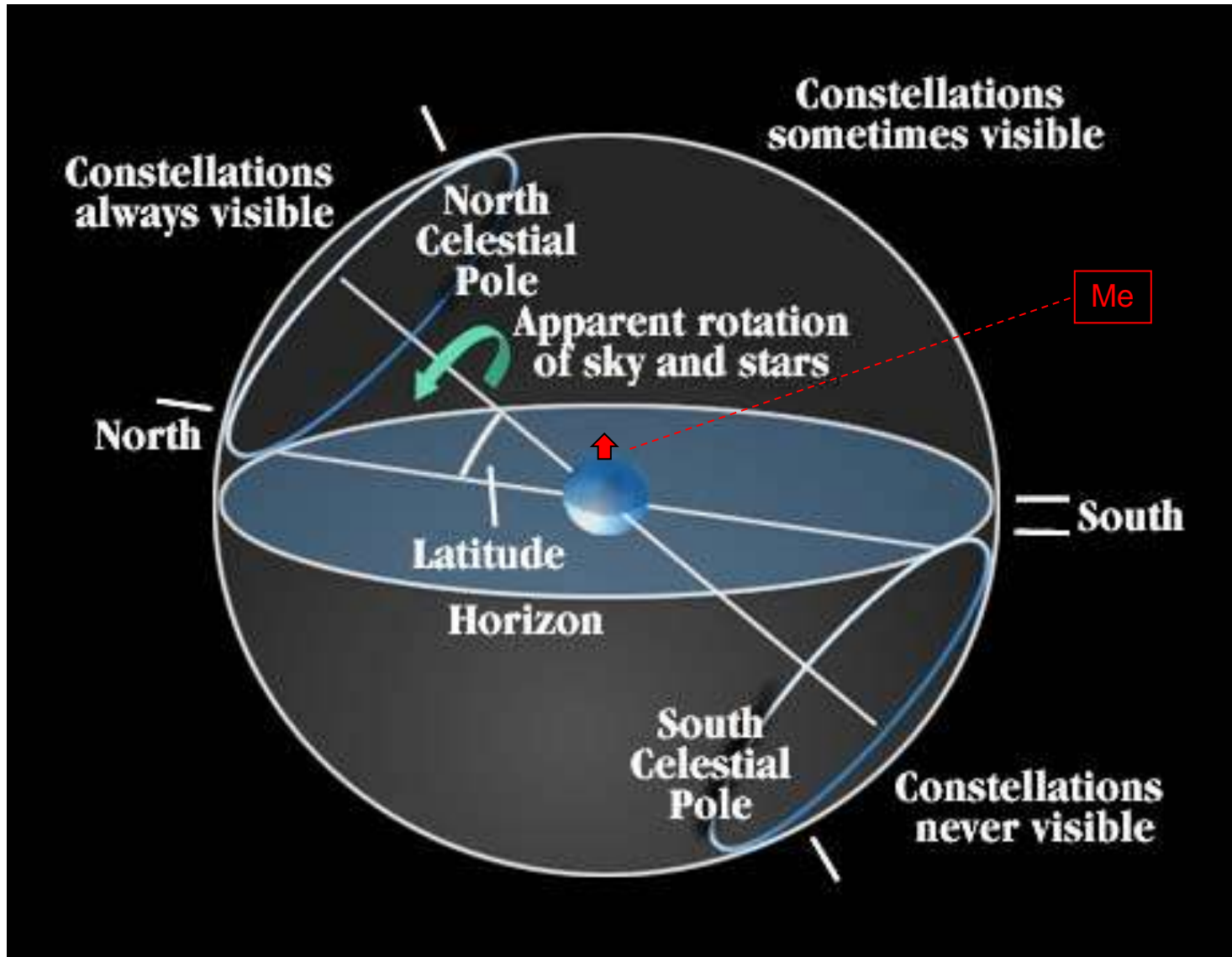
**How the sky appears to move and
how this affects exposures.**

**How to track the moving sky
(if you want to)**

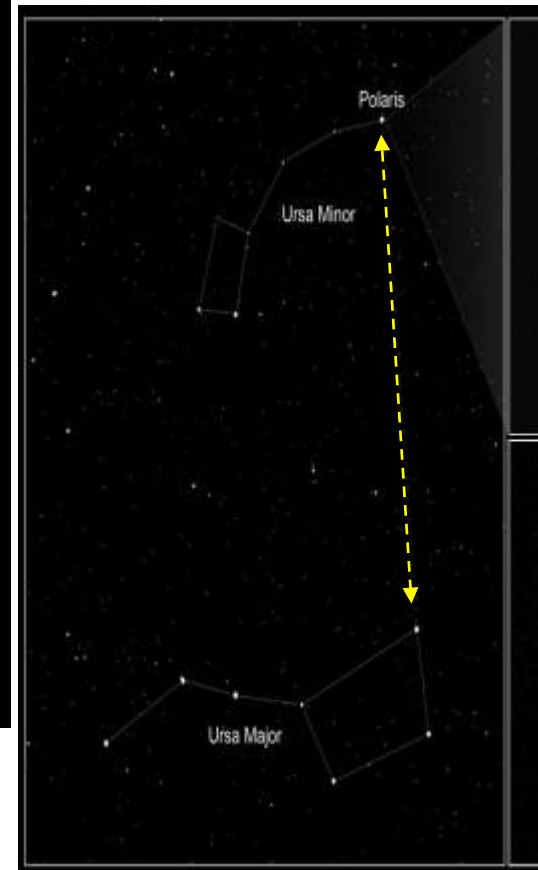
How to describe the sky that seems to rotate around us



Reinforcement!



<http://w.astro.berkeley.edu/~basri/astro10-03/lectures/CelestialSphere.htm>





Long exposure of stars in a northerly direction on a fixed tripod

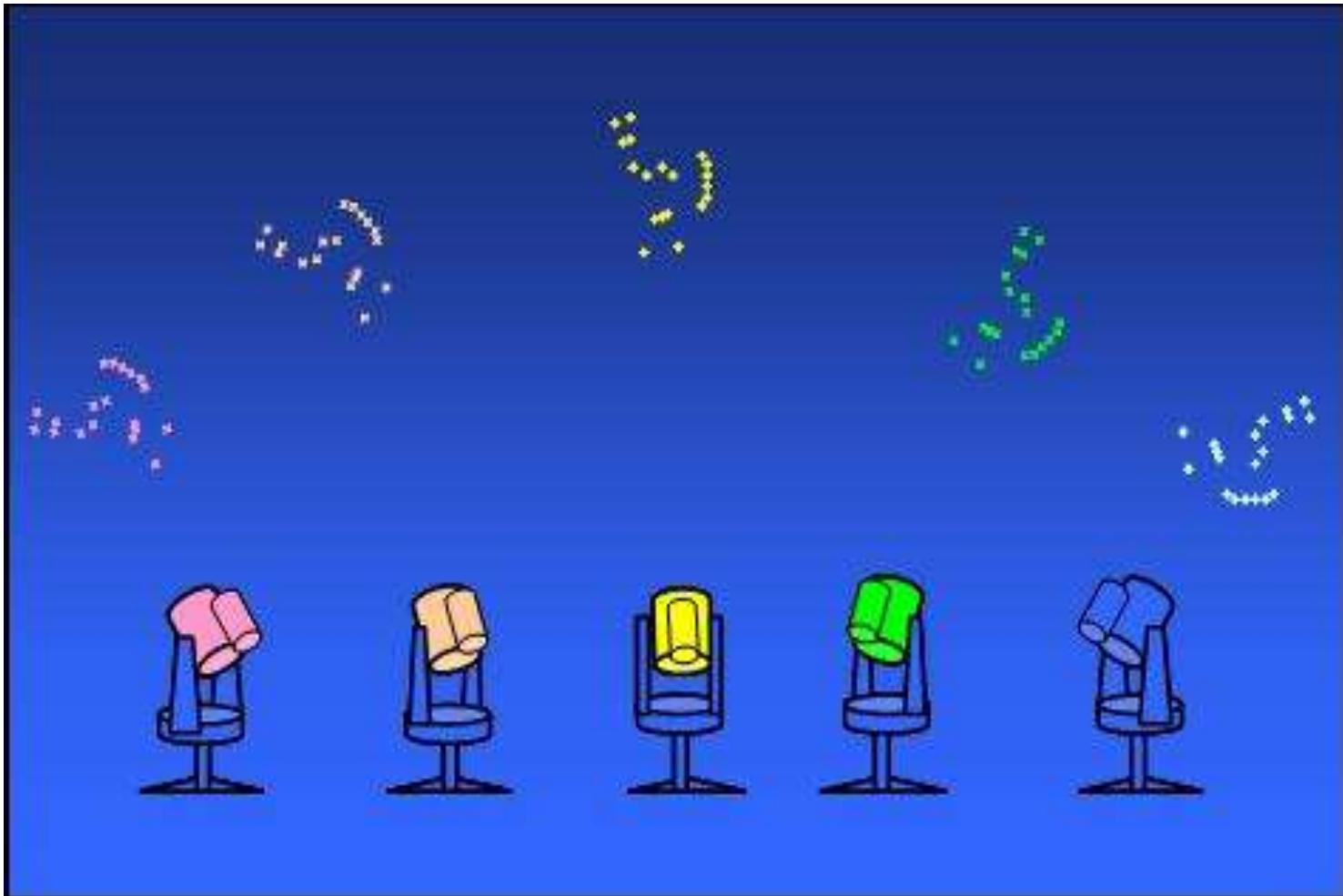
The sky goes around one circuit in nearly 24h.

Just like a clock (almost – 23h 56m).

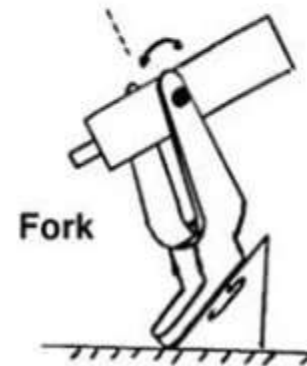
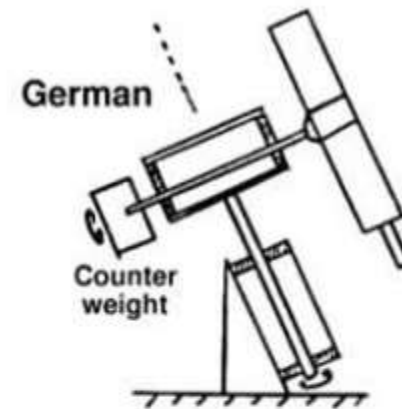
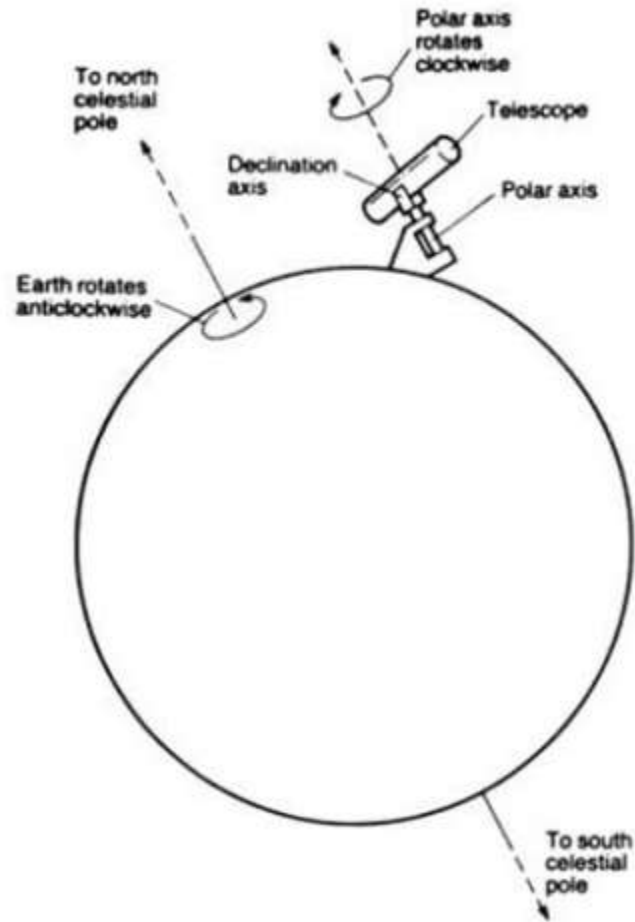
So stick a clock driven motor on a mount to follow the motion of the stars.

But it's a little more complicated as 'up' for the rotating 'sphere of stars' is really where the pole star is – at an angle to the vertical.

If you follow a pattern across the sky
with a simple mount driven by a clock motor, even
allowing for its curved motion (arc) across the sky then it
will appear to rotate in your picture frame – mount is
'Alt-Az' (Altitude-Azimuth)



You need an equatorial mount, where 'up' is pointing at the North Pole in the sky for prolonged exposures



Reinforcement!

Alt-Az (like a normal camera mount);
Equatorial Mount;

short exposures
long exposures

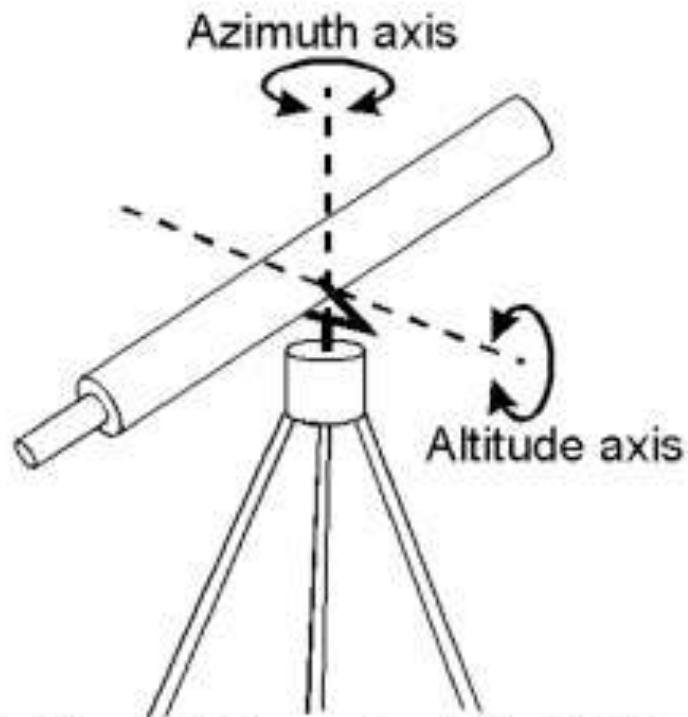


Illustration 1: Dobsonian (alt-Az) Mount

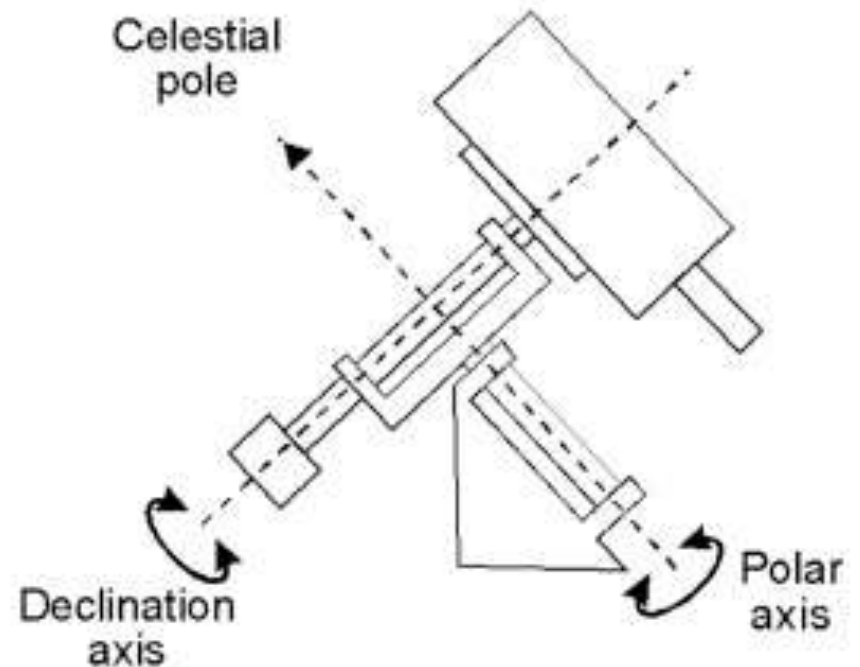


Illustration 2: Equatorial Mount

Equipment.

And your progression as an astrophotographer!

- Start with a camera and 50mm lens, on a fixed tripod/mount
- With experience consider attaching camera and standard lens to motor driven aligned mounts
- Then maybe use a telephoto lens ($>100\text{mm}$) or attach camera body to a telescope on a driven mount. Small field of view – good tracking required.

Note: Telescopes are simply large telephoto lens

Camera requirements summary



- Must be able to switch off automatic focussing
- Must be able to control exposure time, ISO sensitivity and lens aperture manually
- Best quality requires RAW images for download (*maybe JPEG initially while practising*)
- Remote trigger or cable for starting exposures
- Use a DSLR so you can change lenses or attach to a telescope
- Bulb setting (eventually) for long exposures

You will be downloading to a computer for post processing including stacking multiple images

ISO 1600-3200

50mm lens or less is good for widefield views of constellations

Open the lens aperture fully – and back off one stop

Focus with Infinity setting; or choose any really bright star and tape the adjustment! Don't autofocus.....

FIXED TRIPOD SHOTS



Make a 'dew shield' to protect the lens from misting over long exposures. Use a yoga mat and gaffer tape!

Can buy 12V heater strips too - only if you really get into it...



Star trails



Just 10 mins exposure or so

Longer star trails



Camera fixed on the ground. Total 2 hours exposure. Full Moon

Note: full moon is not the astrophotographers friend – unless you want a full moon shot



Some artistic effects.

It's easier to see colours in stars when de-focussed.

Here is a progressive de-focussing over a 15min exposure (total of several)

To get no visible star trails

Rule of Thumb

Exposure time(seconds)= 600/focal length(mm)

Example; 50mm lens, exposure = 12s

In practice, decent images may be obtained with up to twice that exposure time rule.

Also depends how near the north pole you target.

Single frame, Orion



No telescope. Single frame. Fixed tripod. 24mm f/4.5 ISO800 32s Wide angle => small trail

Consider the Plough. Fixed Tripod. Take about 70 images, about 8 seconds each. Just simply 'add' all the exposures on top of each other. Just like a 70x8sec single shot



The Plough, stacked properly



Stacking with pattern matching

Each of those 70 images was short enough not to have trails

So now process the same set of 70 images differently: the program matches the star patterns so that each image is twisted to sit exactly over the previous one - and add

Then we build up a long exposure without trails ...



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

Extreme example with one second exposures (3-4 seconds possible)

Orion



24mm f/4.0 ISO6400 205 x 10s = 34.2 minutes total 2015 Feb 9
Canon 5D2 on fixed tripod

Fly in the ointment – light pollution



Filters can help, especially for orange sodium street lights – but not for newer LEDs

Milky Way in Cygnus



No telescope. Fixed tripod. 24mm f/4.5 ISO6400 108 x 8s stacked = 14.4 minutes

The moon is easy with fixed tripod



Typical exposure for a full moon – 1/600s to 1/1000s.
So the largest telephoto or medium telescope will work here without tracking
But – high mag means turbulence or flickering is magnified - blurring



The moon is so bright that long telephotos or telescopes still only require short exposures with no 'trailing issues'

Eclipse of moon



About 1s exposure,
Depending on ISO
Fixed tripod

Telephoto OK

**Let's move on from fixed
to motorised mounts**

**Necessary for telephoto
lenses or telescopes**

Telephoto lenses



f is about 200mm or more

A is typically $f/4$ or worse - less light available

Small field of view (magnified)

Exposures very short to avoid trails for fixed camera

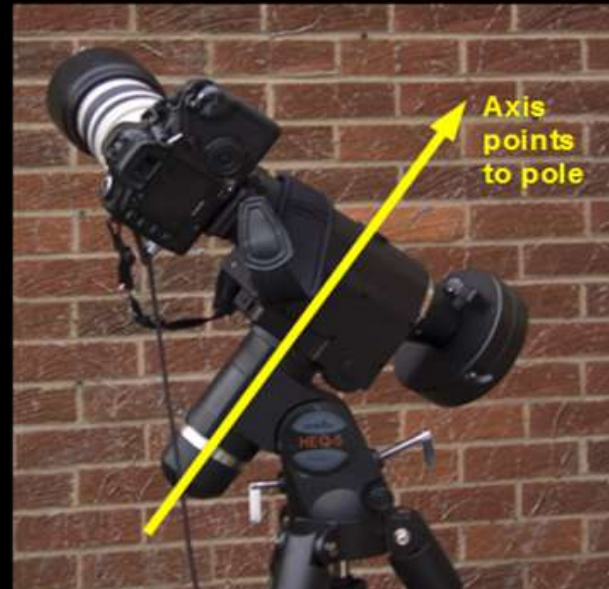
Need a motorised mount instead ...

With a small field of view, you now need to know the sky better to aim at what you want.

Camera on an equatorial mount

Motor follows the stars as the Earth rotates about its axis

Then we can use much longer exposures - a minute or more (but still stack)





3hr 20min (200 x 1min) @ ISO1600
Canon 40D w/ Canon 70-200mm f/2.8L II lens @ 200mm
f/4

(<http://www.cloudynights.com/topic/279754-andromeda-galaxy-m31-wide-field-with-70-200mm/>)

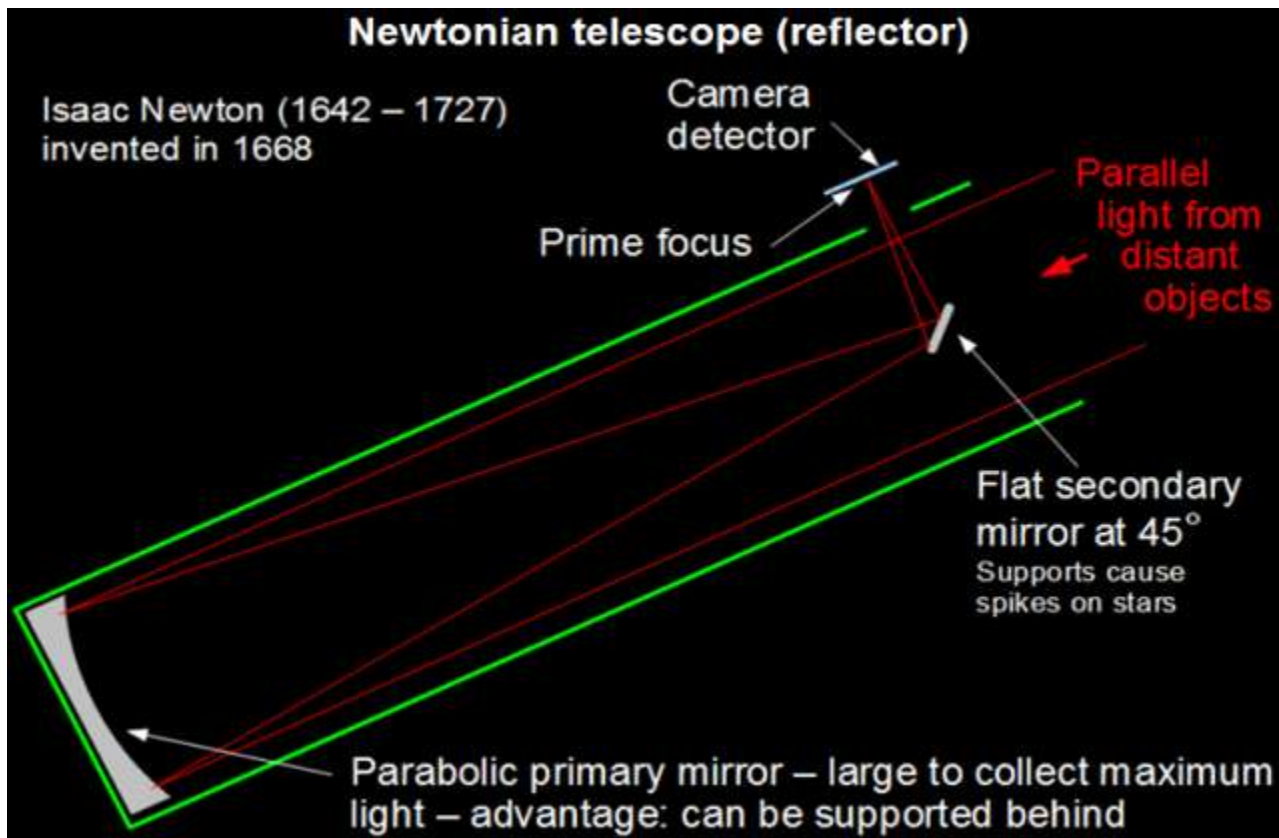
Everything so far is without a telescope.

You really don't need one to do astrophotography.

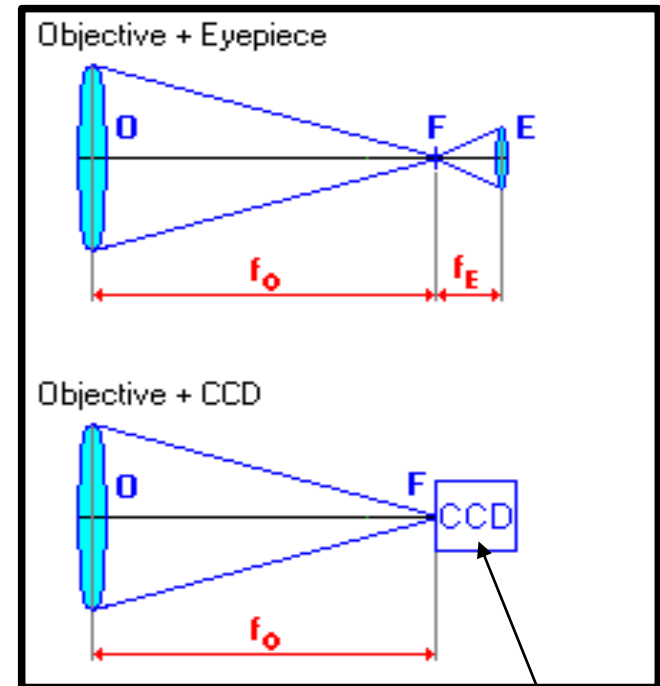
But.....If you remove the eyepiece from a telescope and fix the DSLR body (with its own lens removed) to the eyepiece end the telescope is just a big telephoto focussing onto the camera chip.

Maybe up to 2000mm focal length or more for standard amateur telescopes.

Leads to small field of view. Tougher tracking issues.



Refractor example



or DSLR

The overwhelmingly common approach is 'Prime Focus'

Telescope specifications

To a **photographer** my telescope is a 1200mm (focal length) f/4.8 mirror lens

To an **astronomer** it is a 254mm (aperture) f/4.8 Newtonian telescope

Astronomers are more concerned with aperture -
for collecting more light and
for better resolving power



Step 3- Attach to digital SLR.



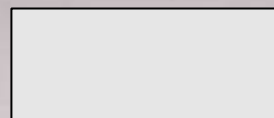
Step 4- Attach digital SLR to telescope.



The DSLR with t-adapter/t-ring assembly is inserted into the telescope eyepiece holder directly (i.e., no eyepieces, Barlows, etc are utilized). **Important tips:** tighten the telescope thumbscrew to the t-adapter securely. Also, be sure to attach the DSLR strap to the telescope in case the camera falls. I have actually had this happen a few times in the past, but my camera was spared since I strapped it

T thread has 42mm dia, x 0.75mm pitch; standard 42mm camera thread has 1mm pitch!

CAMERA



adaptor

telescope



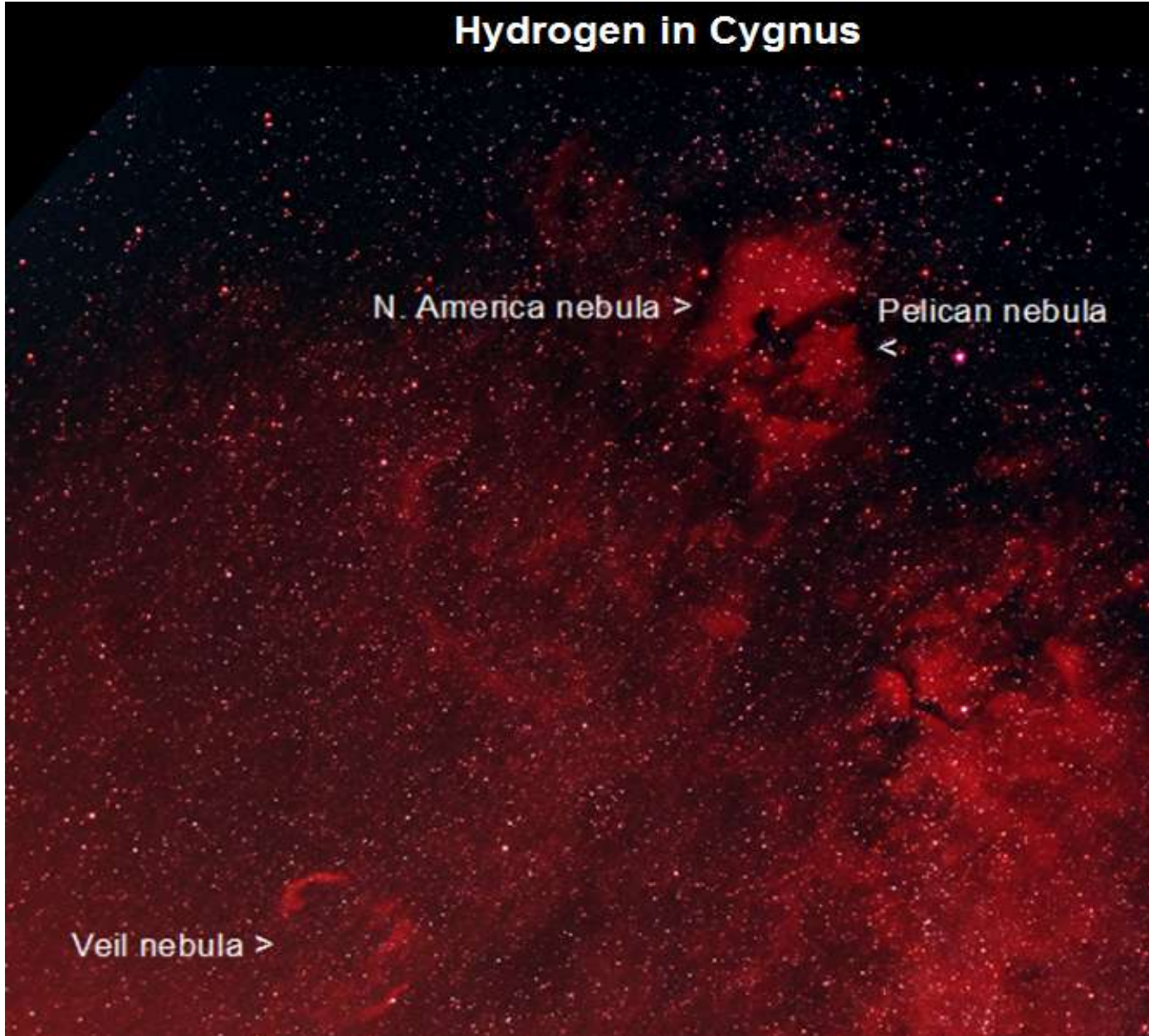


10 x 30s exposures (5min total) on a 1200mm FOCAL LENGTH 8" SCT TELESCOPE



Andromeda Galaxy (M31), 20 x 30s exposures, 1200mm focal length 8" dia SCT

Hydrogen in Cygnus



Advanced tip!

DSLRs have IR filters just before the CMOS chip.

Remove it/get it removed to show red H gas clouds easier. They are everywhere.

But you better be serious about astrophotography for that step.

Canon XXa series cameras include this option.

Post-processing

- The recommendation so far is to take some or many short exposures and add/stack them on top of each other.
- Alignment to the pole star is less critical for short exposures
- Many programmes online, some free, some not.
- Common and recommended freeware is;
'DeepSkyStacker'

<http://deepskystacker.free.fr/english/index.htm>



DeepSkyStacker

Introduction
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Screenshots
User's Manual
DeepSkyStacker Live
FAQ
How to create better images
Tutorials
Technical details
Wiki
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DeepSkyStacker

What is DeepSkyStacker?
DeepSkyStacker is a **freeware** for astrophotographers that simplifies all the pre-processing steps of deep sky pictures.

- Registering
- Stacking
- Simple post-stacking processes to quickly view the final result.
- Saving the resulting image to a TIFF or FITS file (16 or 32 bit)

After a shooting night you give all your pictures (light frames, darks frames, offset/bias frames, flat frames) to DeepSkyStacker and you go to bed. The next morning (or is it afternoon?) you can see the result and start post-processing.

If you can't wait, [DeepSkyStacker Live](#) is also available to watch the result of an ongoing imaging session being created as the images are downloaded from the CCD or DSLR.



If you want to translate DeepSkyStacker in another language [click here](#).
[Resource Localizer](#) is used to keep DeepSkyStacker available and synchronized in all the languages.

DeepSkyStacker: Main Features

- Automatic registration of a set of pictures
- Automatic detection of stars using all the picture area
- Preview of registered stars
- Sub pixel registration
- Automatic derotation

You can also align images in Photoshop (Select all images / auto align images, etc)

Post Processing

Quick run through of post processing activities.

None of these are critical but all will improve the final image;

- Dark Frames (same exposure as image but with lens cap on)
- Flat Frames (short exposure of uniform illumination)
- Shortest exposure dark frame (to capture electronic noise in chip – 'bias frame')

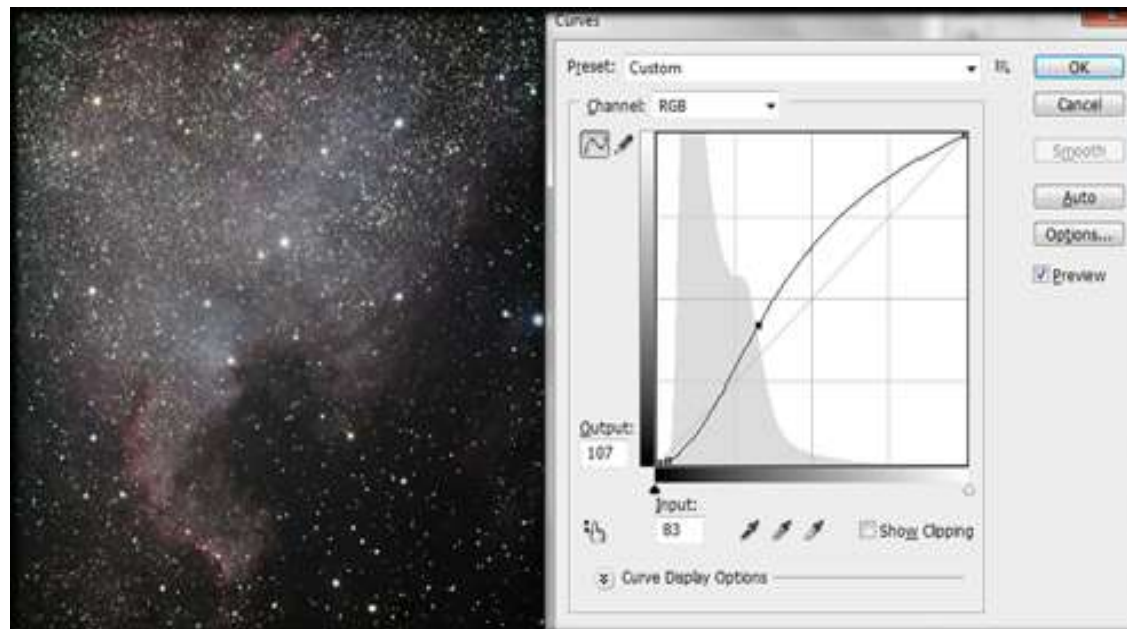
Post-processing programs will automatically use these image processing options

Post Processing

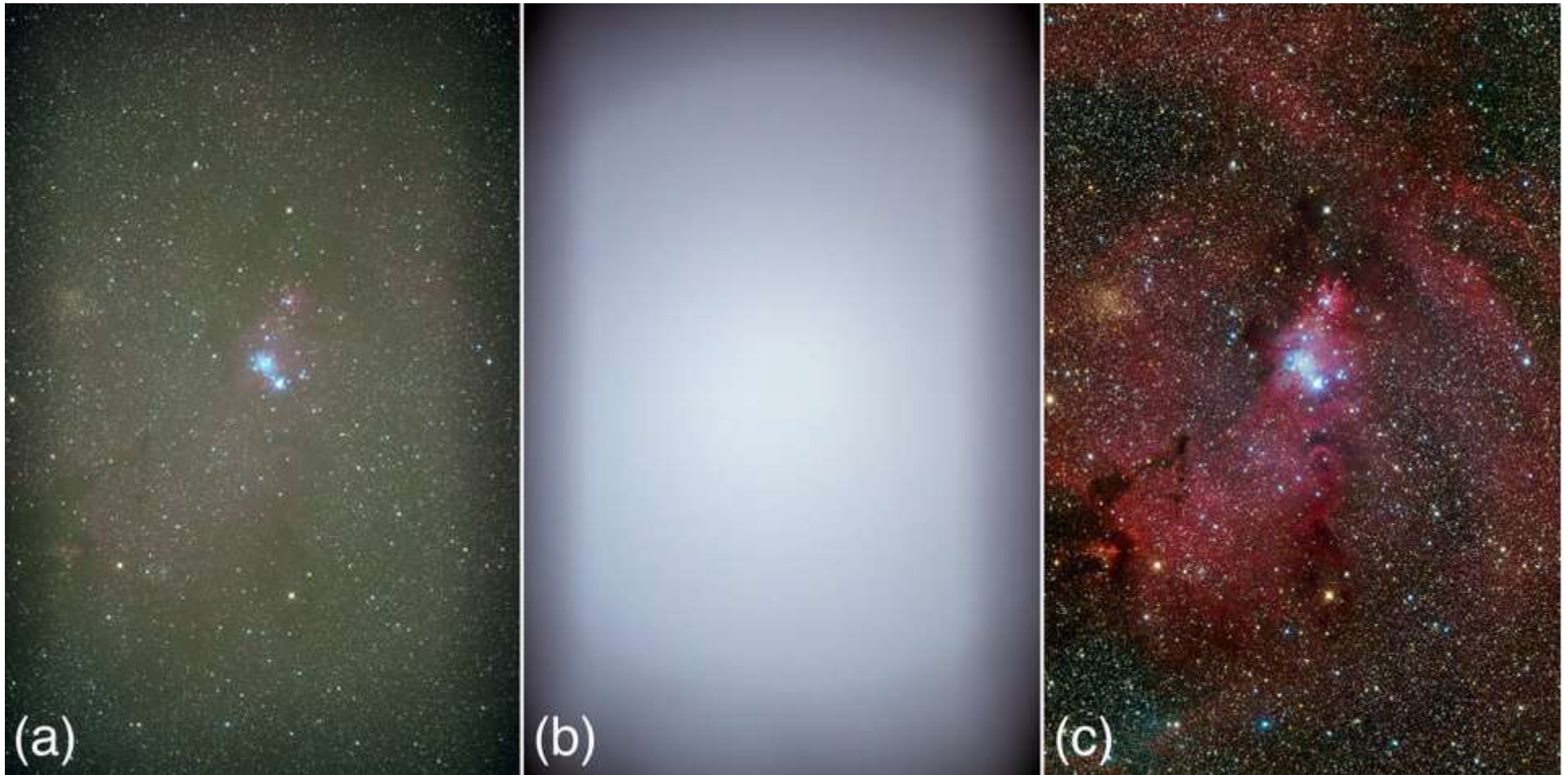
- Even after stacking most astro images will be low contrast and faint. Hard to over expose or saturate the image!
- Use 'stretching' options. Improve contrast and brightness. Remove noise. Unsharp mask?
- Play with colour options – not 'scientific' but definitely improves presentation!

Example of stretching

(even after stacking many images will be dark and 'linear' when opened in Photoshop – non-linear stretching brings out faint detail preferentially)



Example of Flat-Fielding an image



- (a) has some image processing but note the 'vignetting'
- (b) is a 'flat field (uniformly illuminated surface)'
- (c) application of the flat field to image (a) and further contrast improvement

Suggested Projects

1.

- Fixed Tripod.
- Point DSLR with 50mm lens (or less) at Orion.
- Focus at infinity.
- ISO=3200.
- Open lens to its widest f rating (and back one stop)
- Exposure time of 10s, repeat 30 times.
- Download JPEGs to PC and stack with Deepskystacker – maybe 1-2 Dark Frames too.

(preferably use a remote camera exposure switch/cable – mirror lock up option before exposure or ‘Live view’ to minimize ‘mirror lock up’ vibrations)

Suggested Projects

2. (Star Trails)

- Fixed Tripod.
- Point DSLR with 50mm lens (or less) towards the North Pole (north direction and up about 50 degrees)
- Focus at infinity.
- ISO=800.
- Open lens to its widest f rating (and back one stop)
- Single Exposure of about 1h
- Download single image for star trails circling the North Pole – pretty! De-focus?

(Needs dark sky as light pollution in a city will swamp image – hence lower ISO)

End of presentation concentrating on techniques

Have a look at some of the kit over the break

(not discussed inaccuracies in tracking motors for long exposures and how to correct (guidescope/guide camera, 'periodic error correction')