Astronomy

From Galileo to Spitzer and Beyond!

Syllabus

Week 1: Introduction. Beginning Astronomy. Naked eye viewing, finding your way in the (Northern hemisphere) sky, some interesting objects.

Week 2: Telescopes, history, types and use. Visual fields, understanding magnification, what sort of telescope to use for what sort of observation. Some minimal math.

Week 3: Basic physics. What are Stars, planets, asteroids, moons, comets, etc. What do we see in the night sky? What do we NOT see? What is our Galaxy?

Week 4: Telescope setup – how to get the most from your instruments.

Week 5: Local viewing – Moon and planets

Week 6: Stars, gas, dust and Pretty Pictures

Week 7: Looking at Deep-Sky Objects – Nebulae and Galaxies

Week 8: Astrophotography

Telescopes and Observing

Telescopes and Observing

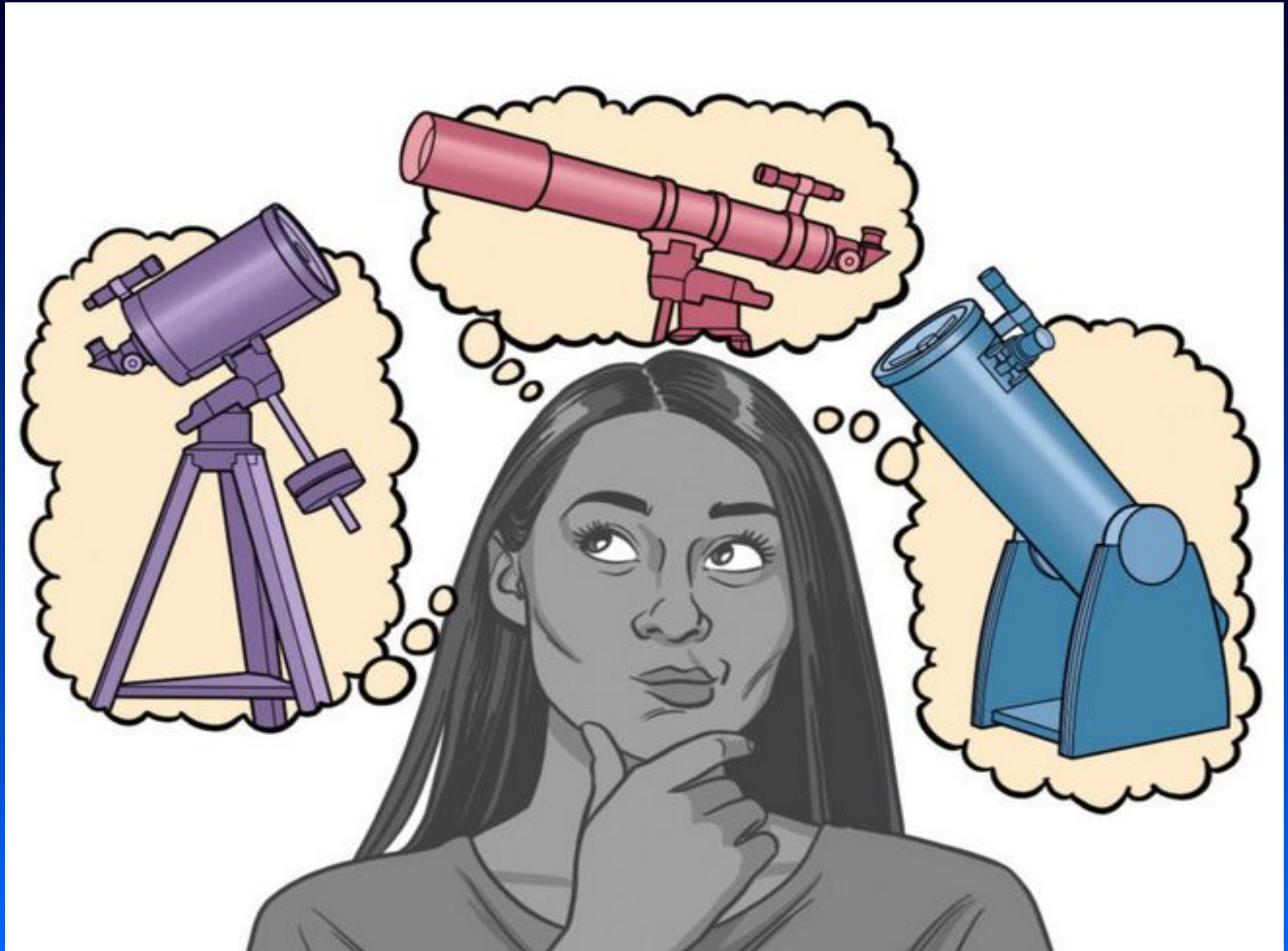

Image from Sky and Telescope, 25Jan2021

Telescopes and Observing

Two basic types of optical telescopes

- Refracting
- Reflecting

Telescopes and Observing

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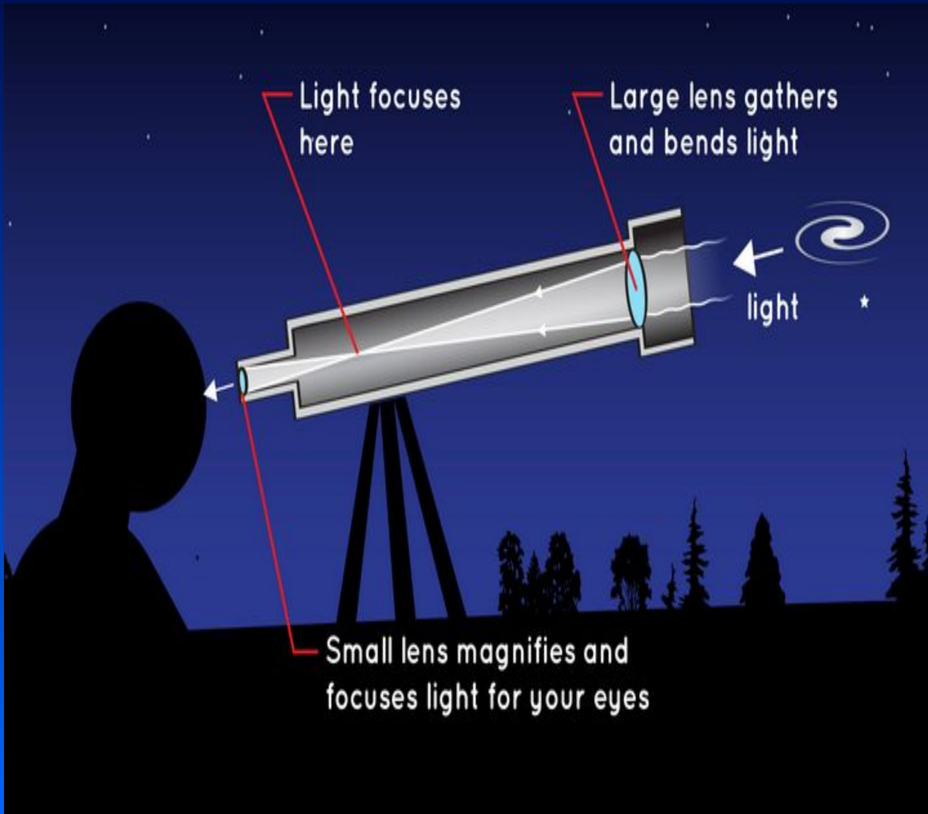
- Refracting
- Reflecting

Refracting telescopes:

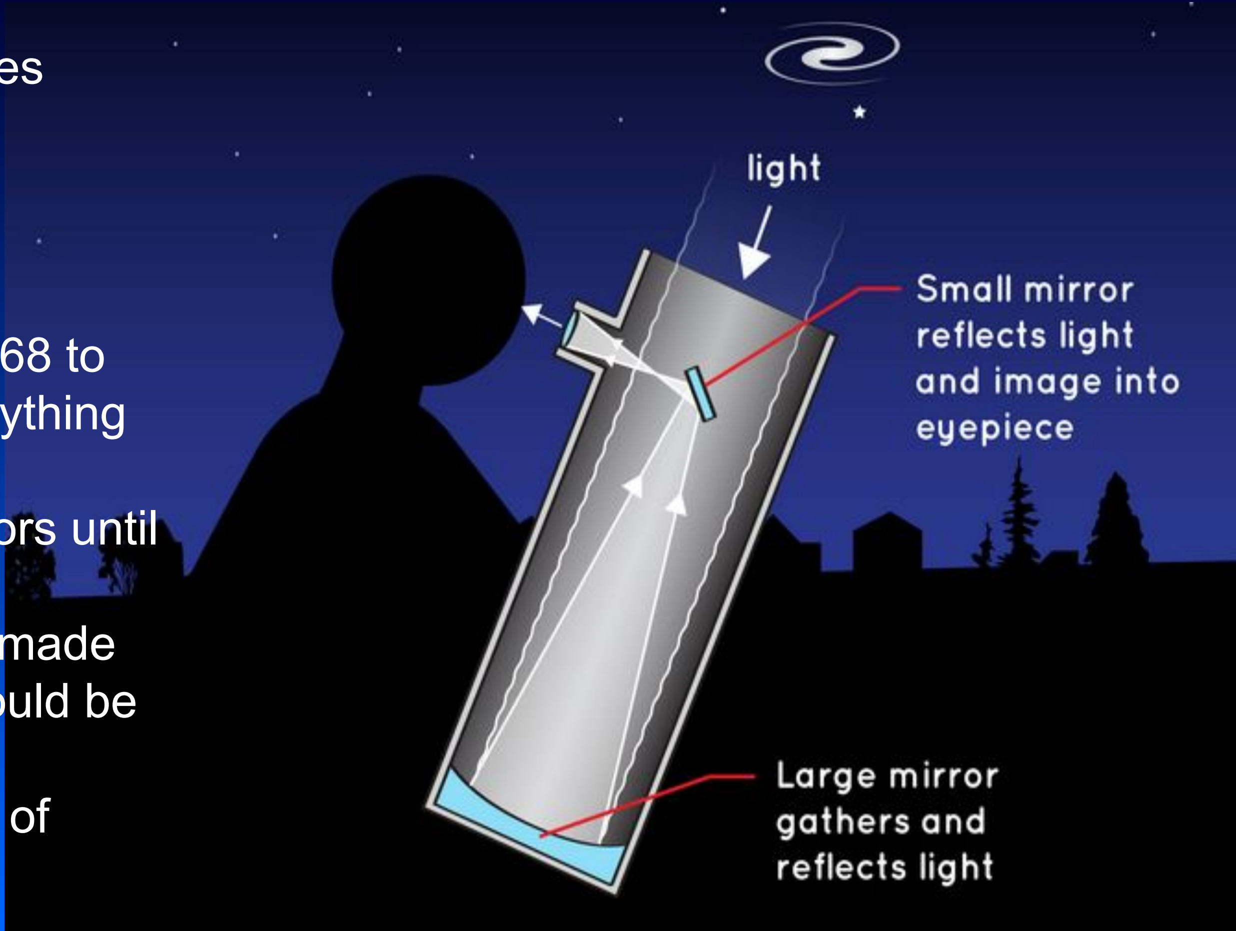
- Oldest type, created (probably) by Jacob Metius in the Netherlands in 1608.
- Light is “bent” (refracted) by lenses and presented to the eye.
- Early versions magnified 2-3 times, minimal clarity.
- No one really is known to have thought to point one at the sky until Galileo.



Telescopes and Observing

Two basic types of optical telescopes
- Refracting
- Reflecting

Reflecting telescopes:
- Invented by Newton around 1668 to solve a problem, not look at anything particular.
- Reflects light by means of mirrors until presented to the eyepiece.
- Early versions had issues that made them unpopular until mirrors could be easily ground accurately.
- Is now the most prevalent type of telescope.



Telescopes and Observing

Properties of all telescopes (an eyepiece is basically a tiny telescope):

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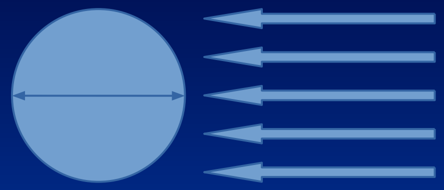
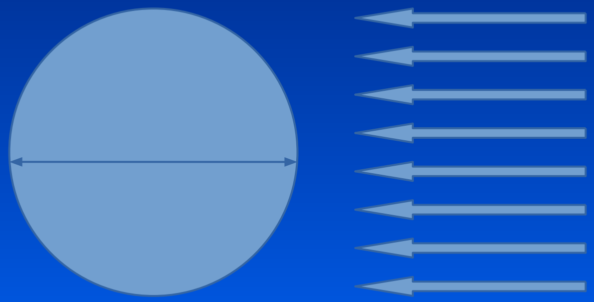
- Resolution (Ability to separate or distinguish very small objects or objects with tiny separation) 116/Aperture (in mm)

Telescopes and Observing

Aperture

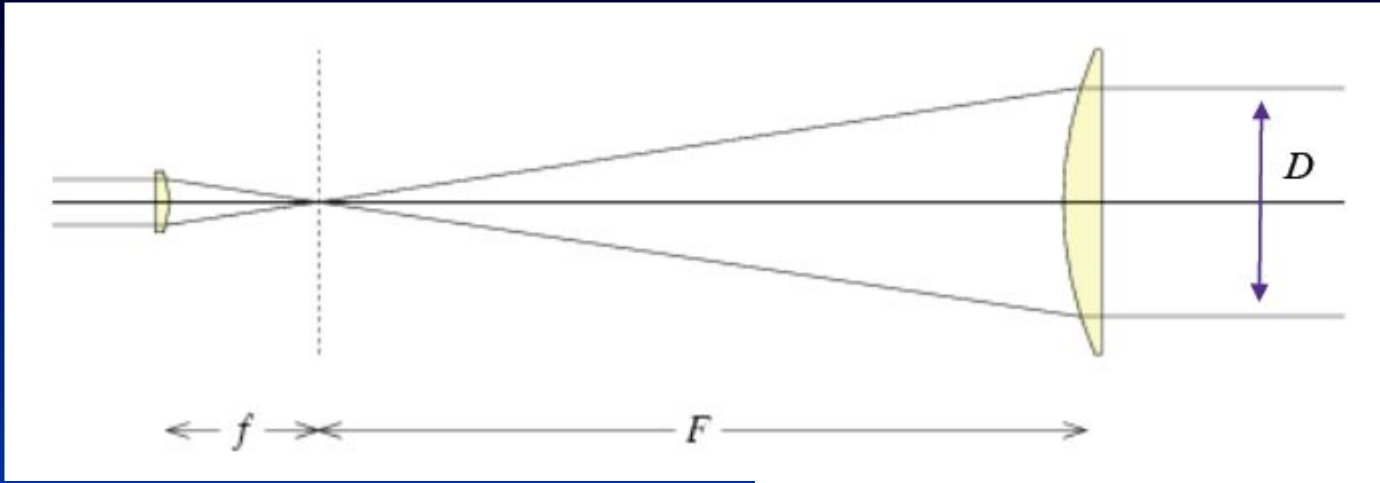


Light into 5” telescope



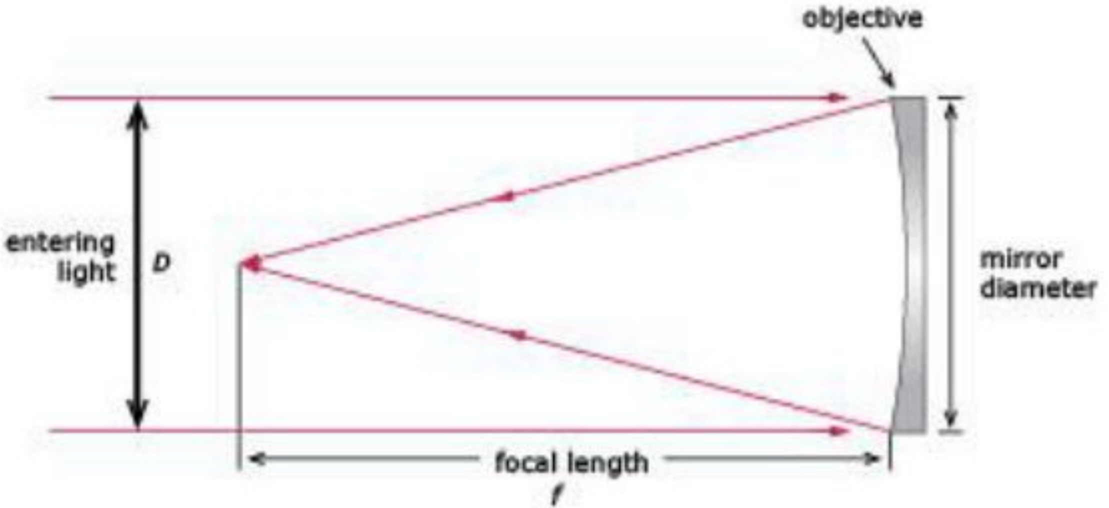
Light into 8” telescope

Telescopes and Observing



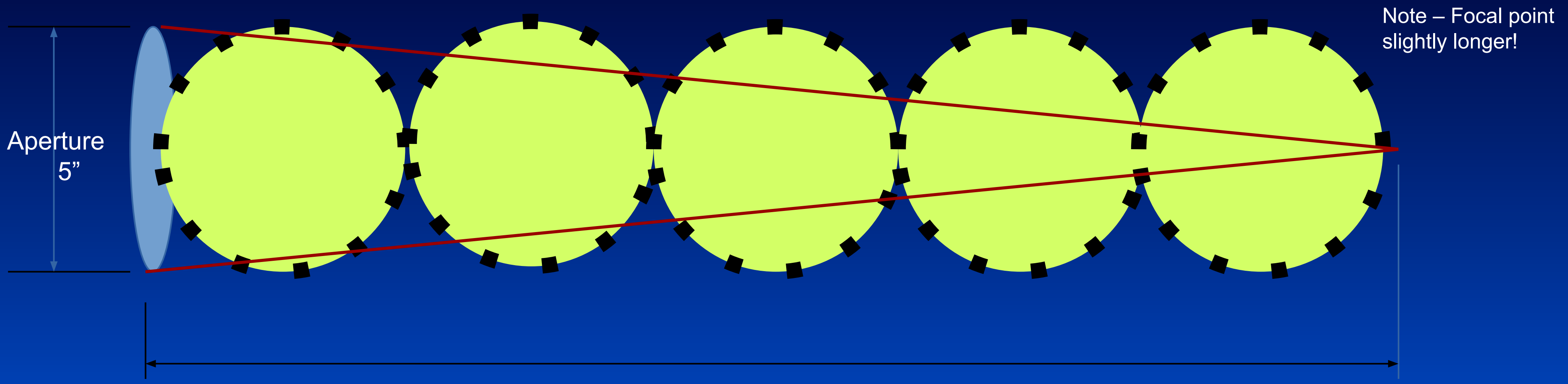
Refractor

Reflector



Telescopes and Observing

Focal Ratio:



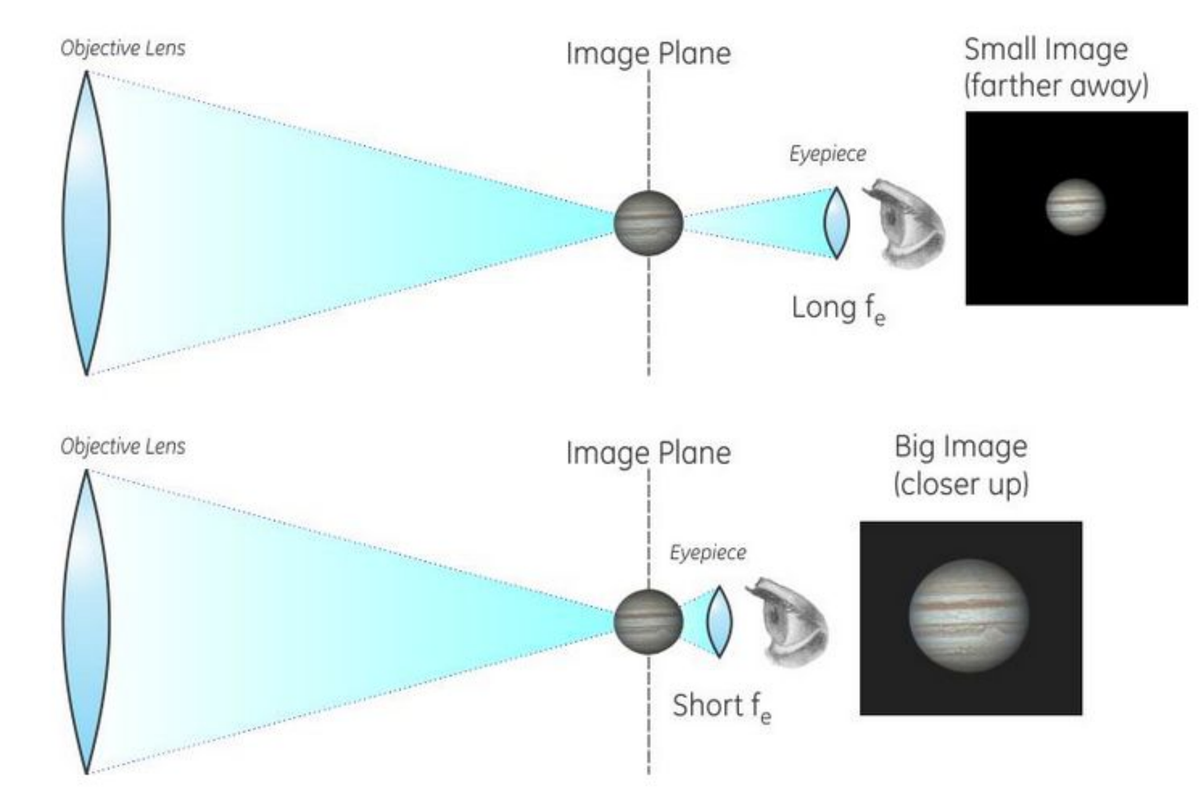
Focal Ratio = Focal Length / Aperture

Example: 5” aperture and 650mm focal length

650/(5x25.4)=5.1

Telescopes and Observing

Magnification



http://www.rocketmime.com/astronomy/Telescope/Magnification.html

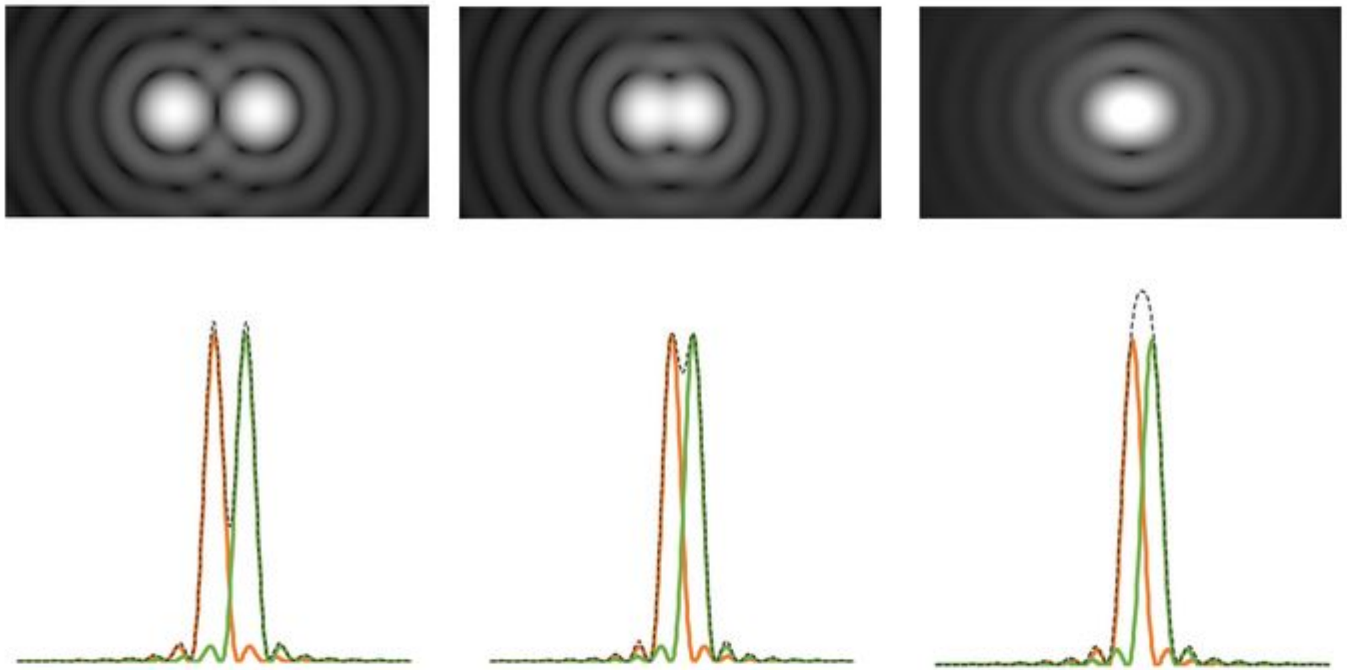
Telescopes and Observing

Limiting Magnification

Telescope: 4.5” (144mm), Fl=900mm, f/8 ... Max Mag=50x4.5=225x
25mm, 10mm and 3.5mm eyepieces
36x, 90x, 257x

Telescopes and Observing

Resolution



These two images can be easily resolved, so two distinct stars or objects can be seen.

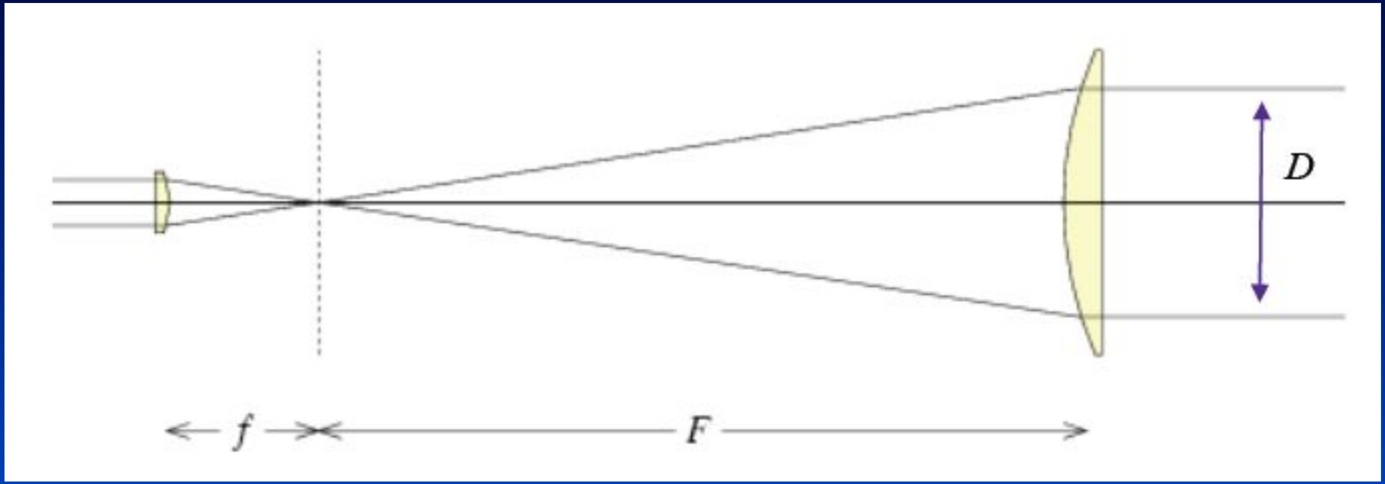
These two images can just be resolved following from Rayleigh's criterion

The angular separation between these two images is too small and they cannot be resolved separately from each other.

Telescopes and Observing

Examples

Image from Cosmicpursuits.com



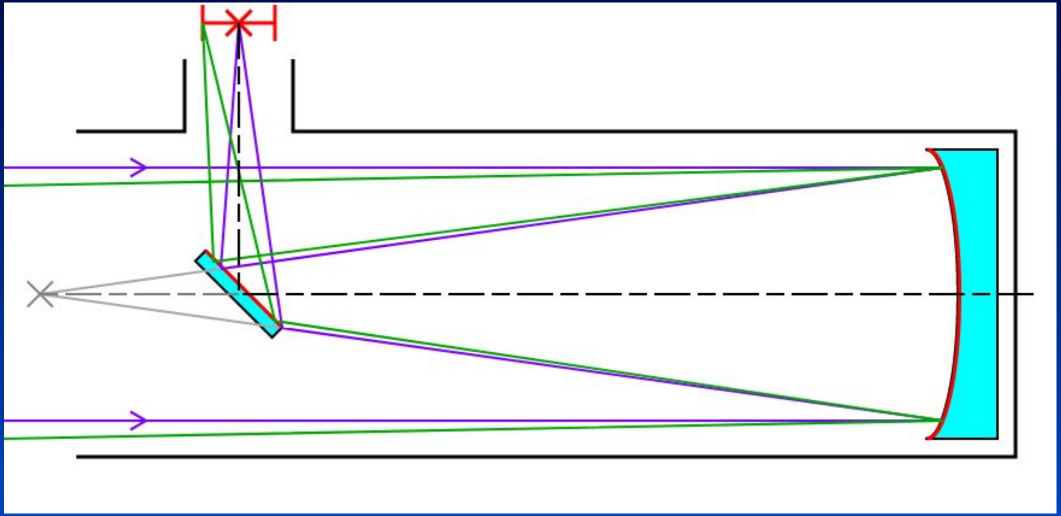
F = Focal length of telescope
f = Focal length of eyepiece
D = Diameter of opening (aperture)
EP=EyePiece focal length

Assume D=6”, F=600mm and f=20mm
Magnification=600/20=30X
Focal Ratio = 600/(6x25.4)=4
Limiting Mag. = 6x50=300X (EP=2mm – silly!)
Res. Power = 116/(6x25.4)=0.76 arc-seconds

Telescopes and Observing

Examples

Image from By Krishnavedala - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=34890843



F = Focal length of telescope
f = Focal length of eyepiece
D = Diameter of opening (aperture)
EP=EyePiece focal length

Assume D=6”, F=2000mm and f=20mm
Magnification=2000/20=100X
Focal Ratio = 2000/(6x25.4)=13
Limiting Mag. = 6x50=300X (EP=6mm – Possible)
Res. Power = 116/(6x25.4)=0.76 arc-seconds

Telescopes and Observing

In the examples, we saw something called “arc-seconds” – what is that and how big is it really?

Circle = 360 degrees
One degree = 60 minutes of arc
One minute of arc = 60 seconds of arc or arc-seconds

Therefore, one arc-second = 1/60 of a minute or 1/3600 degree

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OK – So???

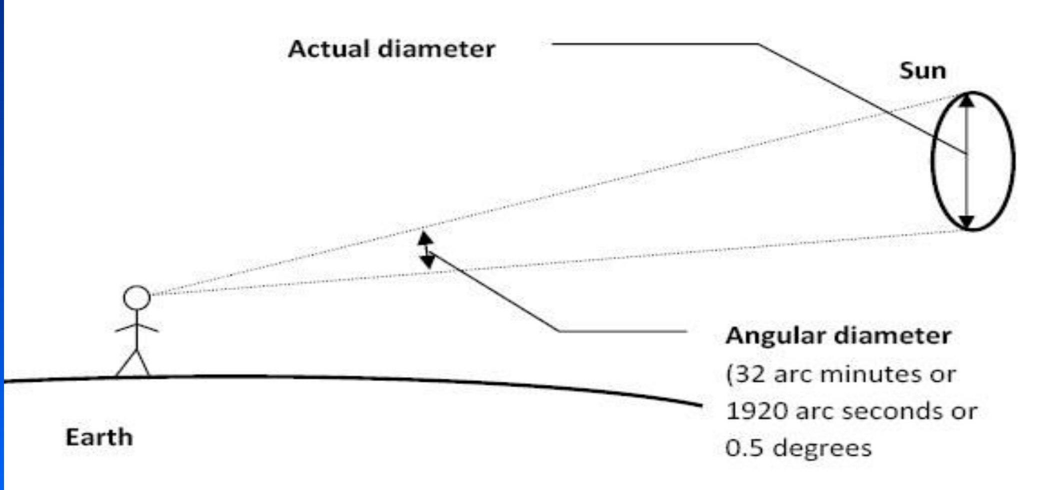
Telescopes and Observing

The Sun (or Full Moon) is – generally – about 0.5 degrees or 32 arc-minutes or 1920 arcseconds

Jupiter is about 50 arc-seconds

Betelgeuse is about 0.055 arc-seconds

If your resolving power is 0.9 arc-seconds then it is easy to see Jupiter as a disk, but IMPOSSIBLE to see any star as anything other than a point!



Telescopes and Observing

Here’s a fun thing:
Take a yardstick (or a meter stick if you prefer)
Take a single piece of 20 lb (0.004” thickness) paper and place the very end of the yard stick on top of the paper.
The yardstick now forms an angle of around 0.006 degrees or about 23 arc-seconds.
A telescope with the resolving power of 0.76 arc seconds would easily be able to see this separation.

Telescopes and Observing

Image of star system Mizar A and B

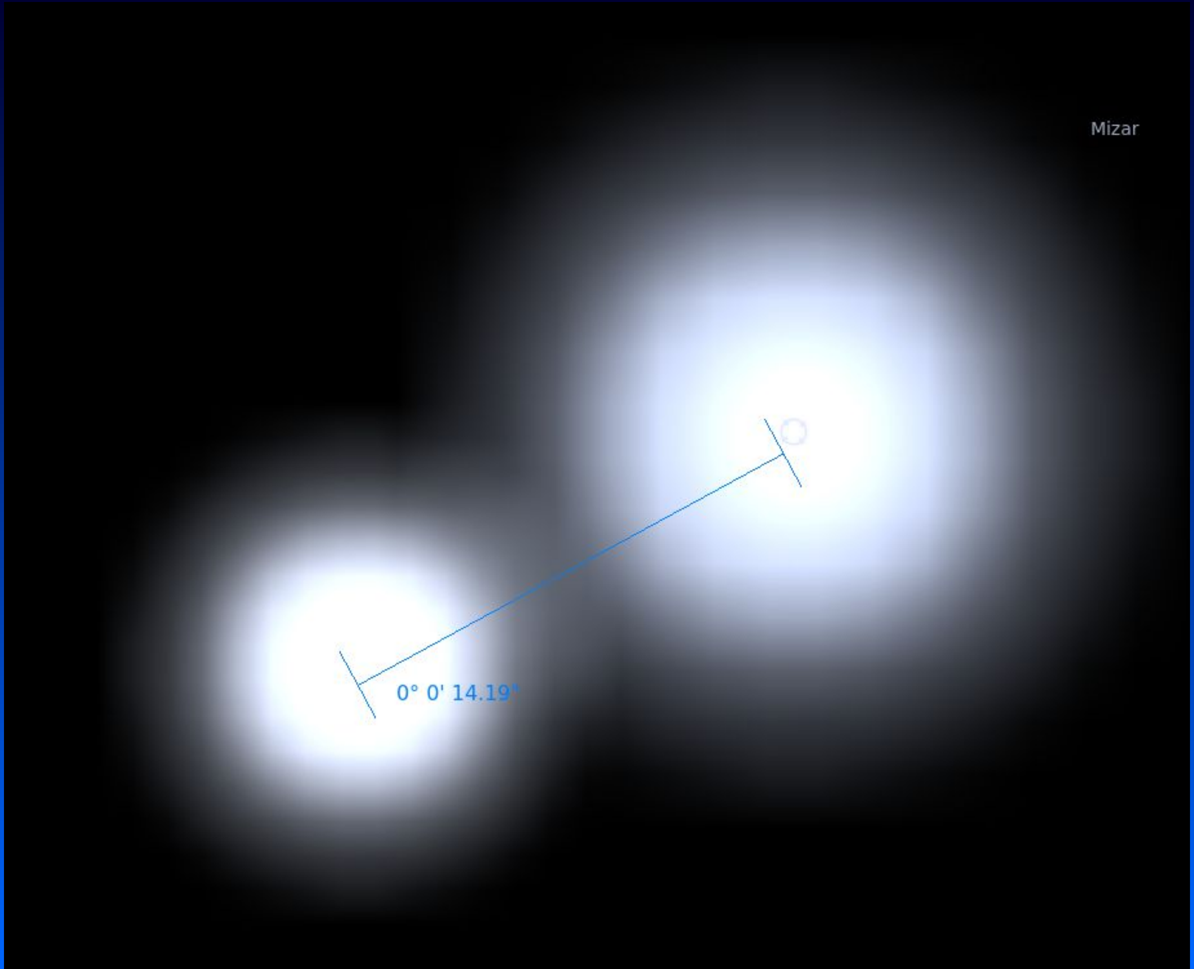
Star separation is 14 seconds of arc

0º 0’ 14.4”

A good telescope can split them

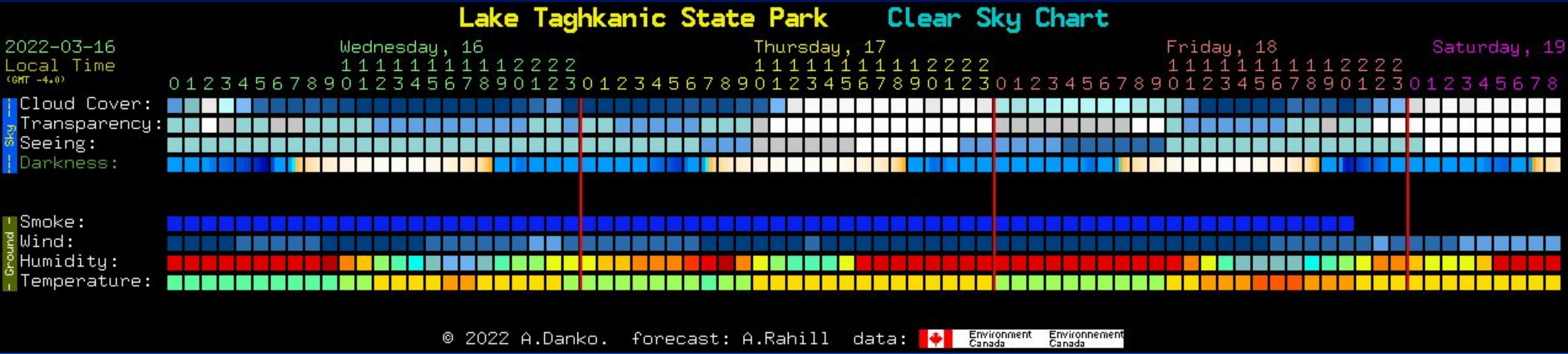
A little less than half the distance of our ruler and paper

Image from Stellarium

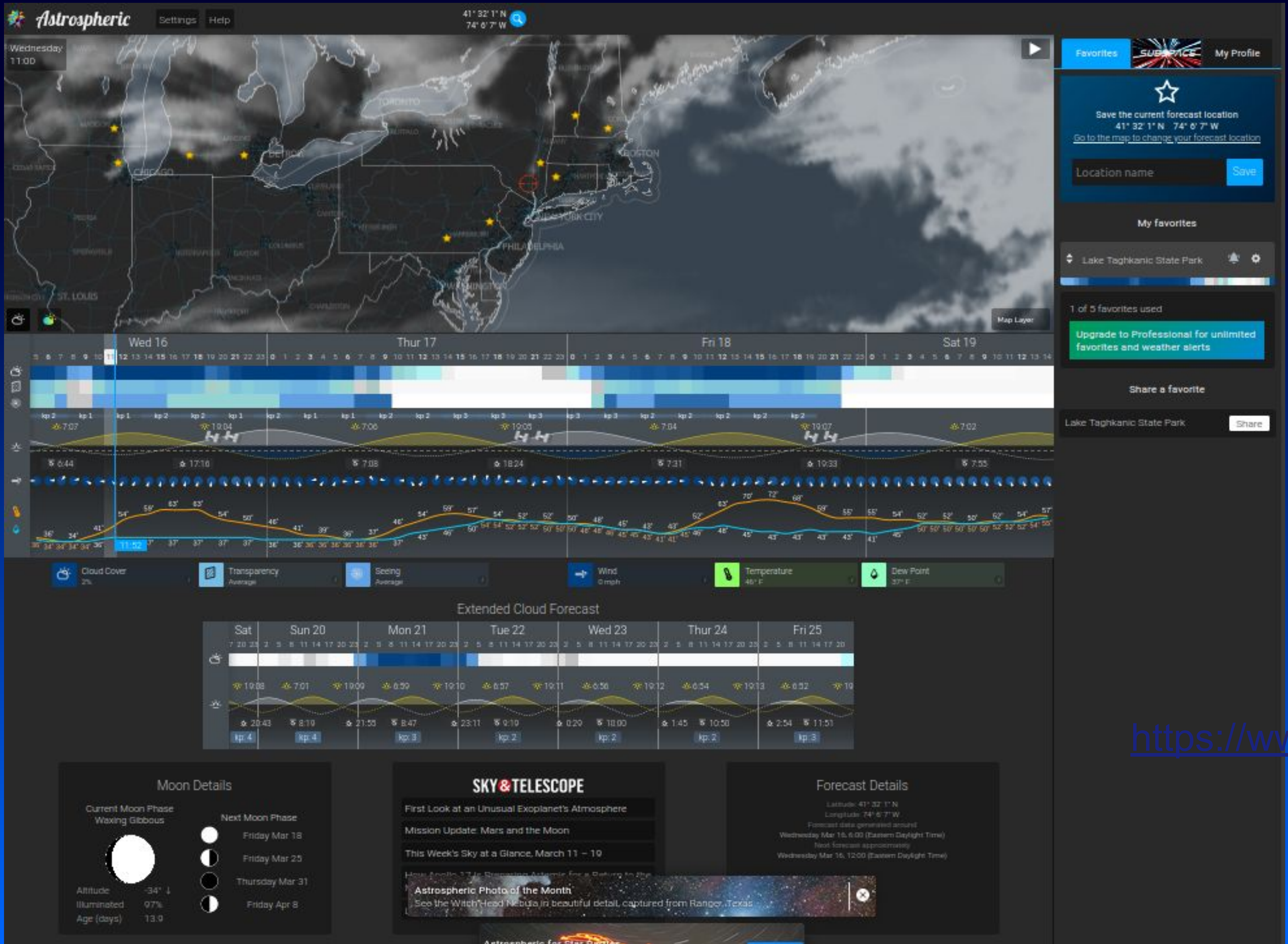


Telescopes and Observing

Atmospherics



http://www.cleardarksky.com/



https://www.astrospheric.com

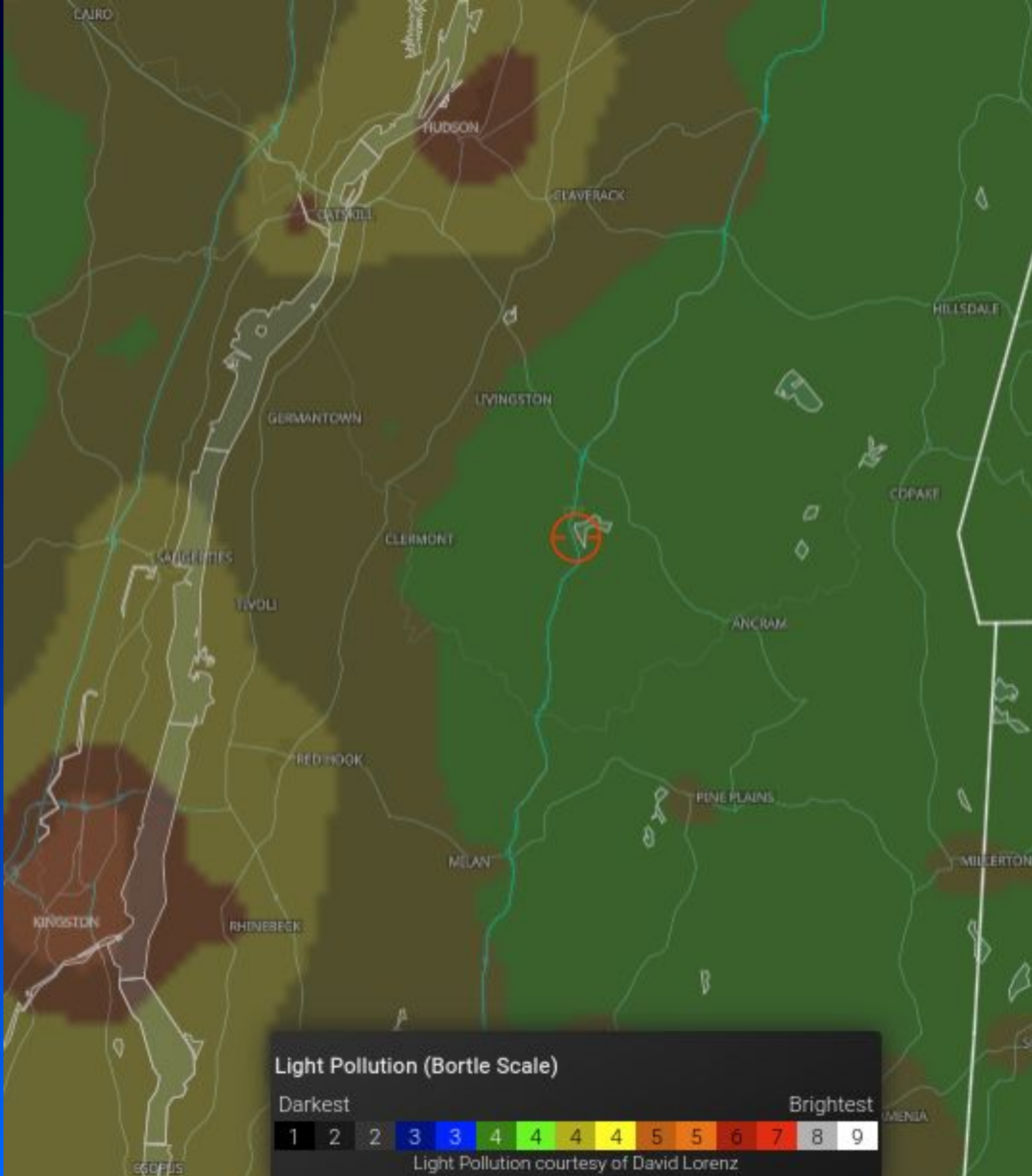
Bortle Scale

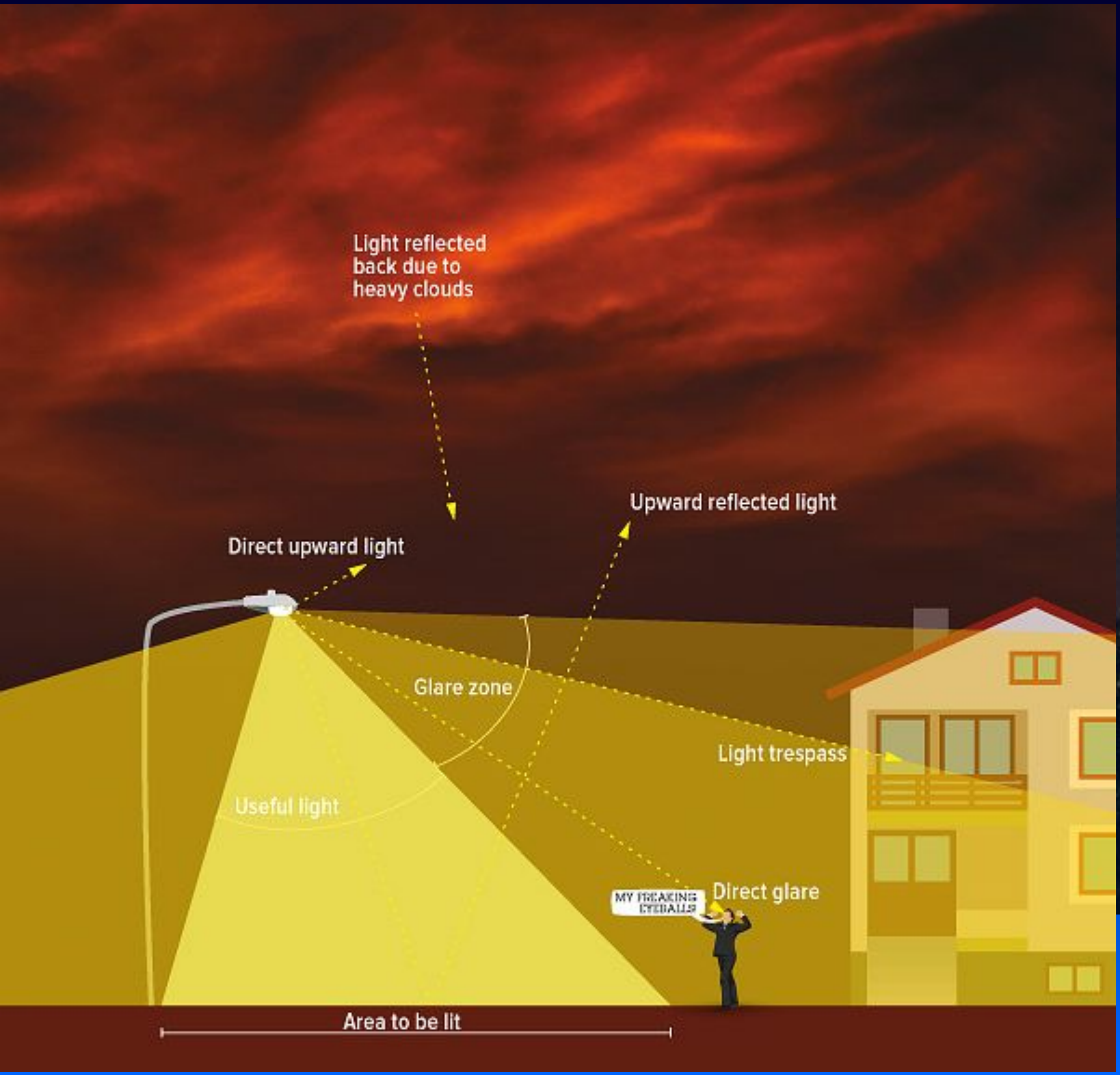
Created by John Bortle Feb 2001

1 is darkest, 9 is city bright lights.

Image is from Astrospheric – layer view, Seeing selection, select Bortle

Centered on MHAA Star Party location, Lake Taghkanic State Park




Light reflected
back due to
heavy clouds
Upward reflected light
Direct upward light
Glare zone
Light trespass
Useful light
MY FREAKING
EYEBALLS
Direct glare
Area to be lit


Before
After

Telescopes and Observing

Moon and Planetary viewing:

Long focal length for narrow field of view

Small to medium aperture. Planets are usually bright (though Uranus, Neptune, Pluto and visible Asteroids are not!)

Higher magnifications are possible with long focal length telescopes.

Refractors give superior views of planets but can be expensive.

APO lenses are best – and cost more.

Maksuthov-Cassegrain (Mak or MKC) telescopes are excellent. Long focal length, short tube, generally more expensive

Telescopes and Observing

Galaxies, Star clusters, DSOs

These are dim – you need a fast scope, large aperture.

You also need wide fields of view

Newtonians are cheapest for large apertures.

Schmidt-Cassegrain (SCT) gives long focal length in a short tube.

SCTs are more expensive but commonly have drive motors for tracking.

Telescopes and Observing

We will cover mounts in more detail later – for now, a quick overview from simple to very complex.

Simple: Alt/Az (Altitude/Azimuth)

- Moves scope up and down, rotates around a central axis

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Simple: Alt/Az (Altitude/Azimuth)

- Moves scope up and down, rotates around a central axis
- Like camera or movie camera mount
- Modification is the Dobson mount
- Can be computerized, but movement is in two axes to follow Earth rotation.

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More complex – Equatorial mounts and wedges

- Sets scope rotational axis parallel to Earth

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- German Equatorial type – Manual
- GEM – Powered tracking
- Massively computerized tracking with correction

Telescopes and Observing

So – What telescope to purchase first?

Telescopes and Observing

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This one! Well – maybe not this EXACT one, but one like it.

Numbers are magnification and aperture – 8x70 means 8x magnification, 70 mm aperture.

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Large aperture units may require a tripod, but they all benefit from the stability.

Try to get one with a tripod mounting option.

Absolute best are Image-Stabilized units – but expensive. More than some good telescopes!

Telescopes and Observing

Image-stabilized, 18x50, about $1300

Image-stabilized, 10x30, about $600

Telescopes and Observing

A Binocular Parallelogram is a very handy way to hold binoculars. It keeps the orientation fir different heights.

Mounts to standard tripod.

Great for sharing views with people of different heights.

Telescopes and Observing

If you already have a telescope, or you run right out and purchase one tomorrow, you will probably want to learn how to set it up.

See you next week where we will go over setting up for good viewing!