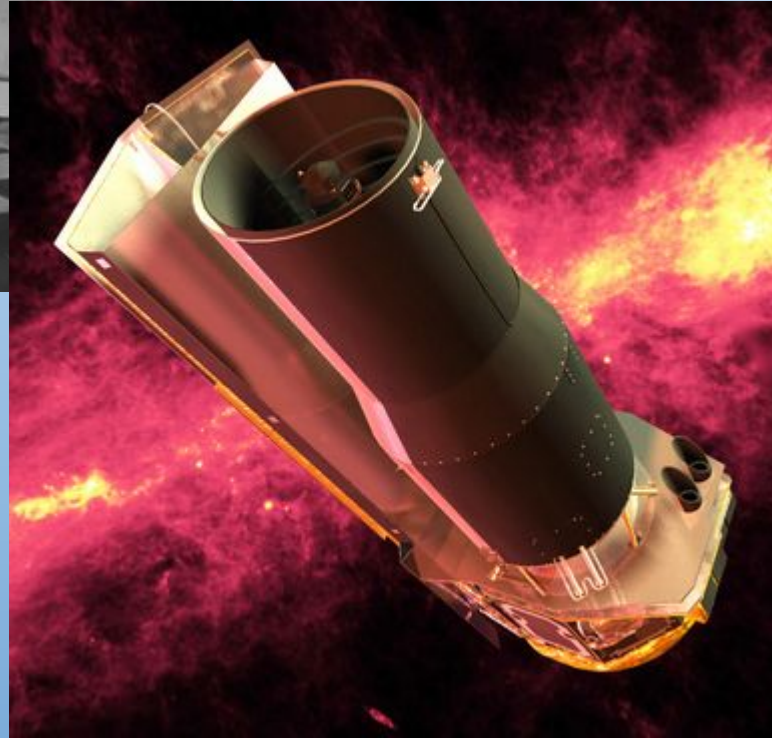


# Astronomy



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

Week 4: 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 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

# Observing the Moon and Planets of the Solar System



(This representation not to scale....)

# Observing the Moon and Planets of the Solar System

To Plan or Not to Plan?

If you want to observe the moon, and go out when it's dark and there is no moon...

# Observing the Moon and Planets of the Solar System

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If you want to observe the moon, and go out when it's dark and there is no moon...

Planning does not need to be detailed, but it helps to get an idea of what you might want to look at – even generally. Trying to look for the Orion Nebula between May until perhaps September? it may not be visible at all, or later in the year, rise very early in the morning. It helps to know what is in the sky when you go out.

# Observing the Moon and Planets of the Solar System

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In the case of the moon, best observing is in one of the quarter phases, or for a challenge, when it is freshly past new or, in the early morning, about to become new. A Full moon is impressive visually, but very flat and boring to look at through a telescope, and a new moon is in the Sun and, unless eclipsing the Sun, impossible to see.

# Observing the Moon and Planets of the Solar System

The Moon is our easiest target. It is Obvious, Bright, Big, if you can't find it, it probably isn't there. Or it's cloudy. Or your scope cover is still on.

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The Moon passes through phases we are all familiar with. New, Waxing Crescent, First Quarter, Waxing Gibbous, Full, Waning Gibbous, Third (or last) quarter, Waning Crescent and back to New.



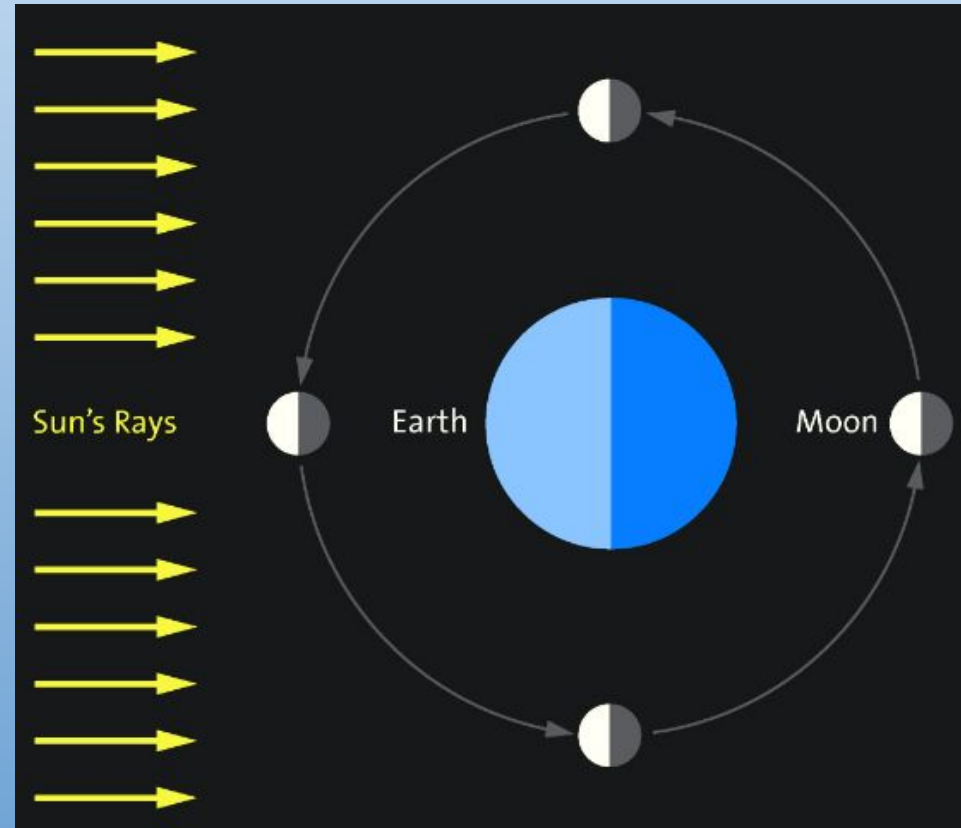


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The phases are related to the angle the Sun hits the moon as seen from our perspective on Earth. When the Moon is in the same direction as the Sun, it is "New". We are looking at the shadowed side of the moon and as such, in the glare of the Sun, we do not see it.



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As it moves away from the Sun, we start to see bits of the sunlit side, gradually growing greater and greater, until a "Full" moon is presented when the Moon is on the opposite side of the Earth as the Sun.

The process continues with a diminishing illumination until we return to New.

# Observing the Moon and Planets of the Solar System

Two best times to observe the moon:

- Just past new to a few days after First Quarter
- Few days before Last Quarter to just before New, when Moon is lost in the sunrise

During these times, Shadows are longer and contrast is strongest The reflected light from the moon is controllable and there may be clear sights of crater ridges inside the shadowed area – the Terminator.

Another image with a crater ridge peaking out way over the edge!



Philip Ditchfield, Preston, UK.



# Observing the Moon and Planets of the Solar System

Compare this image of the Full Moon to the other images – it looks “washed out”, lacks detail, is overly bright to look at through a telescope and is generally unsatisfying.

It is also not ENTIRELY full – meaning it has less than 100% of the face toward us lit.

Why?



# Observing the Moon and Planets of the Solar System

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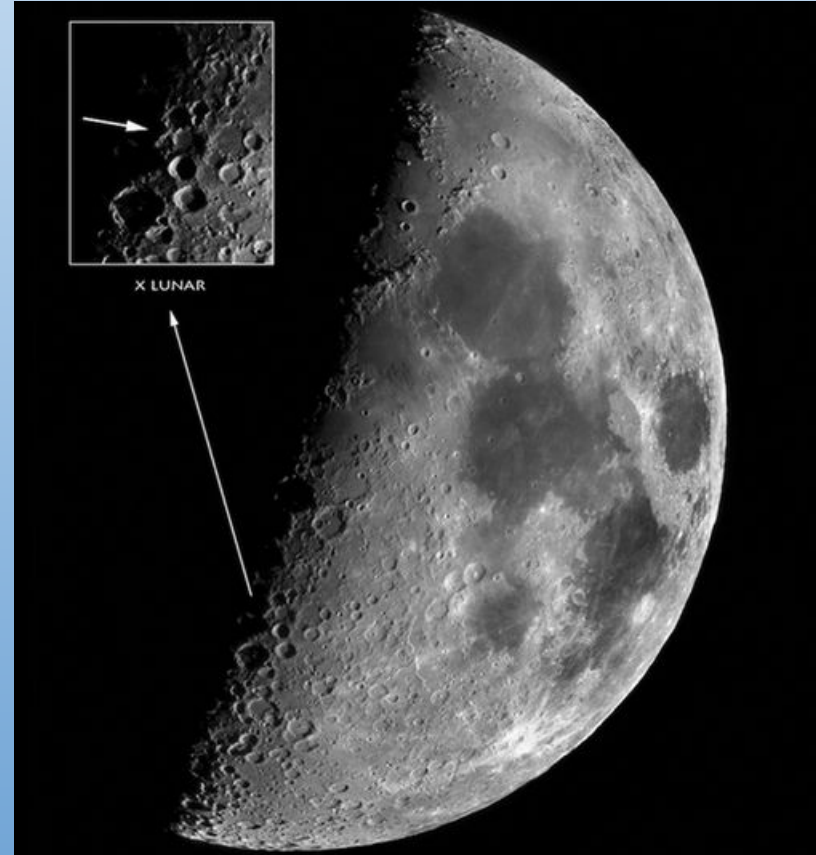
Why?

In order to be “Full”, the Moon is lit from behind (our perspective) – however if it was actually behind Earth from the sun – we would have a Lunar Eclipse! So it must be slightly off to the side – meaning it isn’t COMPLETELY lit. Just mostly – about 99%. Close enough for us.

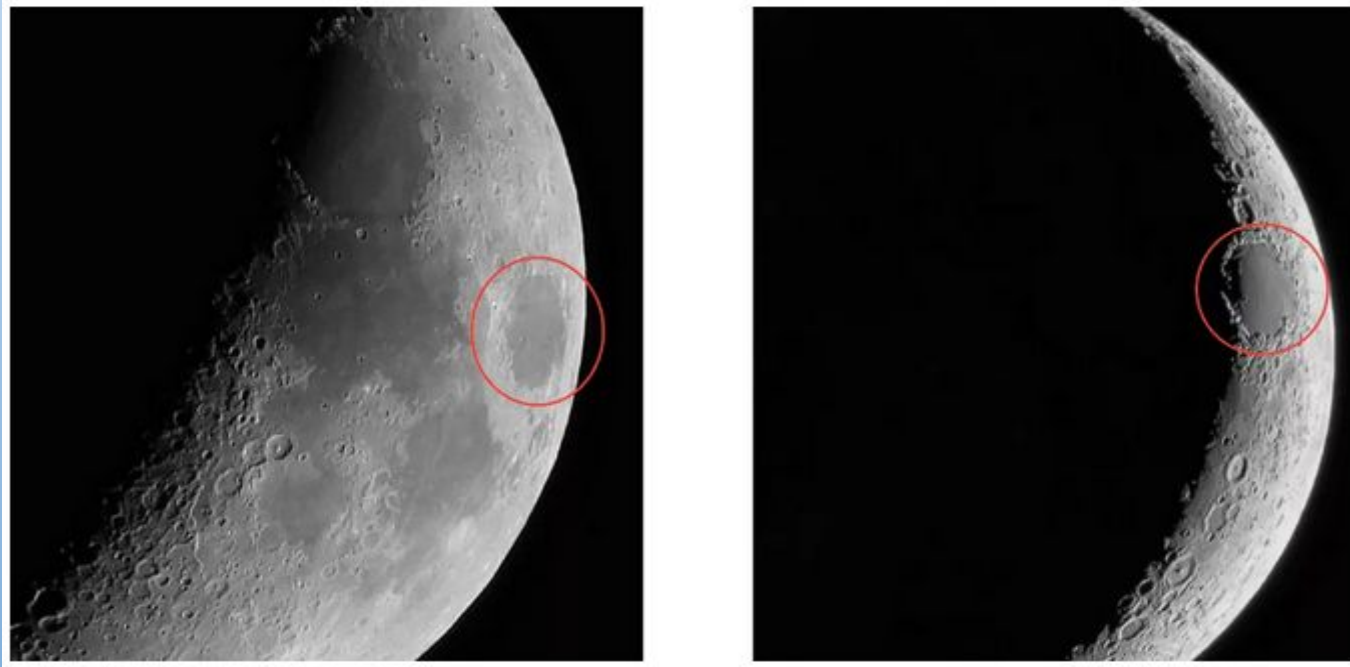


# Observing the Moon and Planets of the Solar System

The best time to view the moon is when there is a distinct “terminator” or shadow/Sun line. This shadow area increases the contrast with surface features on the Moon and gives us a much nicer view than when these features are in “full sun”



# Observing the Moon and Planets of the Solar System



Mare Crisium in full sun (left) and on the Terminator (right) - detail from the long shadows when it is near the terminator is quite obvious.

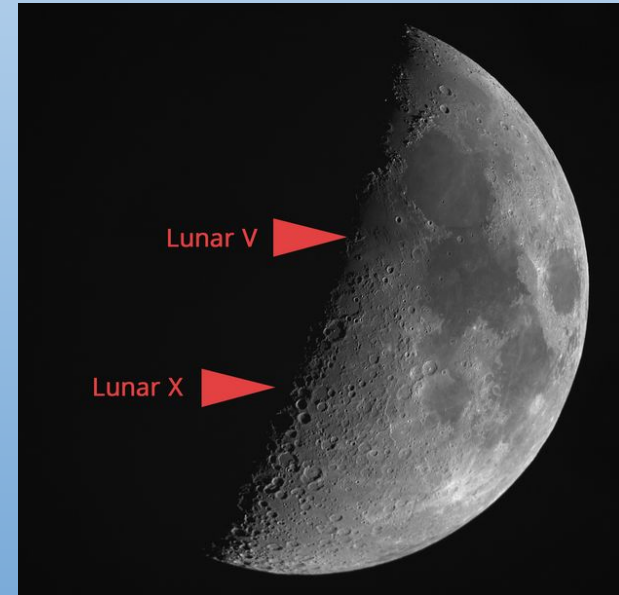
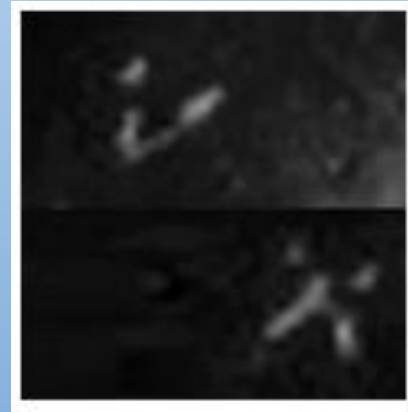
[Moon Libration video](#)



# Observing the Moon and Planets of the Solar System

Celestron has [some viewing recommendations](#). These include some (to me, at least) surprising objects, like the “V” and “X” formations that can only be seen for a few hours at a certain specific time in the lunar phase! From Celestron:

“The infamous Lunar X and Lunar V are a pair of small, eerie optical illusions on the Moon, visible only when sunlight falls at the right time on the lunar topography. Lunar X, also known as the Purbach Crater or Werner Cross, appears around First Quarter near the terminator between the craters La Caille, Purbach, and Blanchinus. Lunar X is only visible when sunrise is occurring over this region—just four short hours! Occurring at the same time as Lunar X, Lunar V is located higher north in the Mare Vaporum region and forms the letter “V.” It’s slightly bigger than Lunar X and sits on the terminator line. Challenge yourself to spot both letters at the same time!”



[Moon Libration video](#)



# Sidetrack

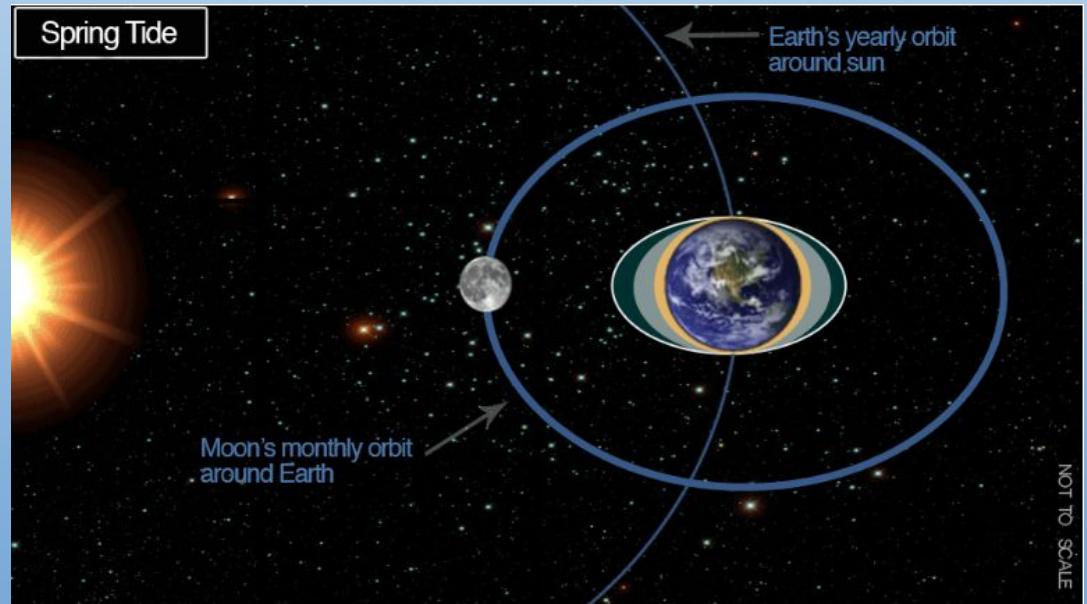
Tides (question from last week): Why are there TWO high and TWO low tides per day?



# Sidetrack

Tides are caused (primarily) by the Moon - though the Sun contributes a little, or subtracts a little.

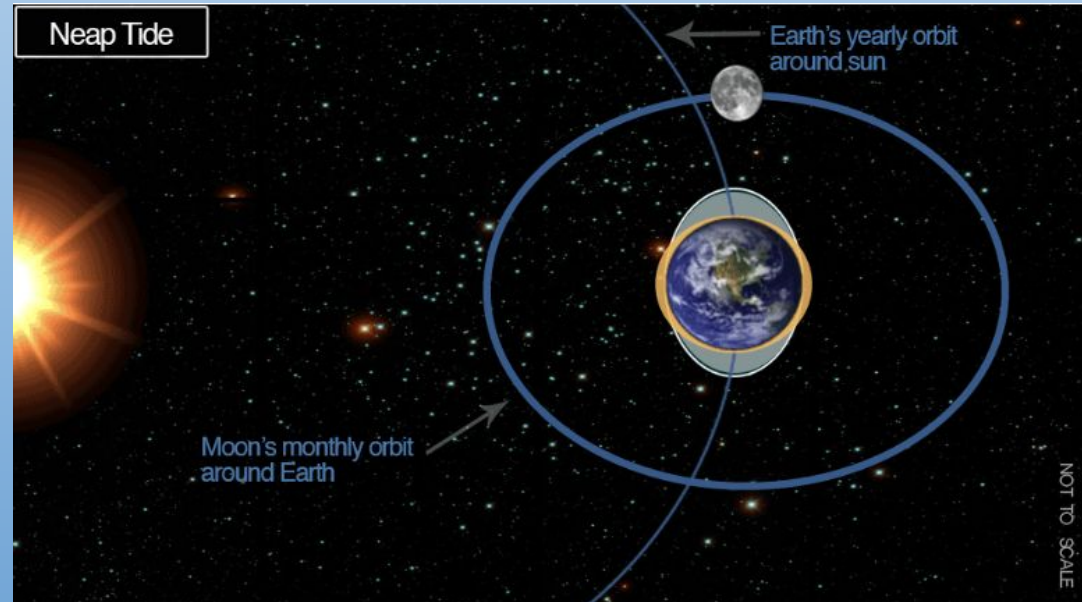
When the Sun and Moon line up - either on the same side or opposite side of the Earth, Stronger (spring) tides result.



# Sidetrack

Tides are caused (primarily) by the Moon - though the Sun contributes a little, or subtracts a little.

When Sun and Moon are at right angles (first and third quarter moon) then minimal (neap) tides result.



# Sidetrack

But ... Why is there a bulge *AWAY* from the moon (and Sun) on the opposite side???

# Sidetrack

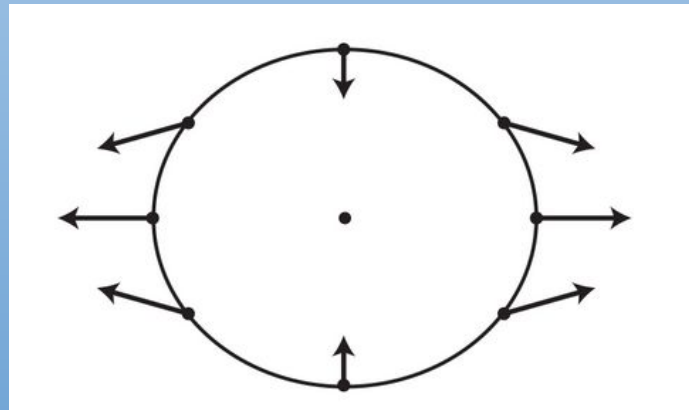
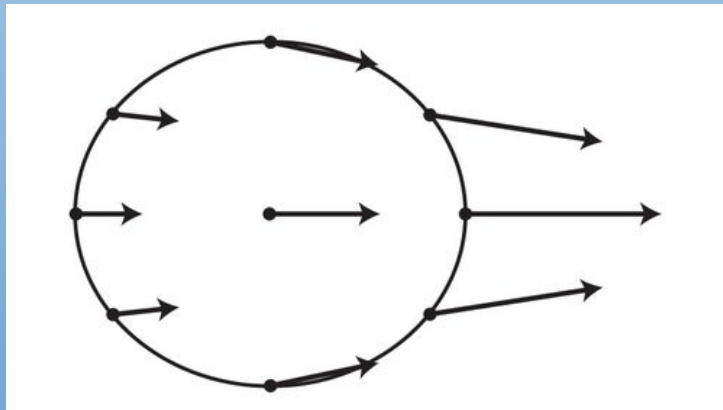
But ... Why is there a bulge *AWAY* from the moon (and Sun) on the opposite side???

[Excellent video explanation.](#)

# Sidetrack

In the event that did not work:

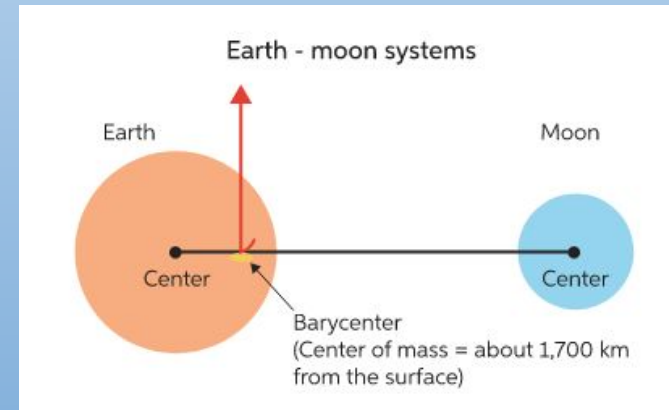
The Moon pulls the water towards it - but as discussed last week regarding a common rotation point, or barycenter, the Earth is ALSO pulled toward the Moon - and although the water on the opposite side is pulled toward the moon, it is pulled LESS - and so a bulge opposite the moon also remains.



# Sidetrack

The [barycenter](#) of the Earth-Moon system is roughly 2,900 miles from the center of the Earth - about 75% of the distance from the center to the crust of the Earth.

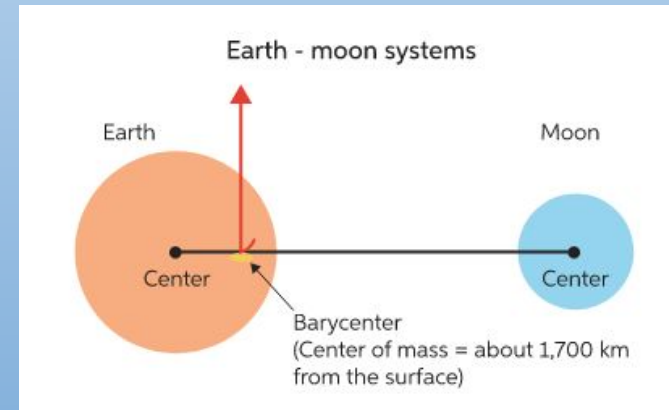
Earth Radius is about 3,963 miles.



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# Sidetrack

two other questions about the Moon from last week: Orbit and orbital precession.

The moon has THREE precession movements relative to Earth.

One (Axial) is like Earth's own precession where the North and South poles circle a small area of the sky relative to the Moon - about  $1.5^\circ$  over 18.6 years.

The other two are Apsidal and Nodal - Apsidal is the rotation of the orbit Apogee and Perigee in relation to Earth. Nodal is the rotation of the angle of tilt of the Moon's orbit with respect to Earth

Wikipedia article on [Moon Precession](#)

# Sidetrack

Finally, two other questions about the Moon from last week: Orbit and orbital precession.

The orbit of the moon is not circular, so the distance changes over the entire rotation, but the mean distance from Earth is also increasing - at about 3.8cm per year.

The Moon is slowing (and slowing Earth's rotation as well) by Tidal friction and moving into a more distant orbit.

Although it “feels wrong”, a slower orbit means an orbit that is farther away!

Kepler's Third Law states that the square of the orbital period of an object like the Moon which orbits the Earth is proportional to the cube of the semi-major axis of its orbit, which is proportional to distance of the Moon from the Earth, meaning a slower orbit is higher.

# Observing the Moon and Planets of the Solar System

Back to Observing!

# Observing the Moon

Equipment:

# Observing the Moon

Equipment: Telescope

The best telescope to observe the moon really depends on what you want to see. Binoculars are quite nice, but a refracting scope is probably the best idea. For less than a GOOD pair of binoculars, some sites recommend the Gskyer telescope. About \$90 on Amazon. Don't expect good optics though - main complaint is Chromatic Aberration (you may see colours that shouldn't be there!) It is advertised as a "child's telescope"

Celestron and others make a similar, possibly better, model.



# Observing the Moon

Equipment: Reflector possibilities

Reflectors are generally less cost for greater aperture, but this can be detrimental for the Moon and possibly planets. Look for a focal ratio of between  $f/11$ - $f/15$  for detailed lunar observations.

Pros: More aperture per dollar, very easy to use.

Cons: lower focal ratios, Inverted images, usually require collimation/TLC to get good views.



# Observing the Moon

Equipment:

Lunar or Neutral Density filter for eyepiece. This reduces the amount of light entering the eye and makes observing the moon more pleasing.

Additionally, a polarizing filter can assist in (at least) two ways:

Polarizing the light reflected from the moon can offer different views. It can also be set to reduce the terribly bright Full (and near-Full) moon light!



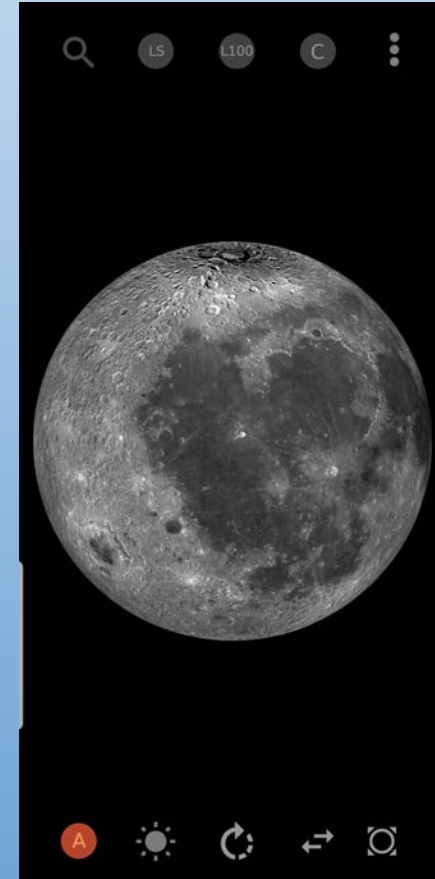
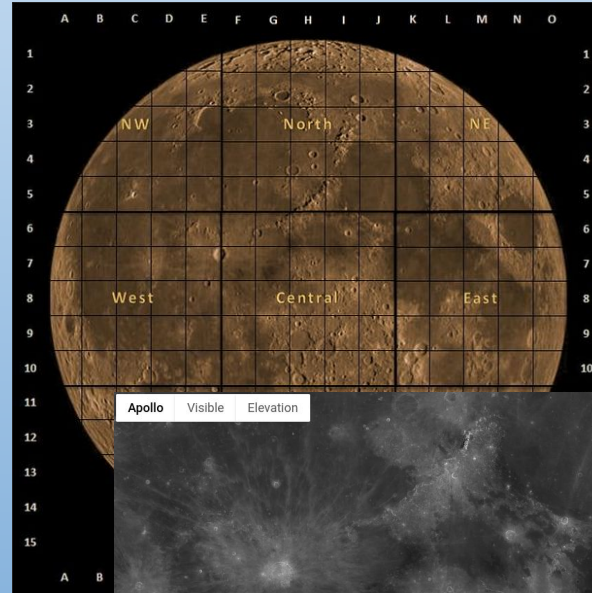
# Observing the Moon

Equipment: Moon atlas, pencil and paper, time!

<https://www.visit-the-moon.com/lunar-atlas>

<https://www.google.com/moon/>

Various phone apps - check your device app provider of choice!

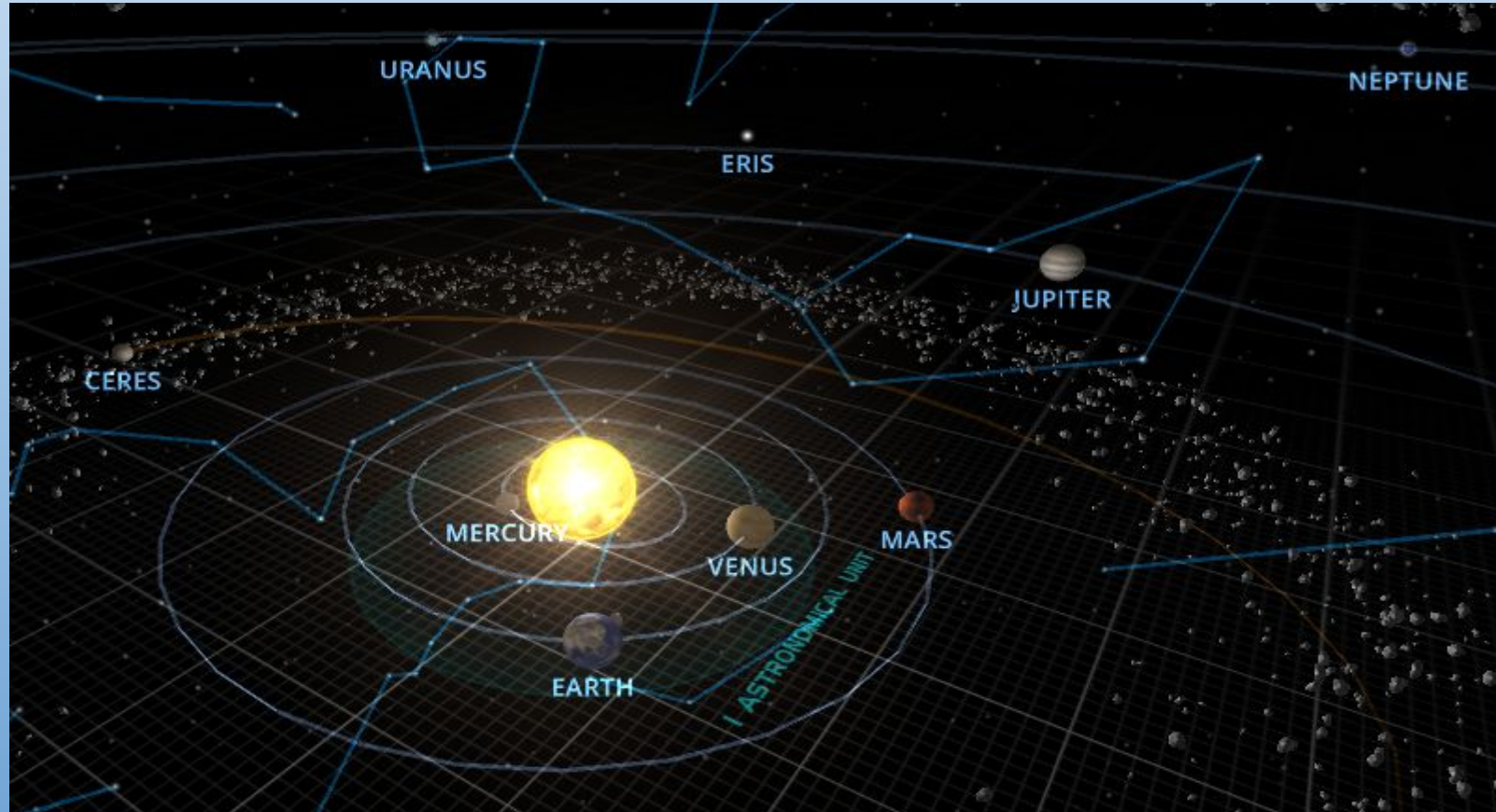




# Observing the Moon and Planets of the Solar System

<https://www.solarsystemscope.com/>

Screenshot of Solar System Scope. Interactive display of the solar system with planets, asteroids, etc. Also, common constellations are shown giving a good idea of what you can see.



# Observing the Moon and Planets of the Solar System

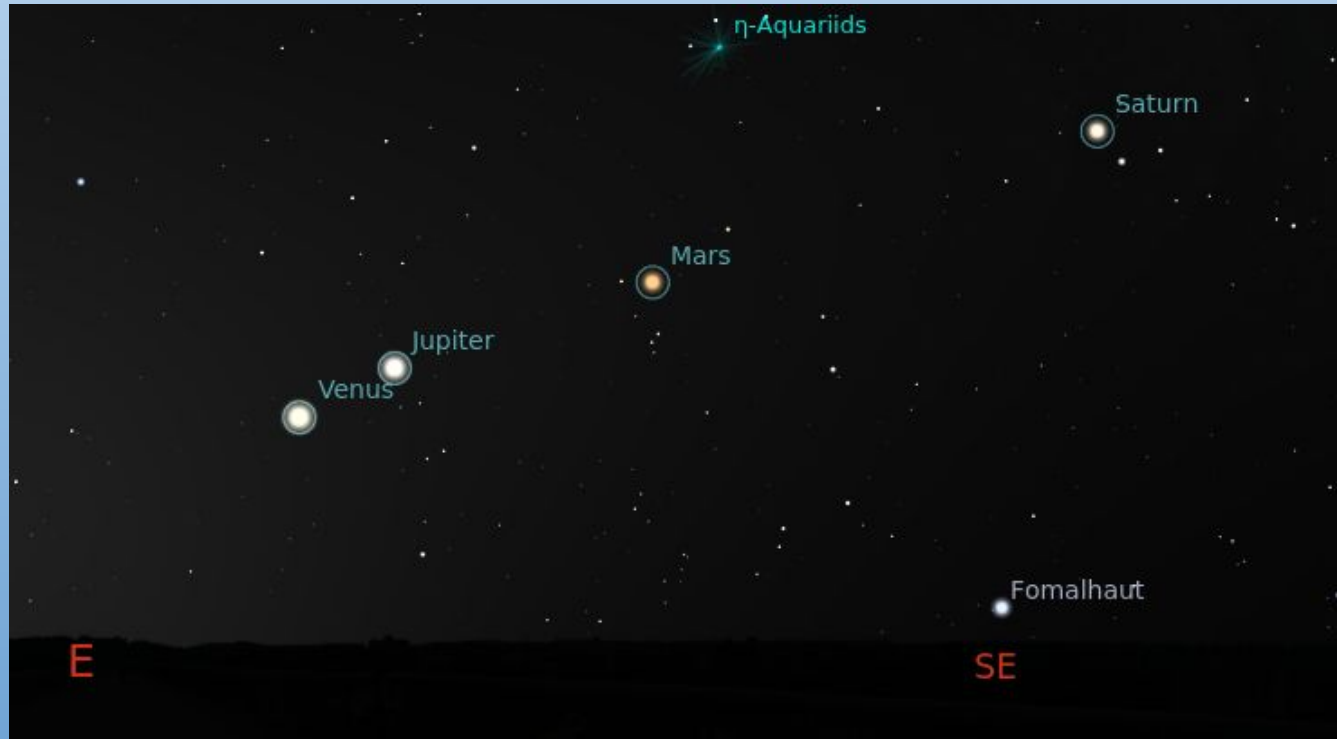
Another incredibly useful tool is Stellarium.

Highly accurate, it allows viewing of the sky – day or night – from any location on (or off!) Earth.

Screenshot of what will be in the sky just before sunrise May 6, friday after presentation.

Free for computers, small charge for Mobile devices, many versions including web-based

<https://stellarium-web.org/>



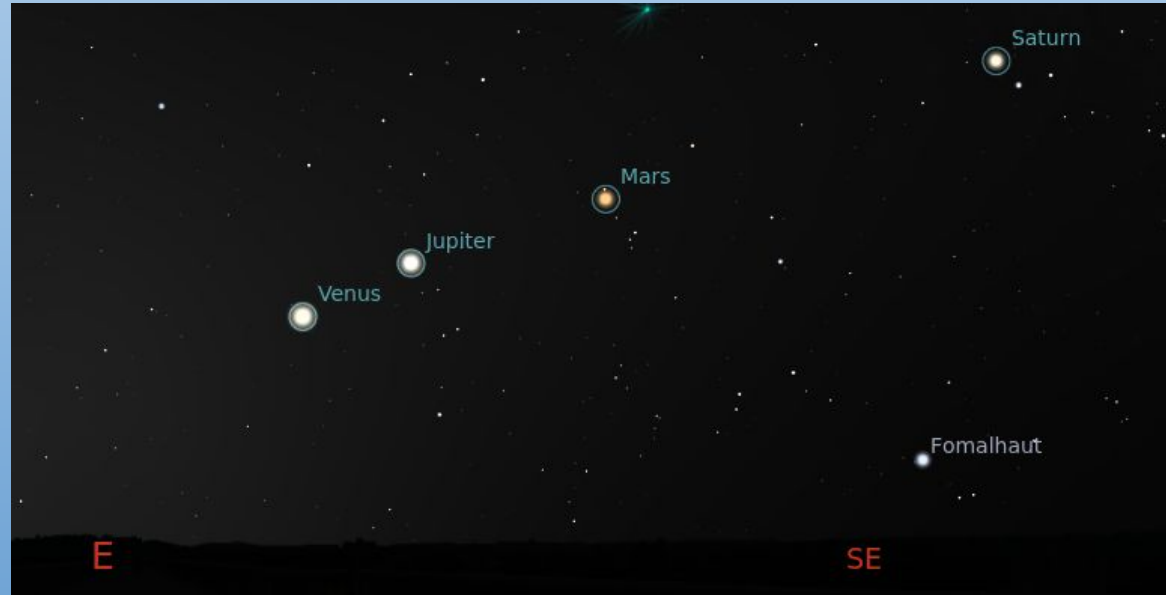
# Observing the Planets of the Solar System

Observing the planets is a longer-term issue than the moon thanks to their much longer orbits around the Sun.

As of this talk, all but one of the normally visible planets are leading the Sun – meaning they rise before the Sun, some only just.

Here's another shot from Stellarium for tomorrow morning (May 6, 2022)

That's nearly everyone – except Mercury.



# Observing the Planets of the Solar System

Mercury is on the opposite side of the Sun and MIGHT be visible with a clear Western horizon just after the Sun sets. It's near the Pleiades and Aldebaran, and Orion's belt just about points right at it. It is getting closer to the Sun every day though so look soon!



# Observing the Planets of the Solar System

Mercury and Venus share a property with the Moon.  
Any idea what that might be?

# Observing the Planets of the Solar System



Venus, 4 May 2022  
Via Stellarium

Mercury and Venus share a property with the Moon.  
Any idea what that might be?

Phases! The complete set from New to Full and back.  
We can see both Mercury and Venus pass through phases similar to those seen on the Moon and for the same reason.  
The reason only these three objects are observed to do this is thanks to their location.

Venus and Mercury are, of course, inside the Earth's orbit around the Sun. The Moon is close enough that the Sun angle is clear to us. Mars does show a little phase change, but not a full set.

Mars, 4 May 2022  
Via Stellarium

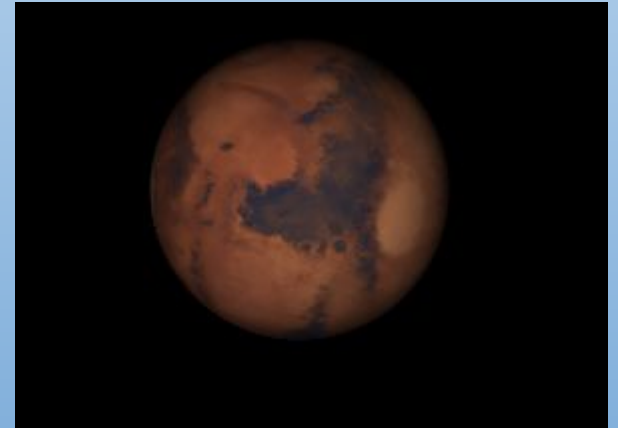


# Observing the Planets of the Solar System

Mars rise is about 0400. It's red, and with a good scope, you might see some white of the snow on one or both caps.

Other than that, and maybe some indication of the canals, it's pretty boring – unless there is a planet-wide dust storm like a few years back and the entire planet goes “fuzzy”. That makes it mildly more interesting.

That and maybe the knowledge that it is entirely populated by Robots – some with lasers and one that can fly!

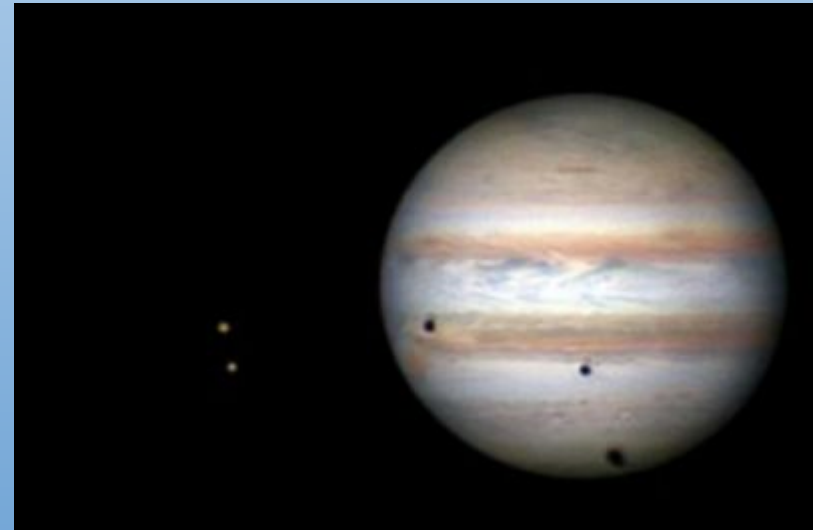


# Observing the Planets of the Solar System

Jupiter is always an amazing site through the telescope. Normally, it is easy to spot the four Galilean moons Ganymede, Io, Callisto and Europa.

Occasionally, you may find one or more have gone hiding – either in front of or behind, Jupiter. Sometimes, if you get the timing just right (or plan for it!) you can watch a moon either disappear behind a limb of Jupiter, or emerge from the opposite limb.

If a moon is passing in front of Jupiter, with a very good scope and a clear viewing night, you **MIGHT** even be able to see a shadow of the moon cast on Jupiter's cloud cover!





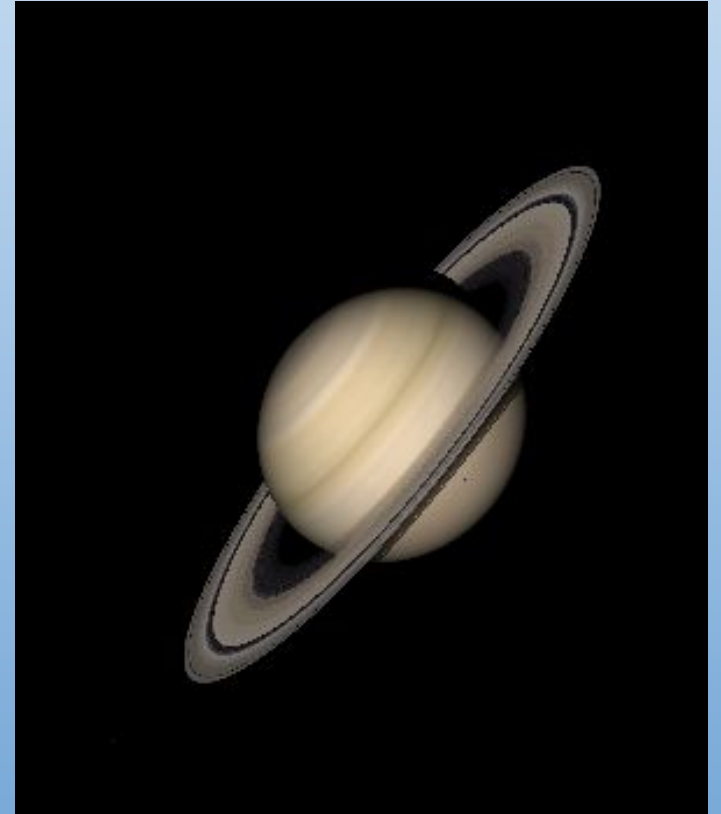
# Observing the Planets of the Solar System

Saturn is generally thought of as our most beautiful planet. Large and with the only easily visible ring system, it makes a marvelous and impressive target.

Saturn rises first of the most visible planets – about 0320. It will appear Golden in the sky and will be immediately apparent in the telescope.

Depending on the scope quality and magnification, see if you can see the gap between the rings. This is the “Cassini Division”.

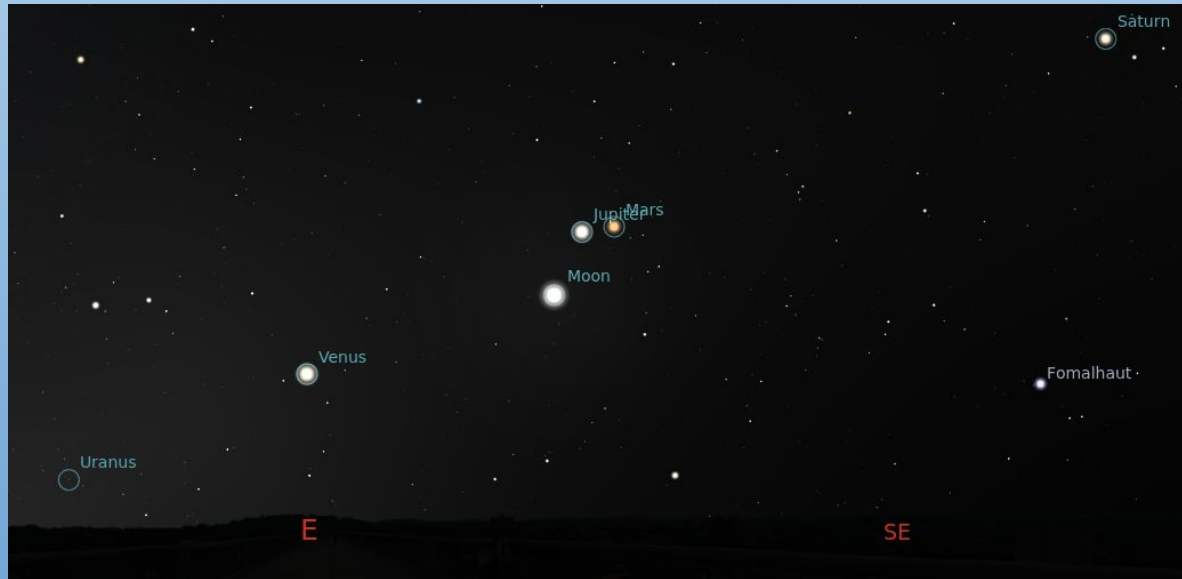
Also look for banding of the clouds.



# Observing the Planets of the Solar System

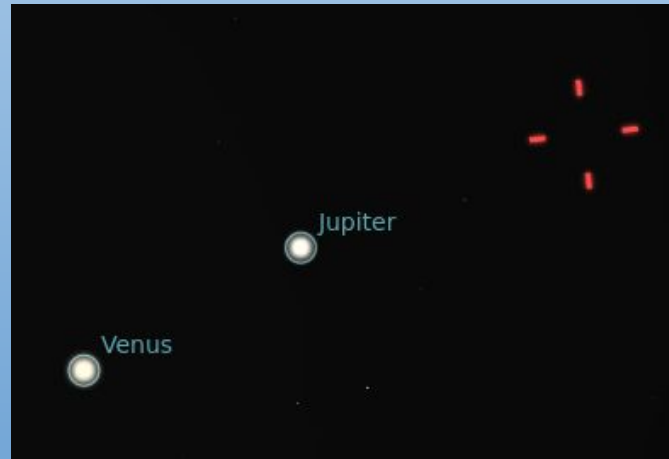
Uranus IS visible both to the naked eye (from a VERY dark location) and with a telescope, but only just. At this time and for the next few weeks, it is much too close to the Sun to be seen though and will be joining the other four major planets in the Morning sky soon.

At 5 AM on Wednesday, the 25th of May, the following view will be possible, if there is a clear sky.



# Observing the Planets of the Solar System

Neptune is not a naked-eye planet. You need a good telescope and either guidance or a good idea of the location to find it. It actually is in the same line shown earlier - for the next few weeks sitting between Jupiter and Mars, about the same distance from Jupiter as Venus is, but on the opposite side. Stellarium isn't showing it because it is below the visible limit set,



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You will need to be up early though - that image is around 4 AM and much later than this, the Sun will definitely interfere!



# Observing the Planets of the Solar System

Others:

- Pluto - forget it. It's half the size of our Moon and about 5 billion KM from the Sun - you aren't going to see it with your little scope.
- Ceres - Did you know Ceres was once listed as a planet and now is considered a Dwarf Planet? It's almost Magnitude 9, so if you are in a very dark, clear location, you MIGHT be able to spot it with a good scope and location, but you won't see it naked-eye ever. If you would like to try, on May 4th, it will be quite close to the crescent moon at about 2130



# Observing the Moon and Planets of the Solar System

Next Week: Stars, Gas, Dust and Pretty Pictures