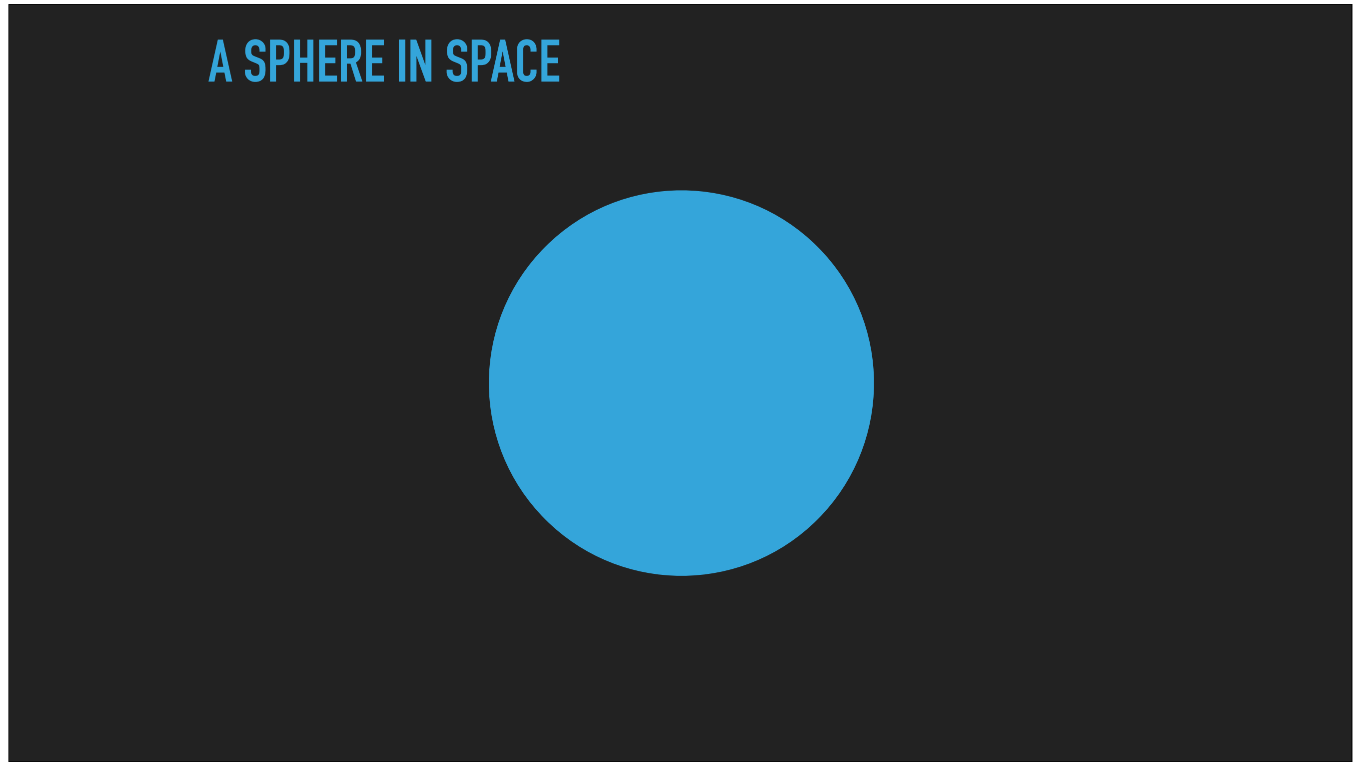
NOW:

TIME

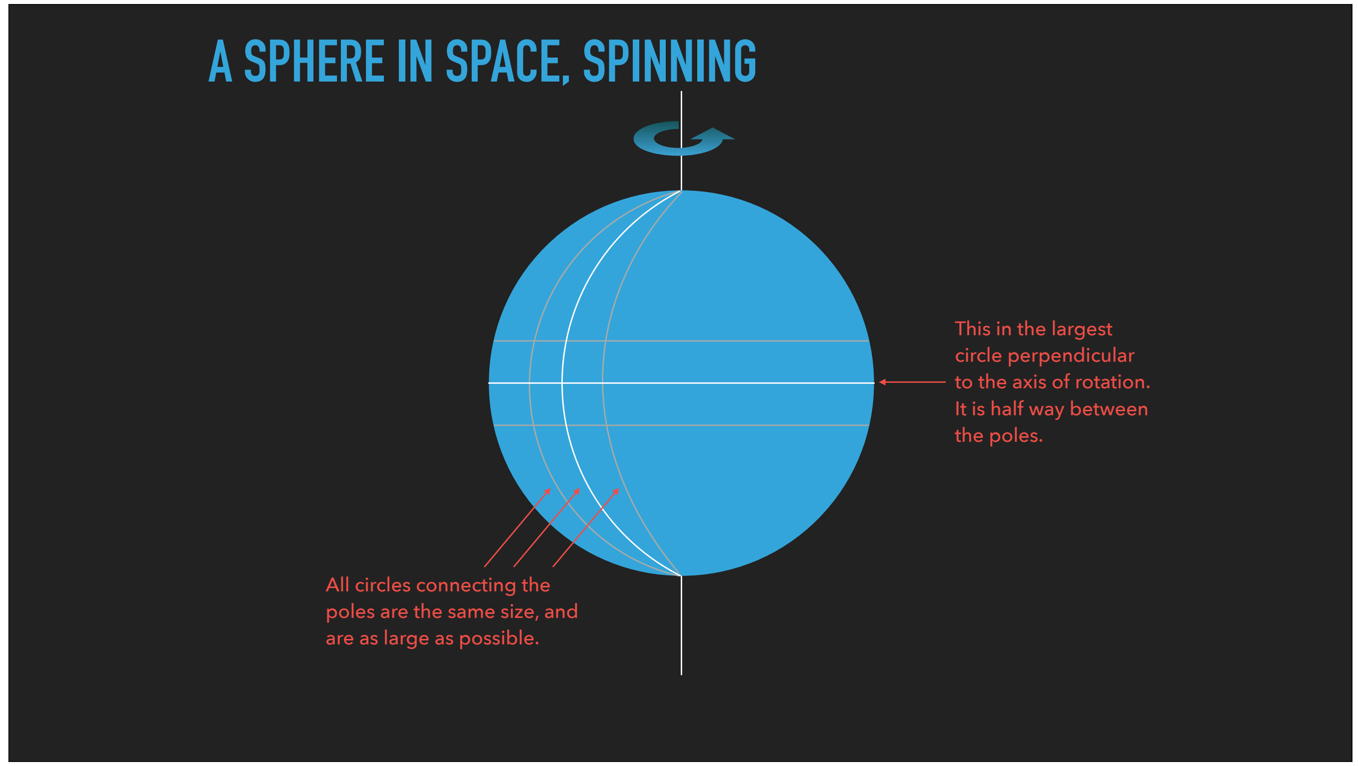
[redacted]

SPACE

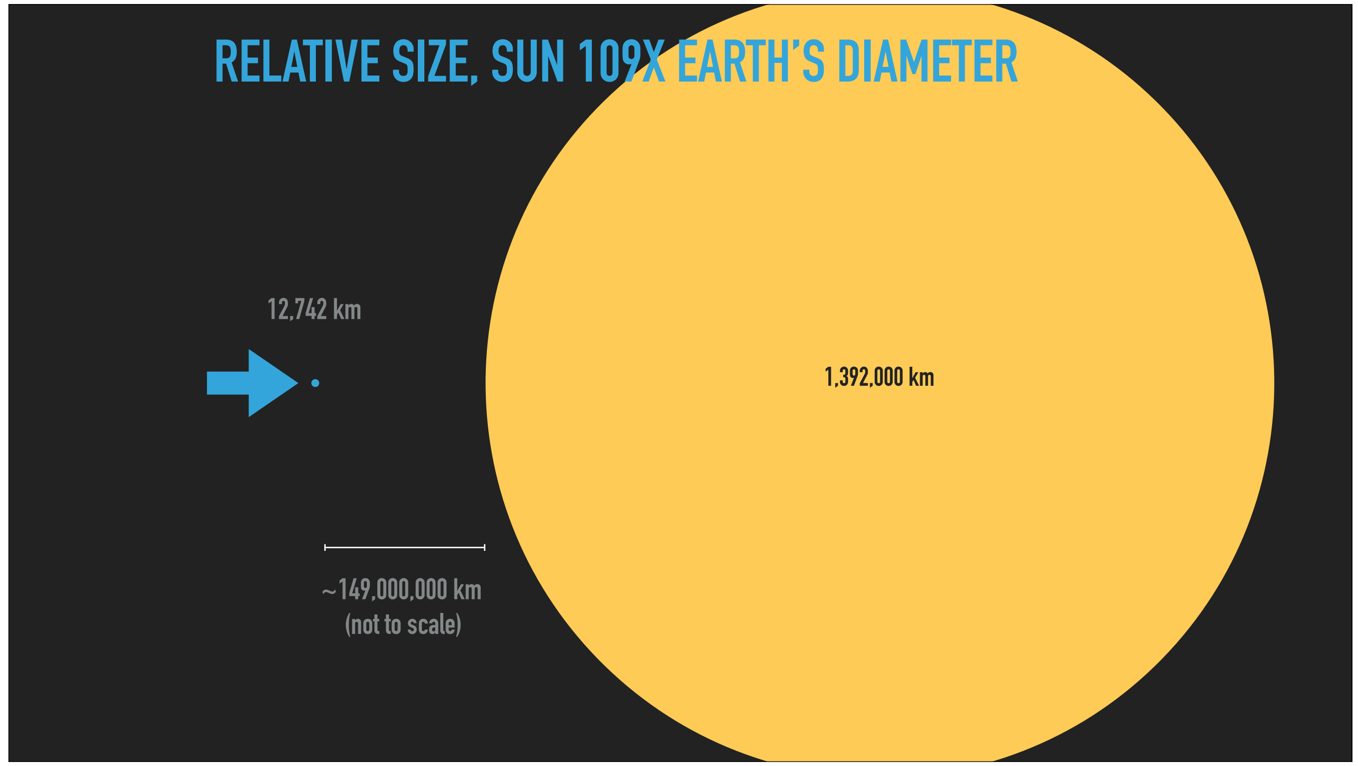
Empty space - even that’s up for debate (Newton, Einstein). Leave that aside for now.



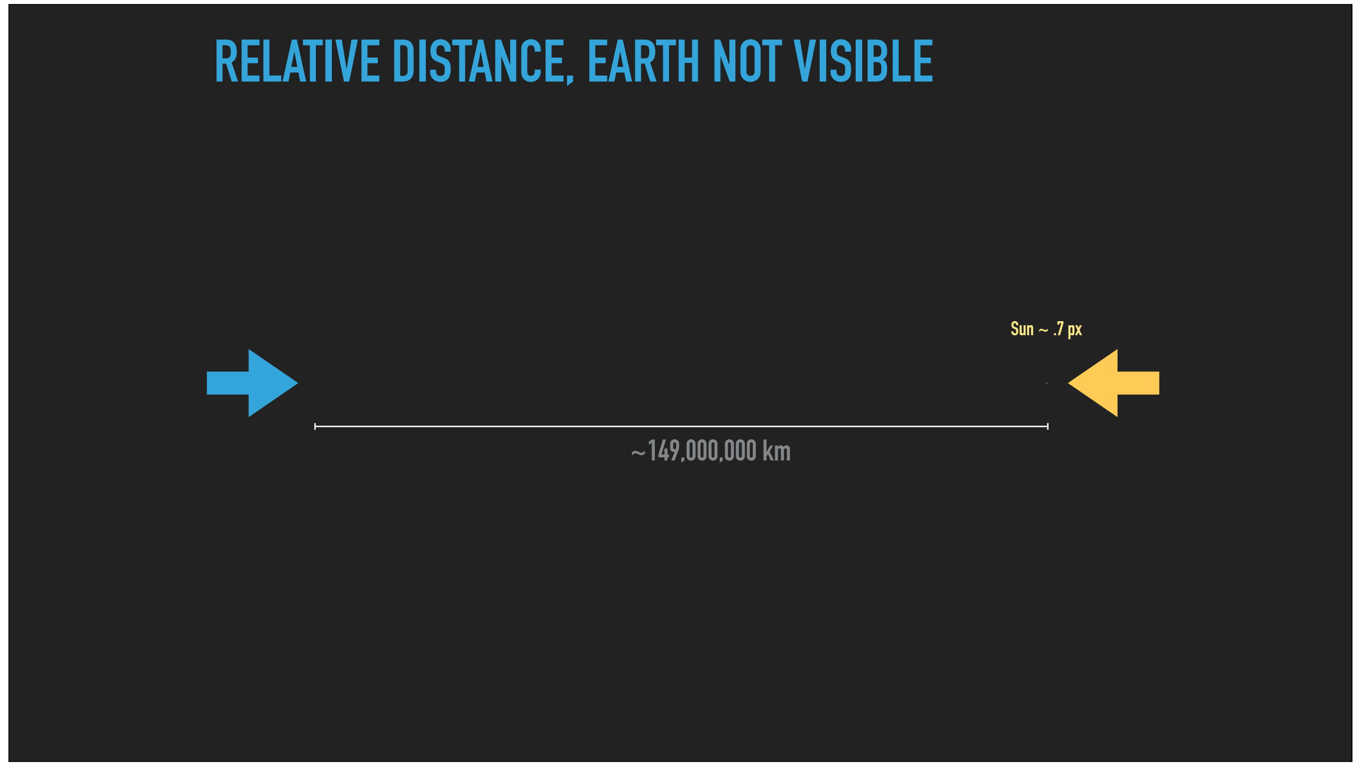
Empty space, plus a sphere.



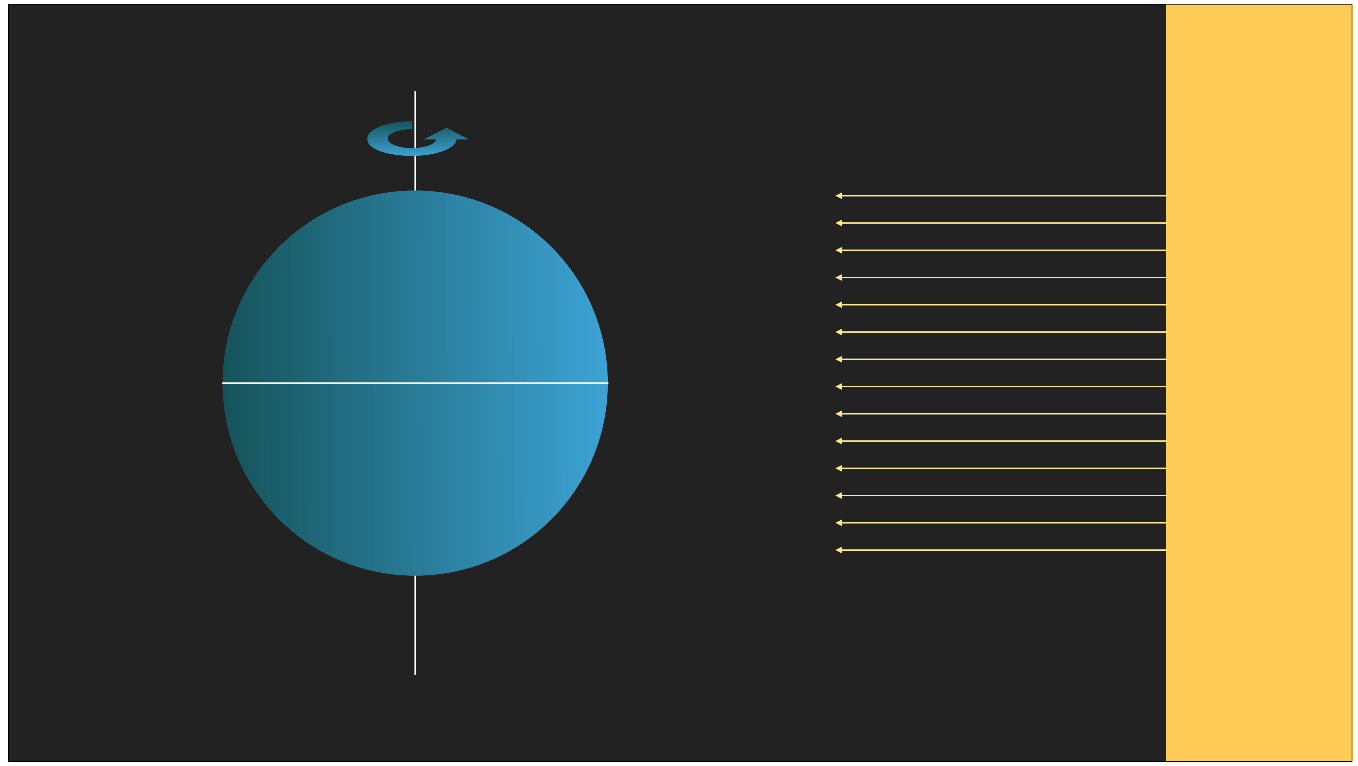
Rotating the sphere introduces, in and of itself, special attributes to the sphere: for example, an equator perpendicular to the axis of rotation and lines of longitude connecting the poles.



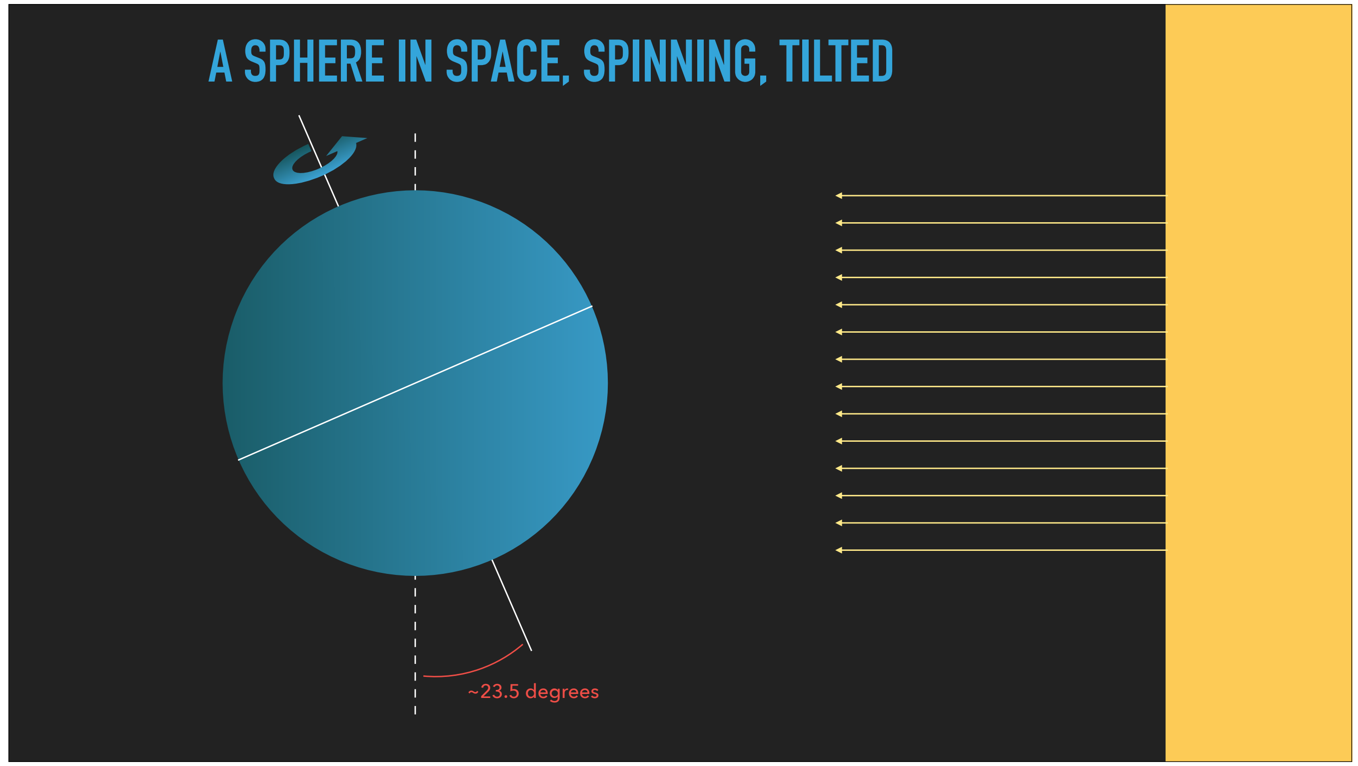
Let's place the Earth in context, starting with the brightest local neighbor: The Sun. The relative size of the Earth and Sun.



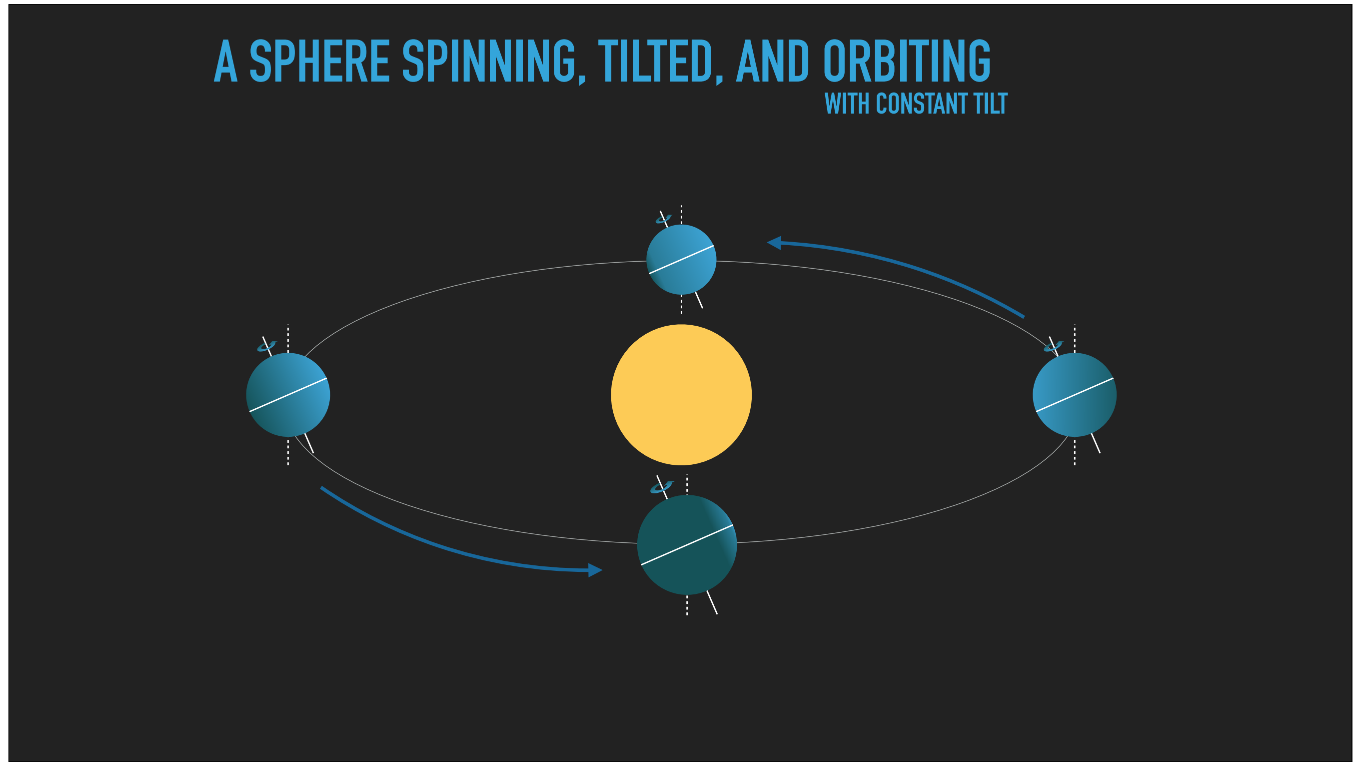
The relative distance between the Earth and Sun. The Sun is smaller than a pixel and the Earth is not shown.



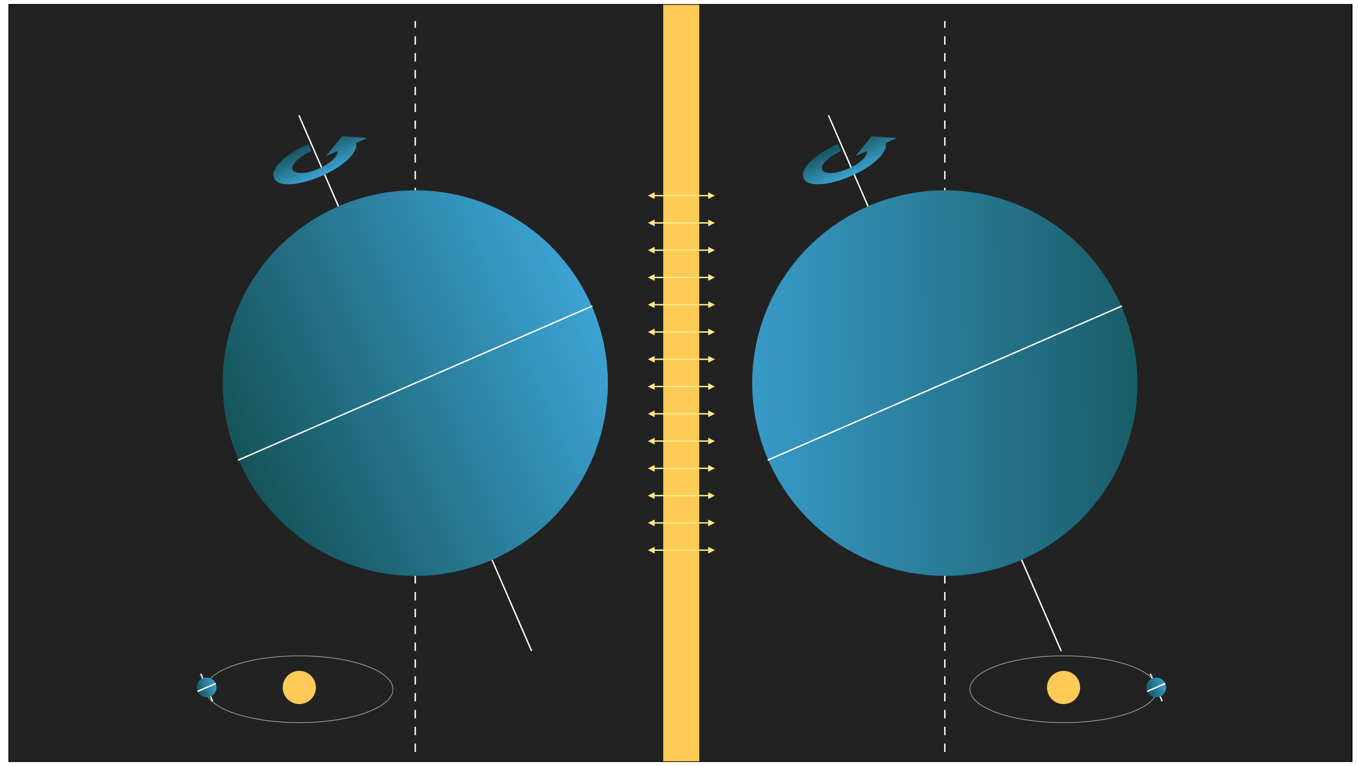
Here’s our s[here again, lit up. The Sun is so large we can consider the light rays from the sun as if they are parallel from a distant “wall” when they strike the earth.



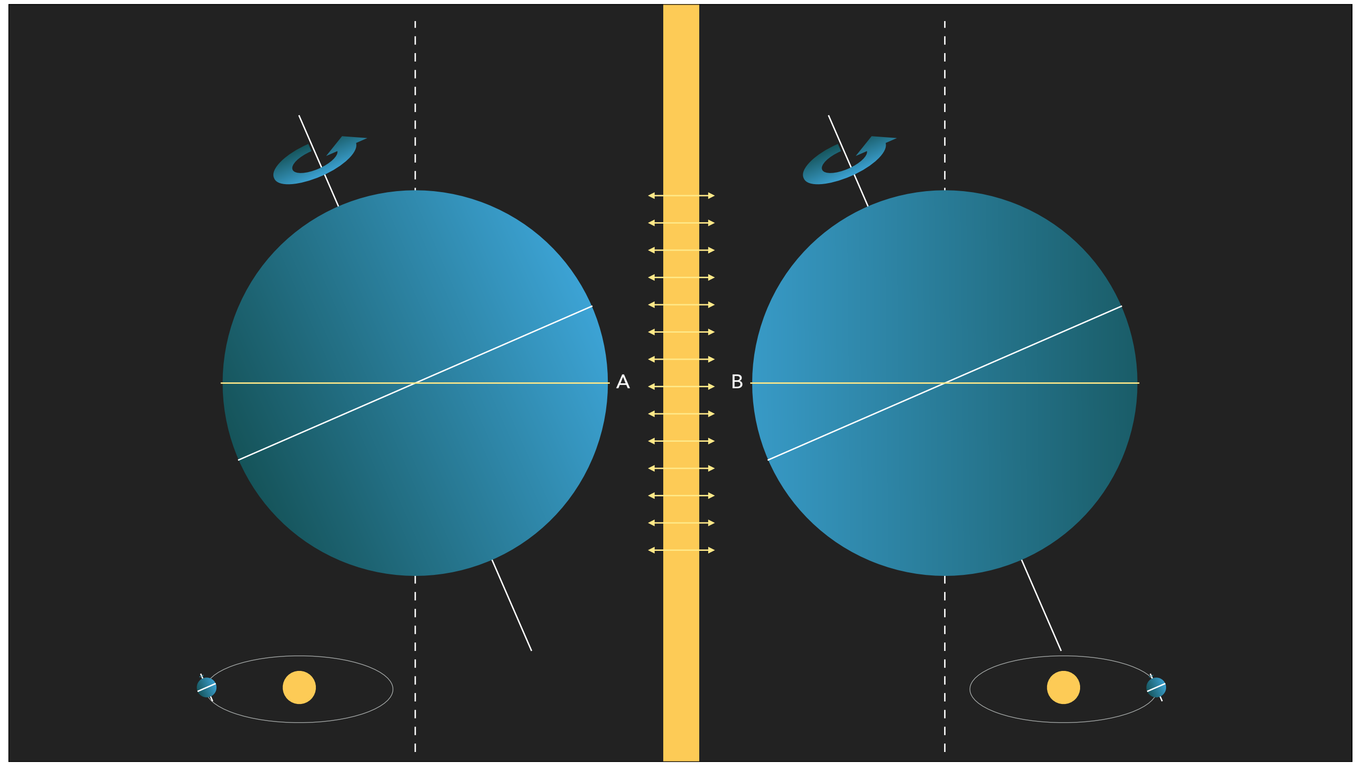
The Earth’s axis of rotation is tilted relative to the path of light from the sun.



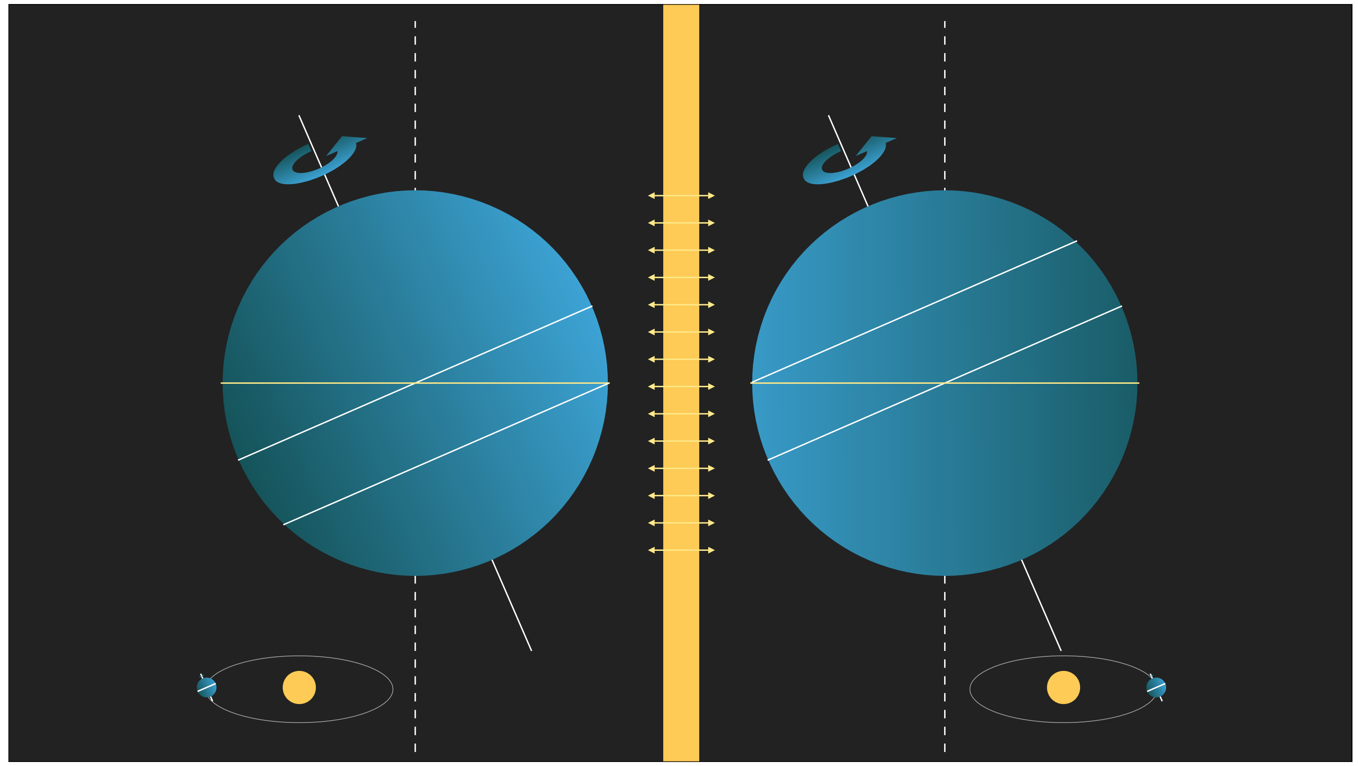
That tilt stays constant in space as the Earth orbits around the Sun. The north pole of the axis points towards Polaris, the North Star



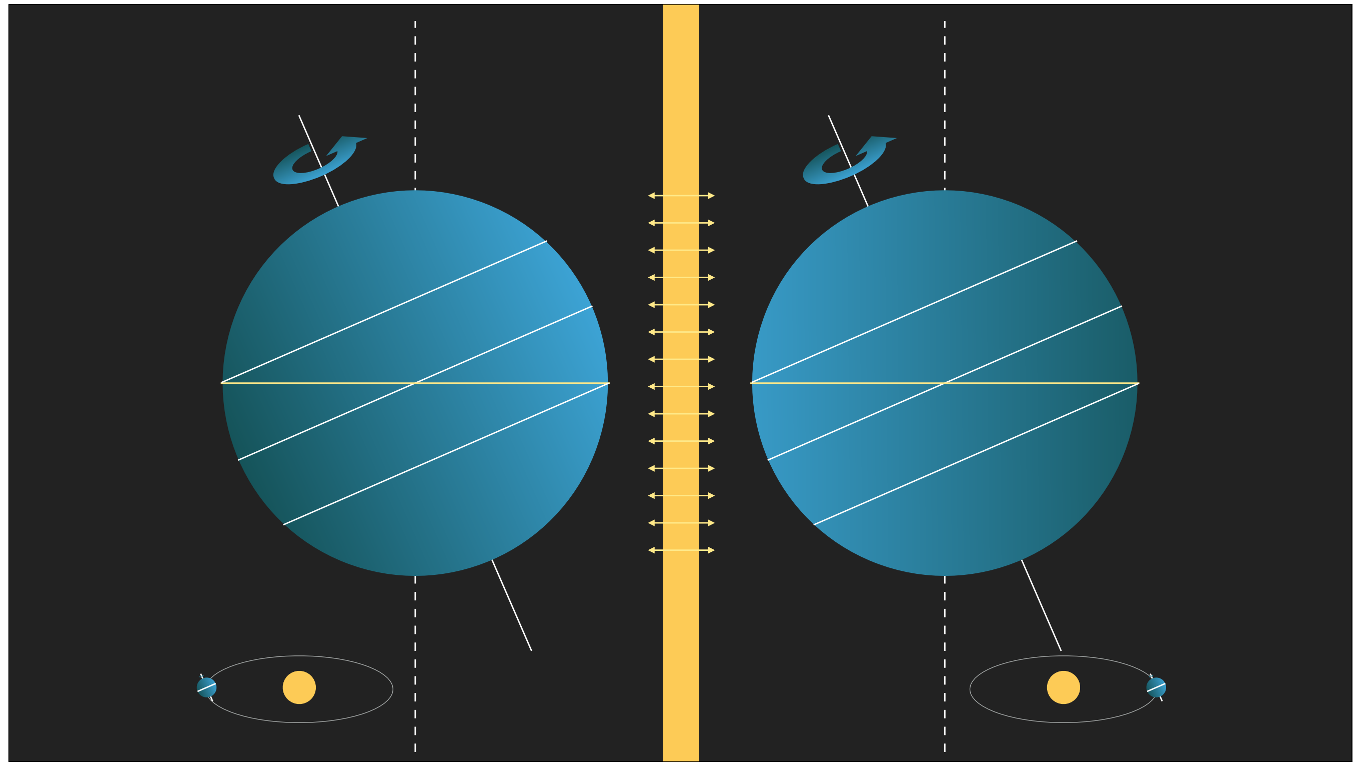
Here we see two extremes of the Earth's orbit, and it's position relative to the sun.



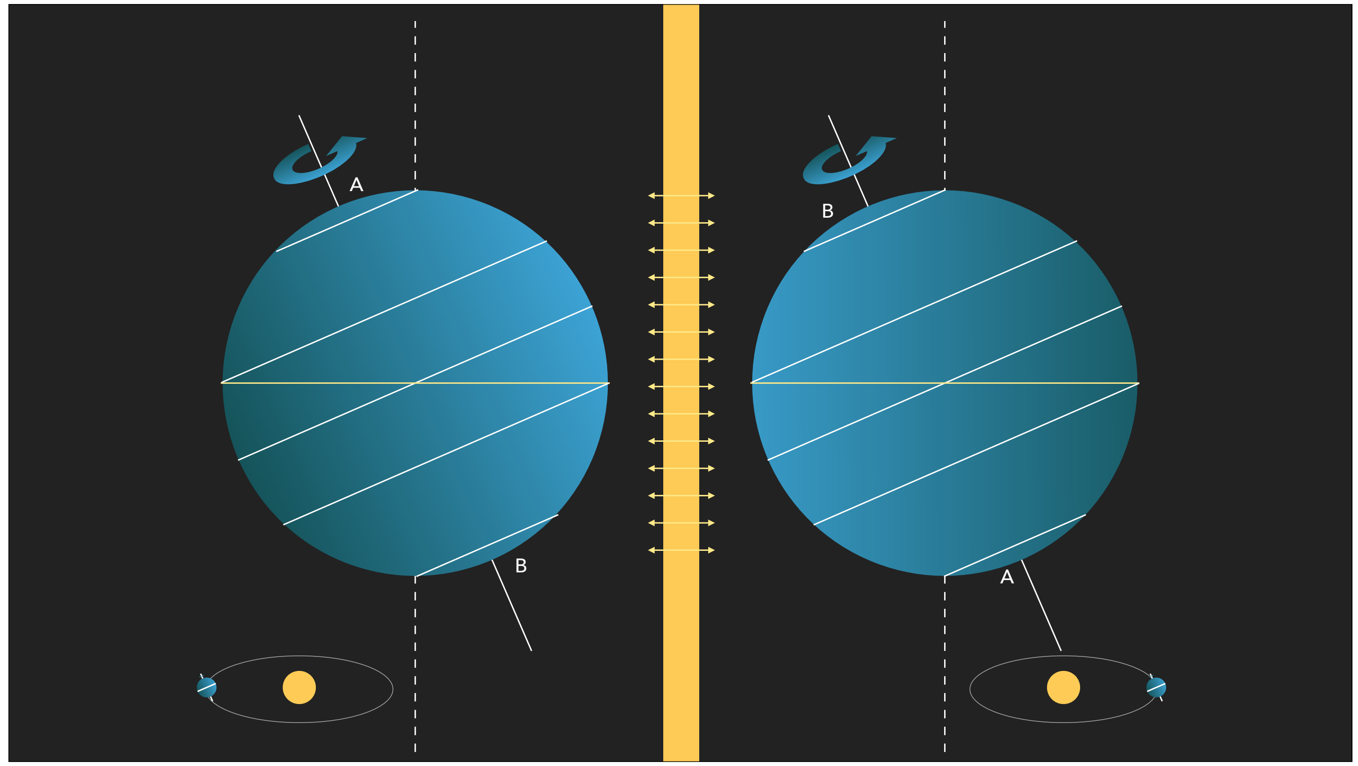
We can start finding interesting points on our Earth that emerge from the Earth's tilted rotation and its orbit. Consider the direction of sunlight on our globe. At points A and B on the Earth, the sun appears directly overhead at noon.



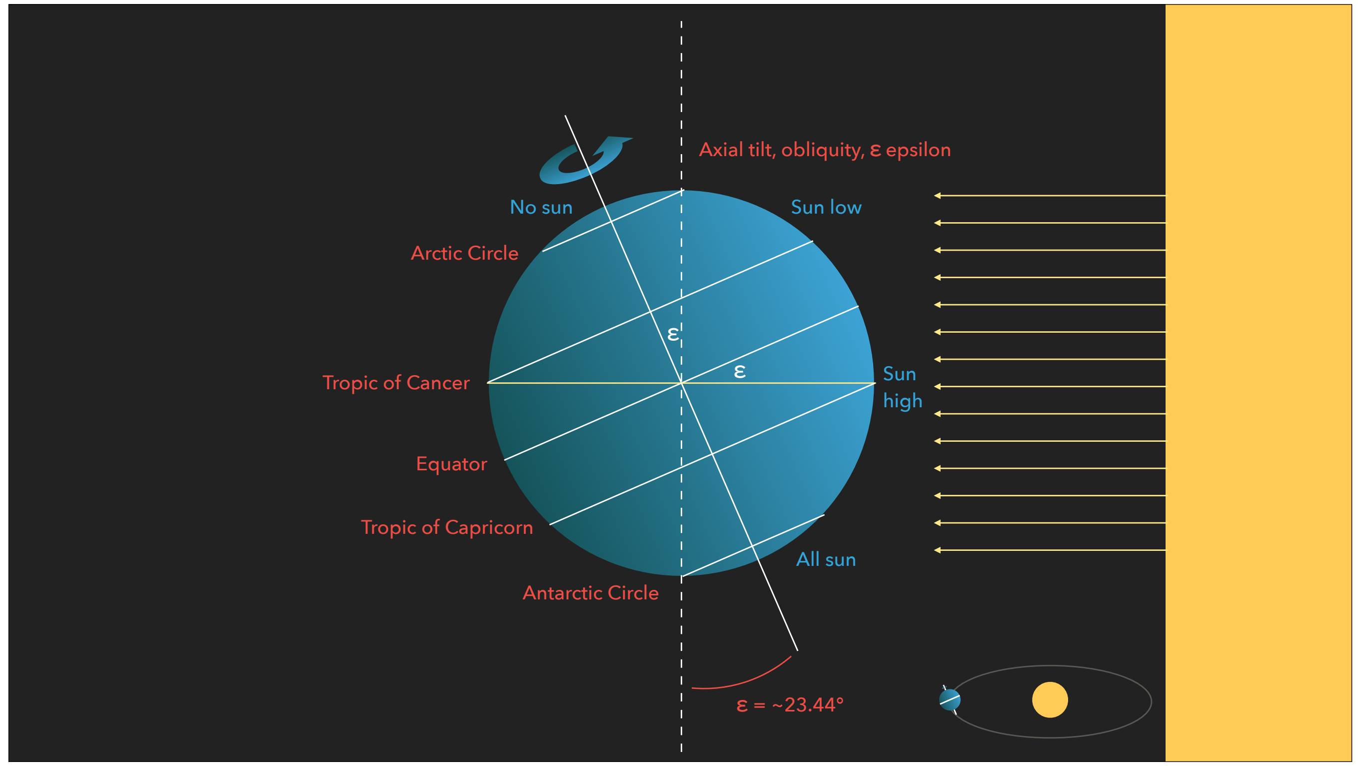
Remember, the Earth is rotating, so let’s trace those points as the Earth rotates



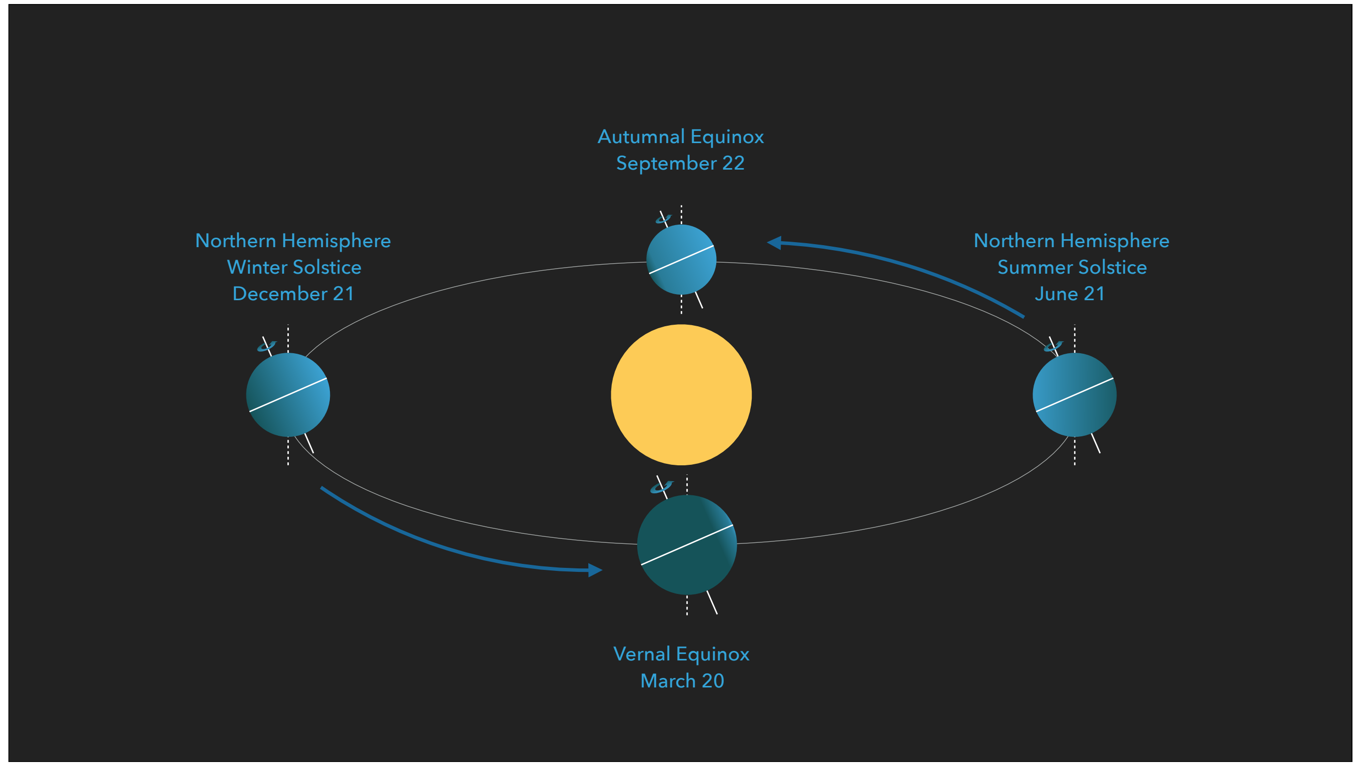
These are the Tropics - within this band, the Sun will appear directly overhead (90 degrees from the horizon) at some point in the year. Beyond those points - to the North and South, the sun will never appear directly overhead, but rather somewhat less than 90 above the horizon at its highest.



We can also see that there are regions that will either be totally dark (A) or totally illuminated (B), no matter how much the Earth rotates. (Remember, this will gradually change as the Earth orbits the sun - we are seeing two extremes of the orbit.)



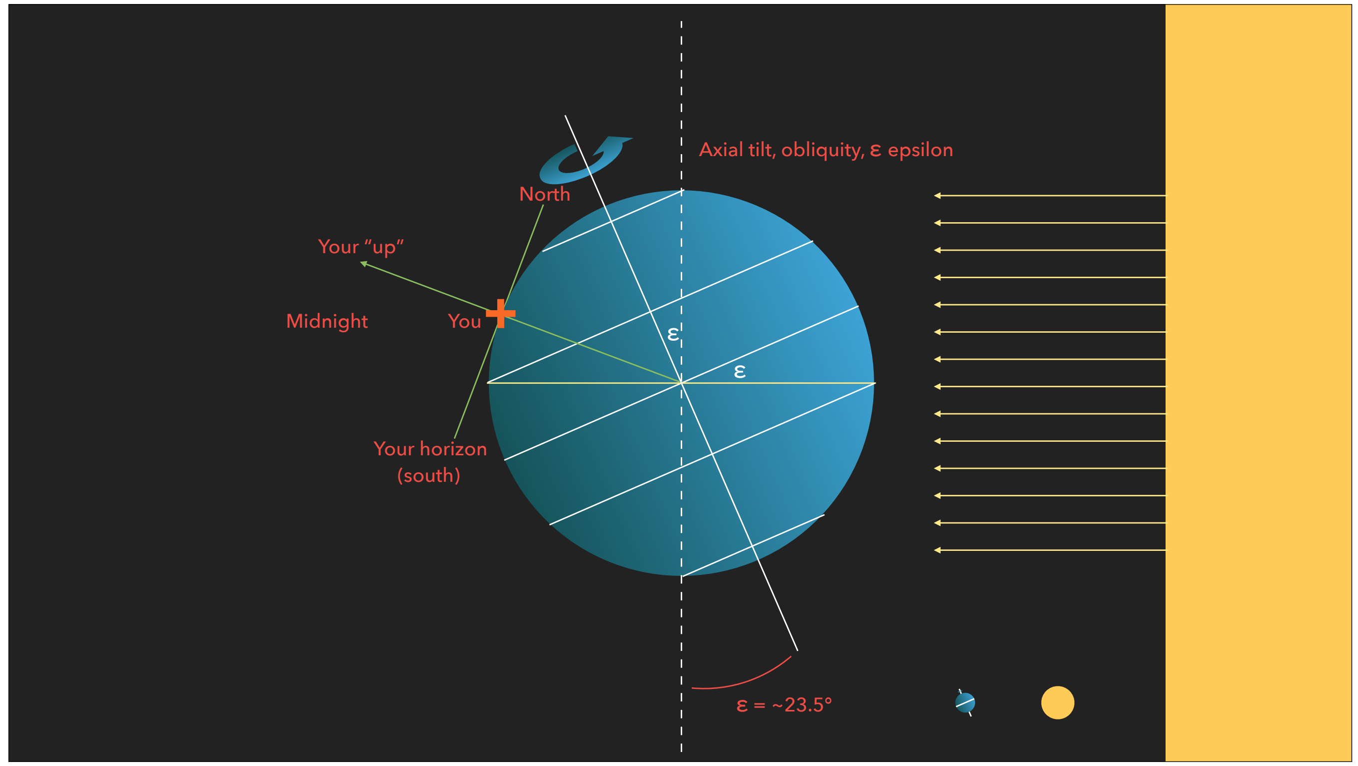
Here’s the Earth with the lines we found given their proper names - The Arctic and Antarctic Circles, the Tropics of Cancer and Capricorn.



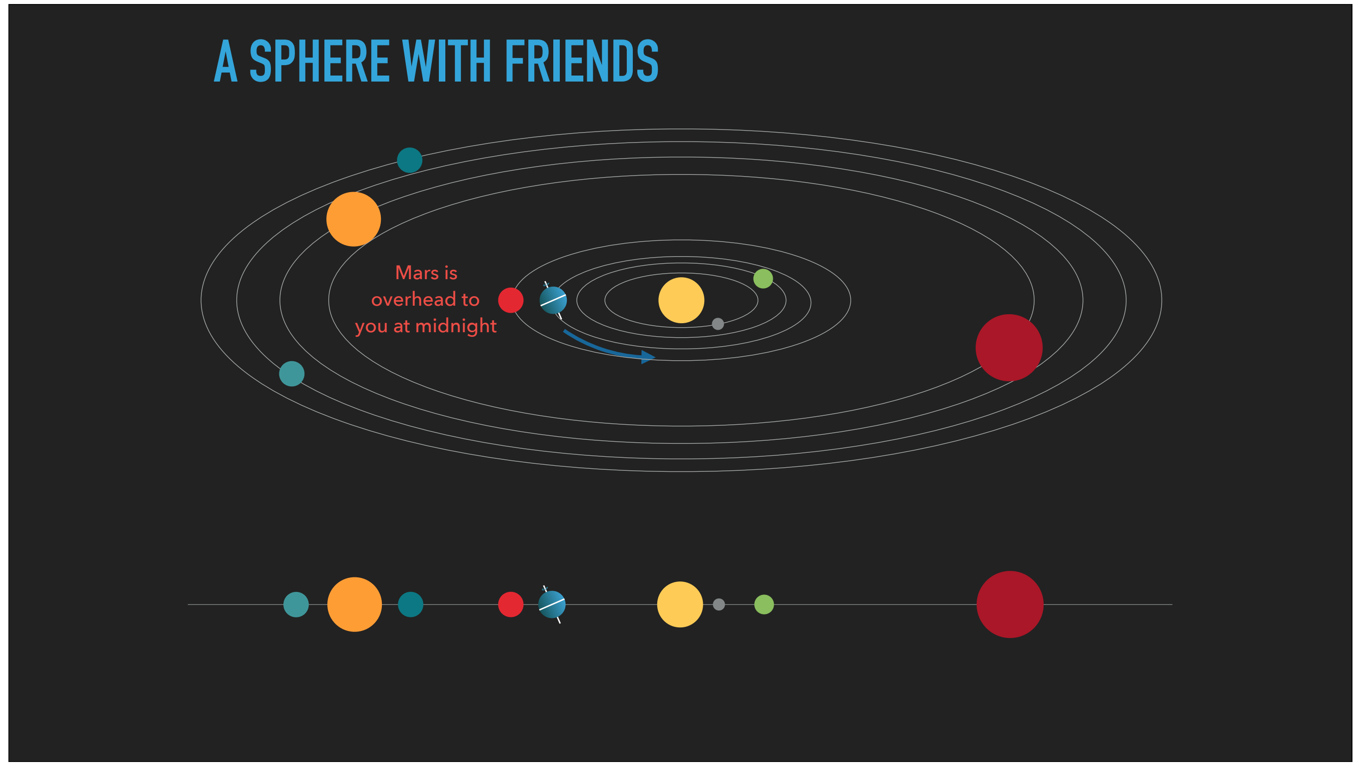
The two extremes we've been considering are the summer and winter solstices. In the northern hemisphere summer solstice, the sun at it's highest (solar noon) will be the highest in the sky it will get all year, and the day will be the longest. At the winter solstice, the noon position of the sun will be it's lowest of the year, and the days will be the shortest. Between these extremes the noon height of the sun and the length of the day vary as the Earth orbits. When the night and day are equal length, we have the spring or summer equinox. In this way, the tilt of the Earth defines a kind of North/South/East/West for the Sun in space.

(PHEW)

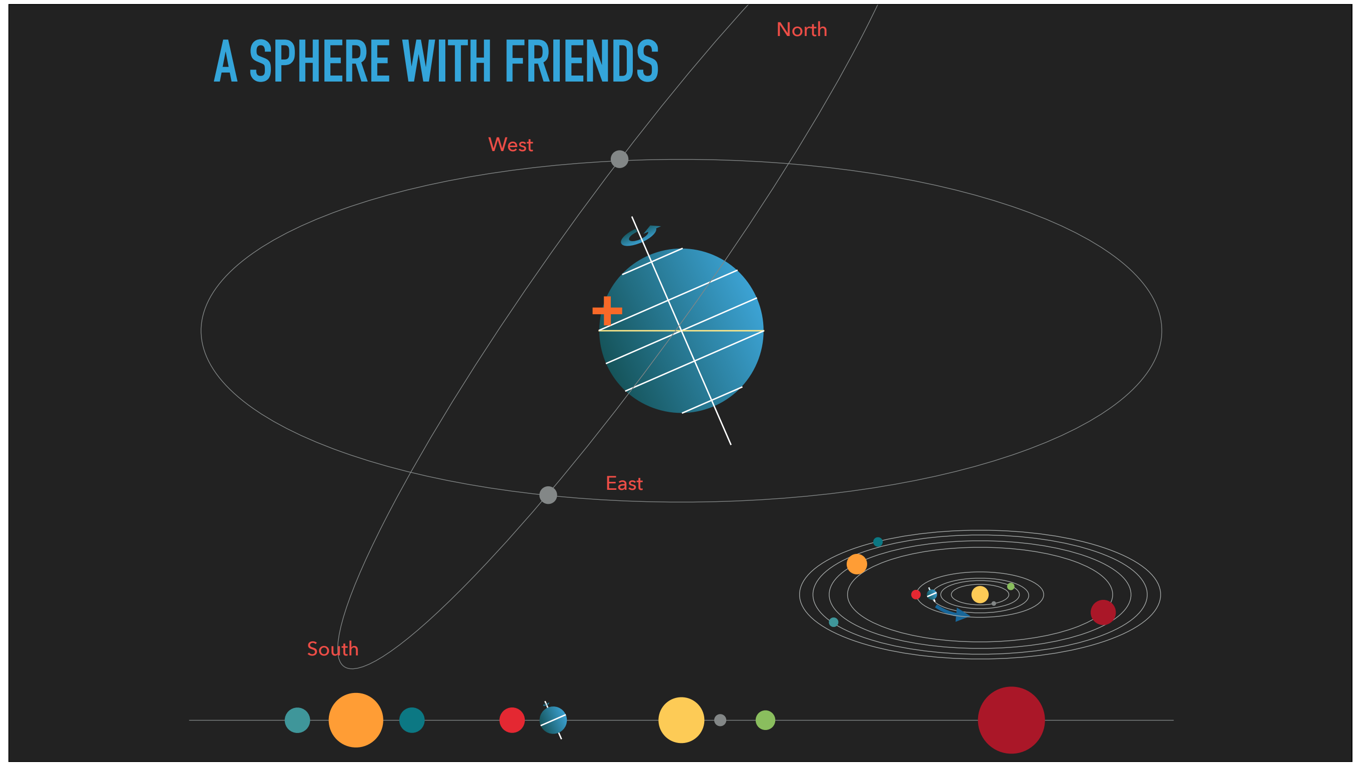
Stand up - stretch!



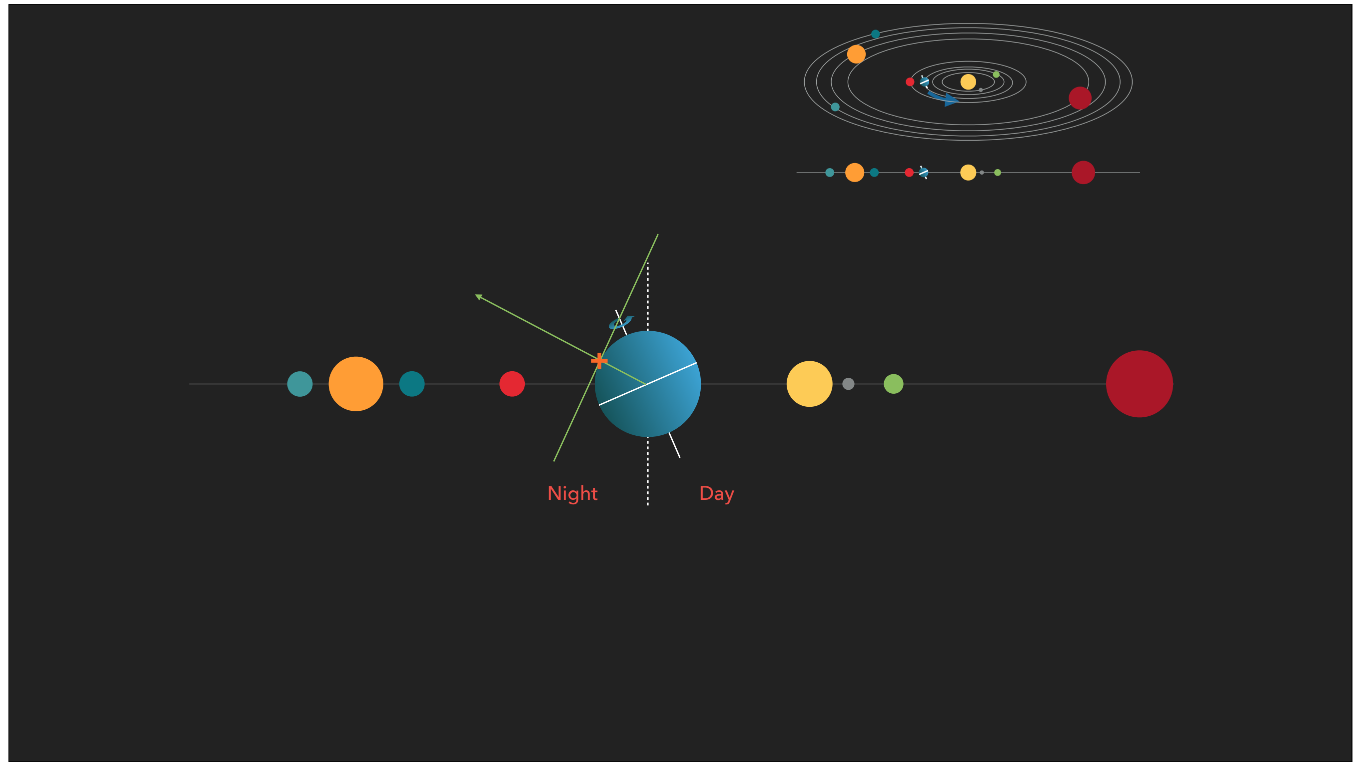
OK - whenever we look at a diagram like this, it can help to imagine that we are somewhere on the surface of the Earth. Our "Up", horizon, and cardinal directions are related to our position on the Earth. These affect what part of the sky we can see.



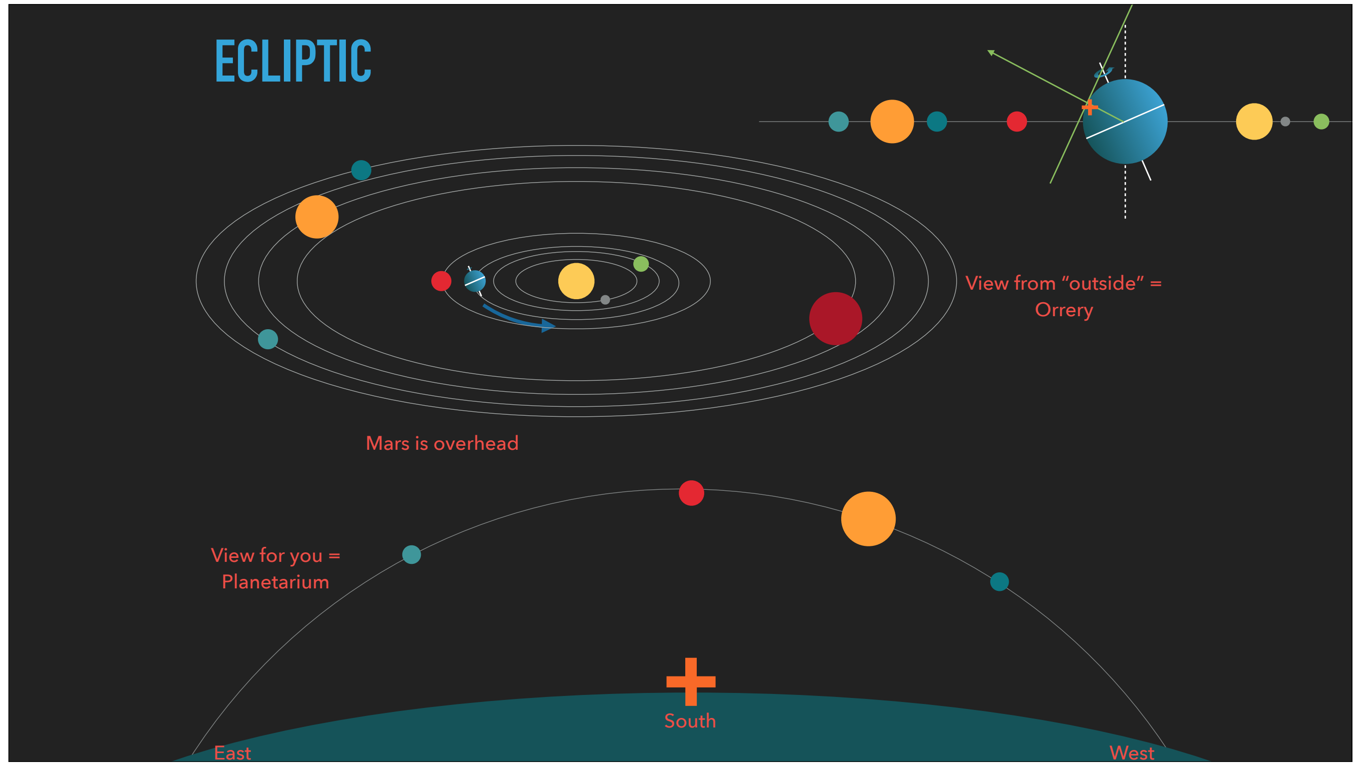
An artifact of how the solar system formed is the fact that all the planets lie more or less in the same plane, and orbit in the same direction.



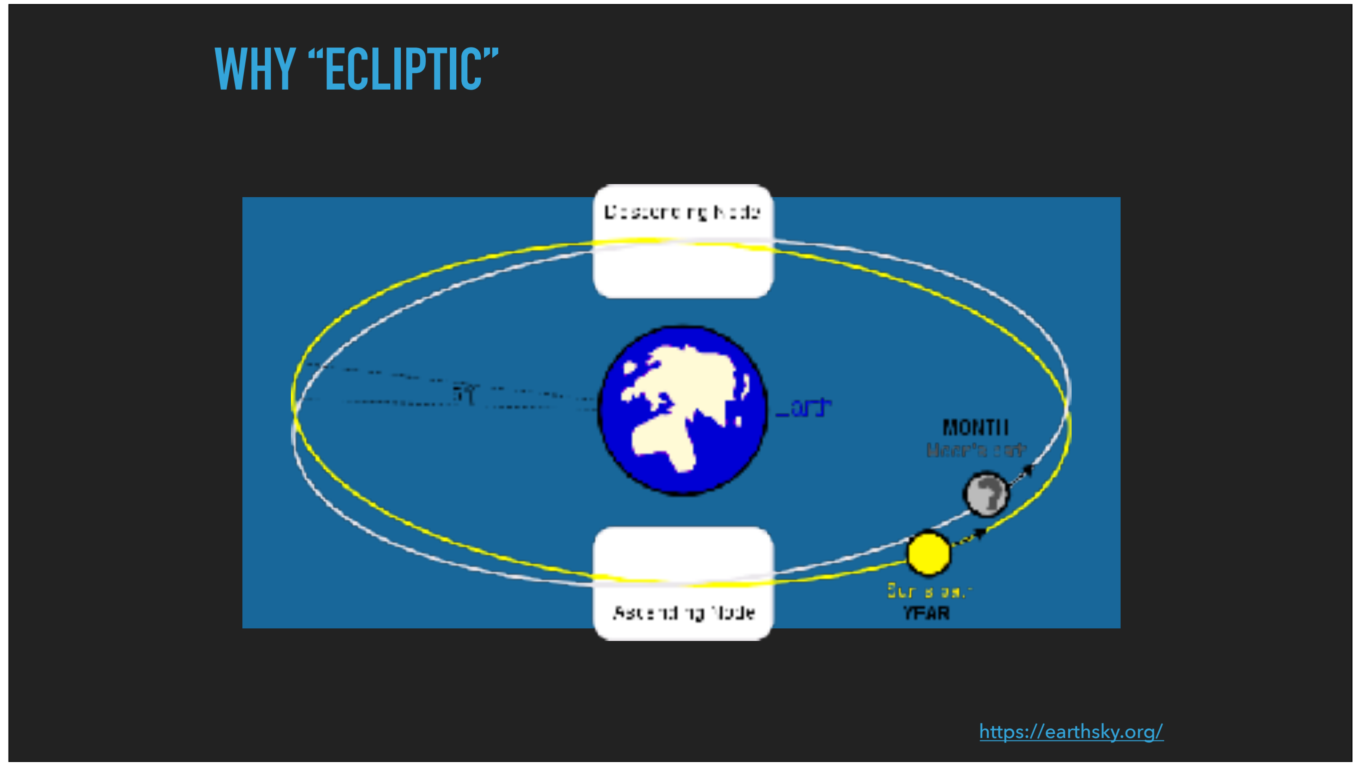
It’s not easy to do - but we need to try to imagine two different perspectives on the solar system: The one from “outside”, as if looking down on the whole system; and the one from our viewpoint as a person on the Earth looking up at the night sky.



As depicted, some of the planets (e.g. Mars, Saturn) are overhead at night for an observer at the point marked. Others, on the daylight side of the Earth (e.g. Venus, Jupiter) will not be visible at night (nor will the Sun because that's what "at night" means).



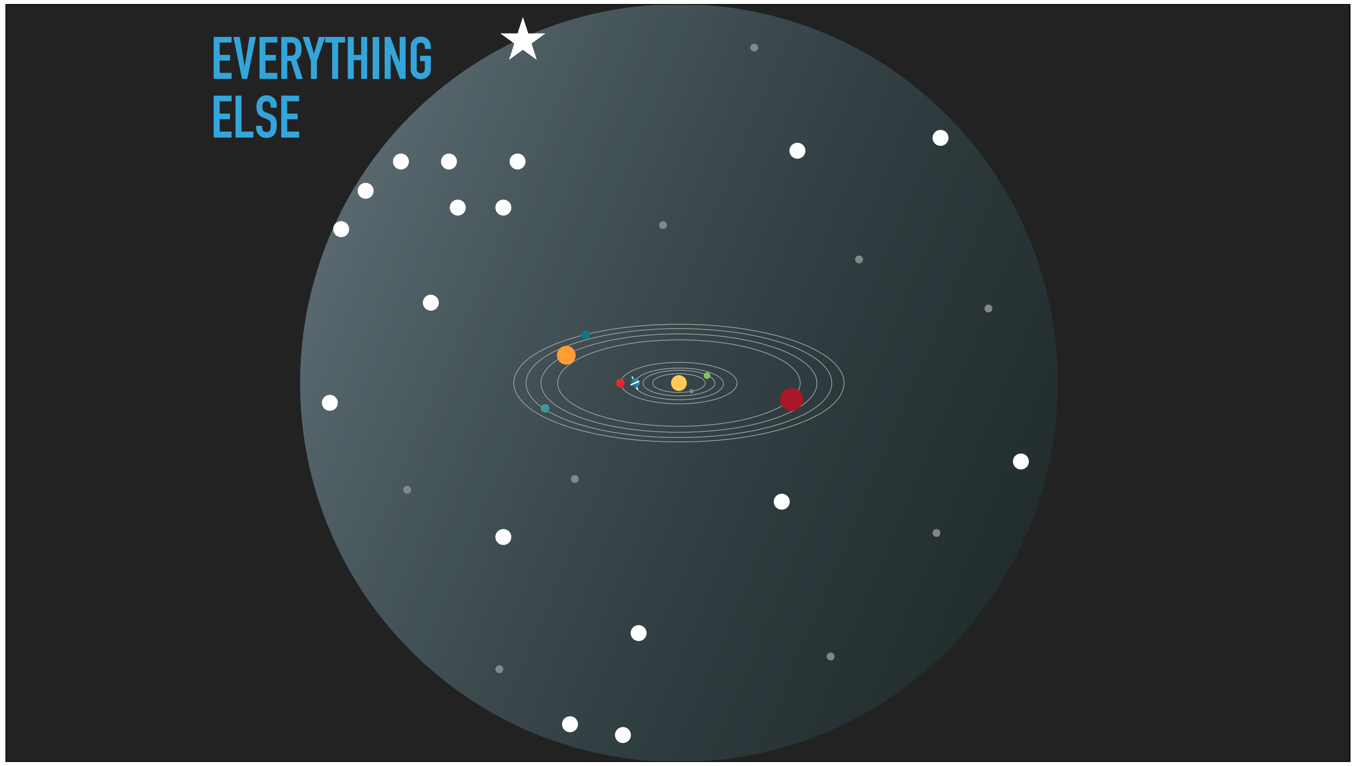
So - the visible part of the plane that all the planets lie near becomes a curved arc from ~East to ~West in the sky as seen from Earth. This special path has all the action in the sky: It is where the Sun and moon will be seen, and at night it is where any planets visible at night will be. The seasonal zodiac constellations also lie here, for reasons we'll learn in part three. The arc is always separated by 180 degrees but the exact points it crosses the horizon vary throughout the day as the tilted Earth rotates. (This aspect I find very hard to visualize, but it's true!).



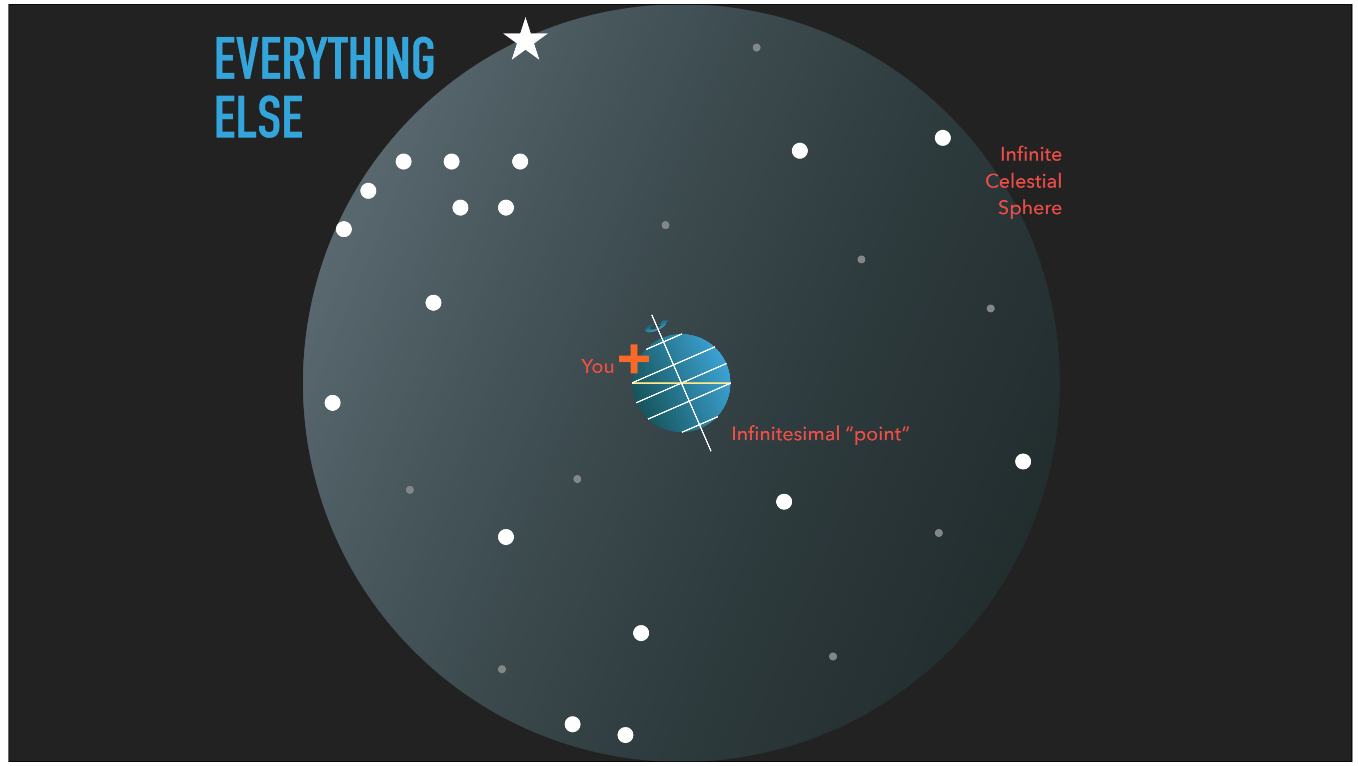
This path is called the “ecliptic”. So far, we’ve ignored the moon (!), but like the planets, it orbits the Earth approximately on the same plane, diverging by a few degrees. When the a new or full moon falls on the ecliptic, there is a solar or lunar eclipse.

(PHEW X 2)

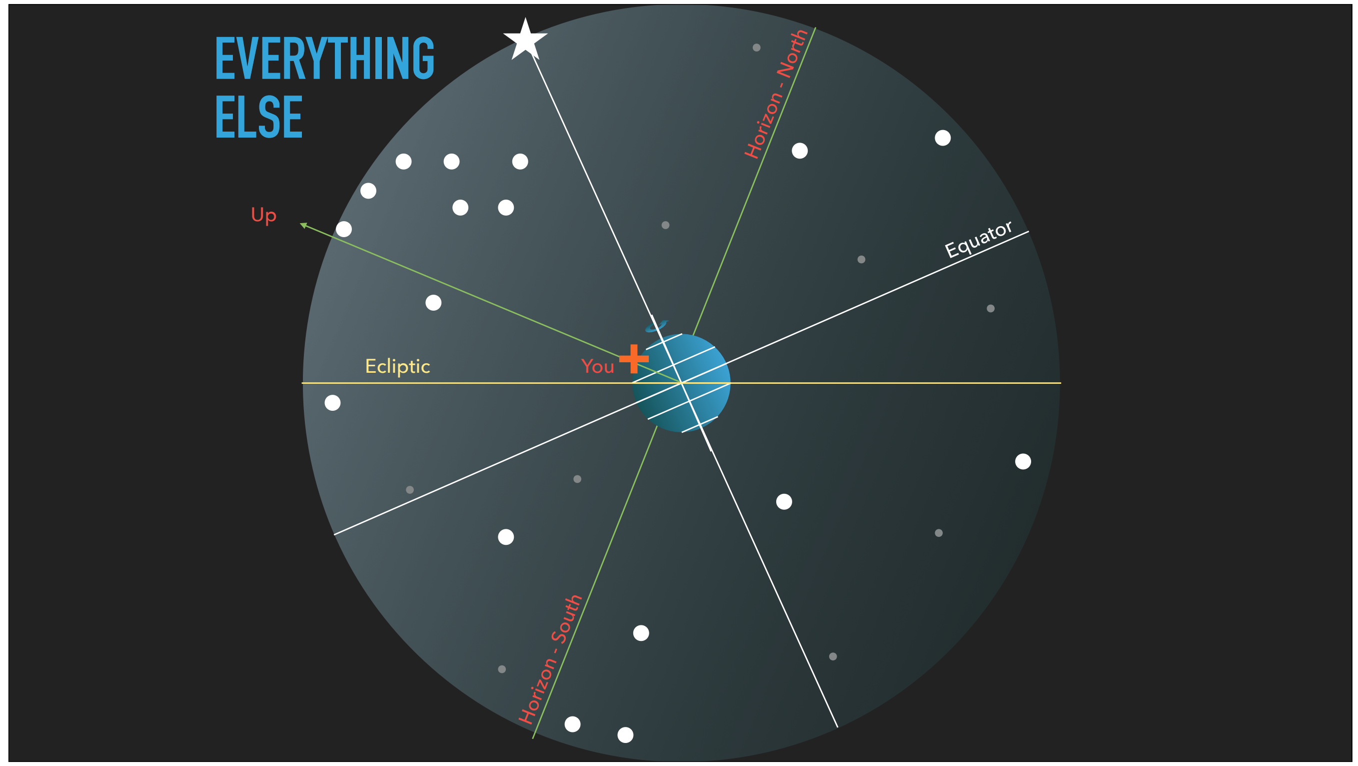
Another break!



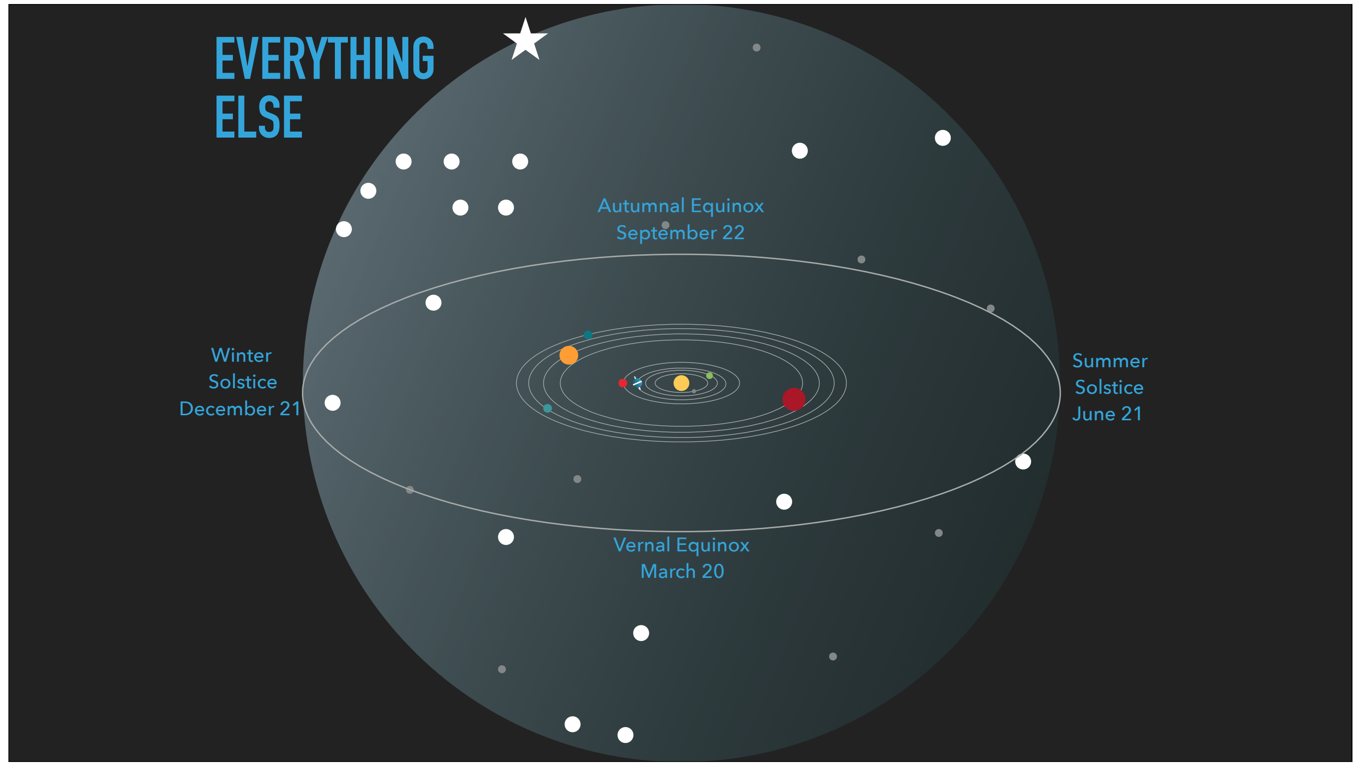
What about the stars?



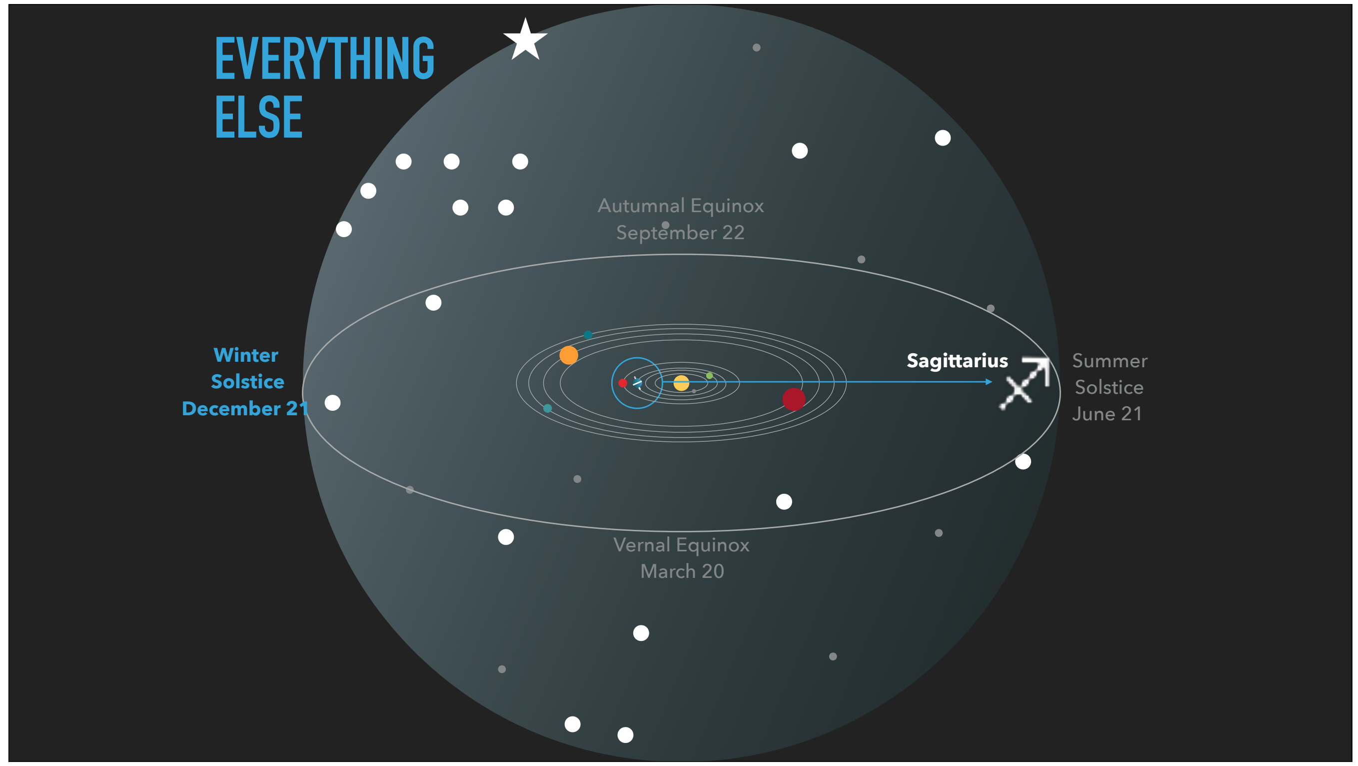
Any star is so far away relative to the size of the Earth that we can pretend that the Earth is an infinitesimal point at the center of a vast, infinite “Celestial Sphere” who’s surface holds the stars. Everything except the planets, moon and Sun appear to be fixed in position and moving together (at human timescales), so the starry sky is sometimes called the Firmament.



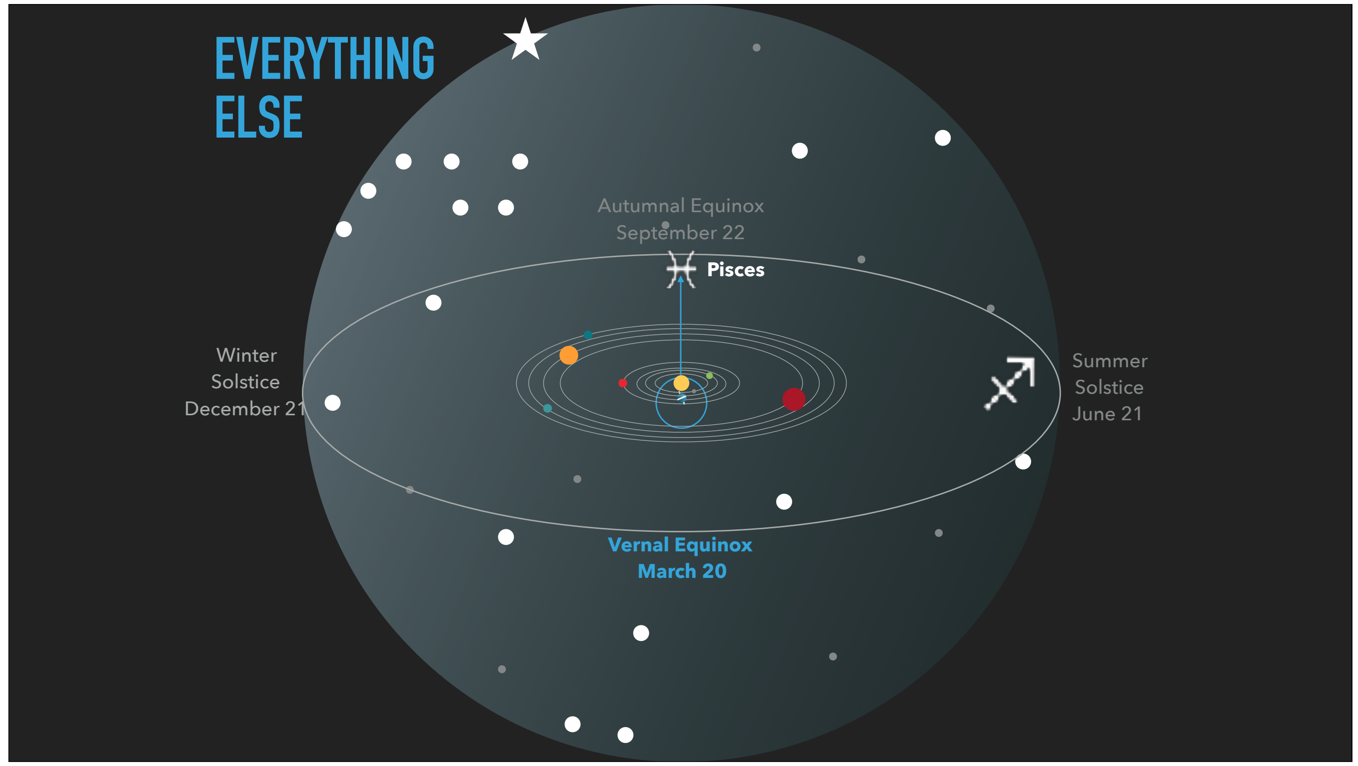
We can project lines on the Earth out onto the Celestial Sphere. The axis of the Earth points almost exactly at Polaris, the North Star. We can see things above our local horizon, and lines like the Ecliptic or the Equator help us orient our position amongst the stars.



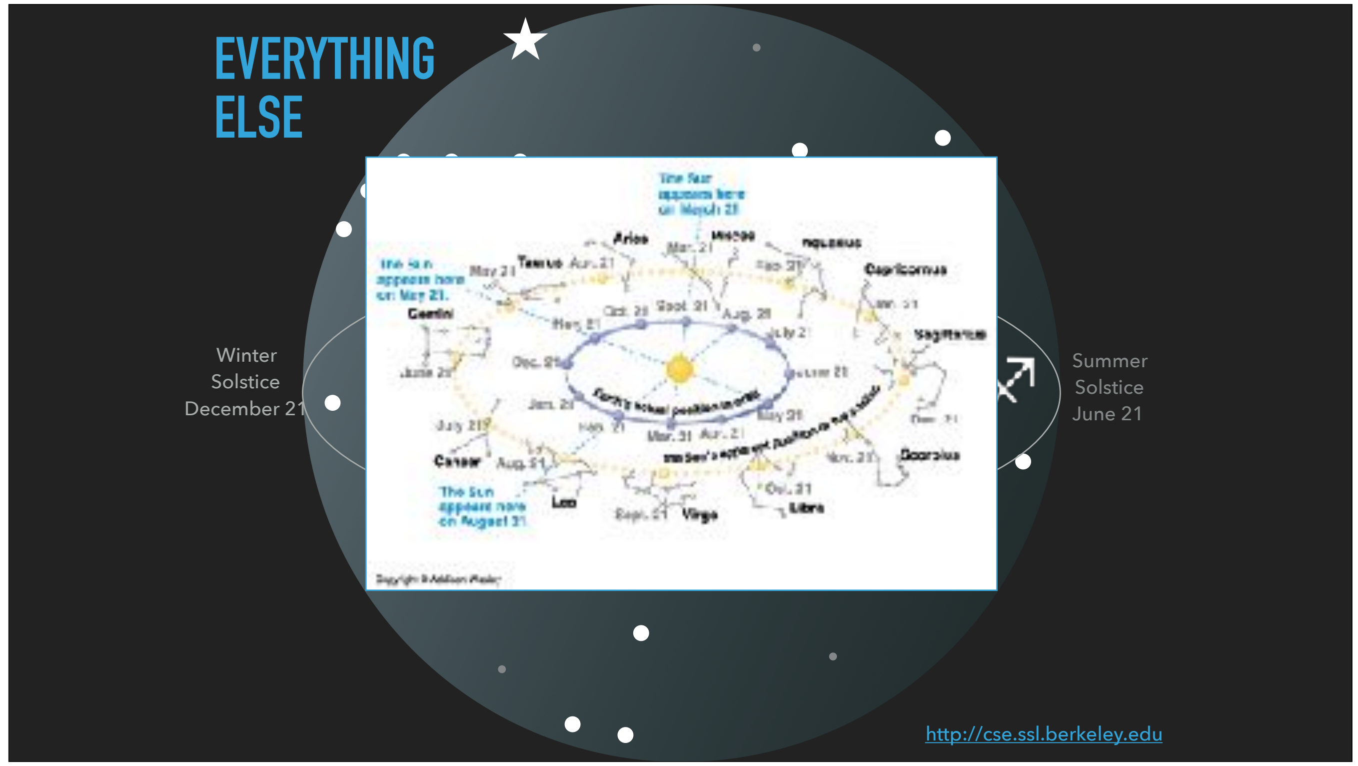
Because Earth's tilt is constant as it orbits, and that tilt gives rise to the solstices and equinoxes, those points are fixed reference points in the celestial sphere.



The zodiac constellations are notable star formations that lie along the ecliptic. These have been noted by many cultures since the planets, sun and moon travel along the ecliptic, as if they “live” amongst those constellations. The seasonal zodiac signs correspond to the constellation the Sun would appear to be in, if we could see stars during the day.

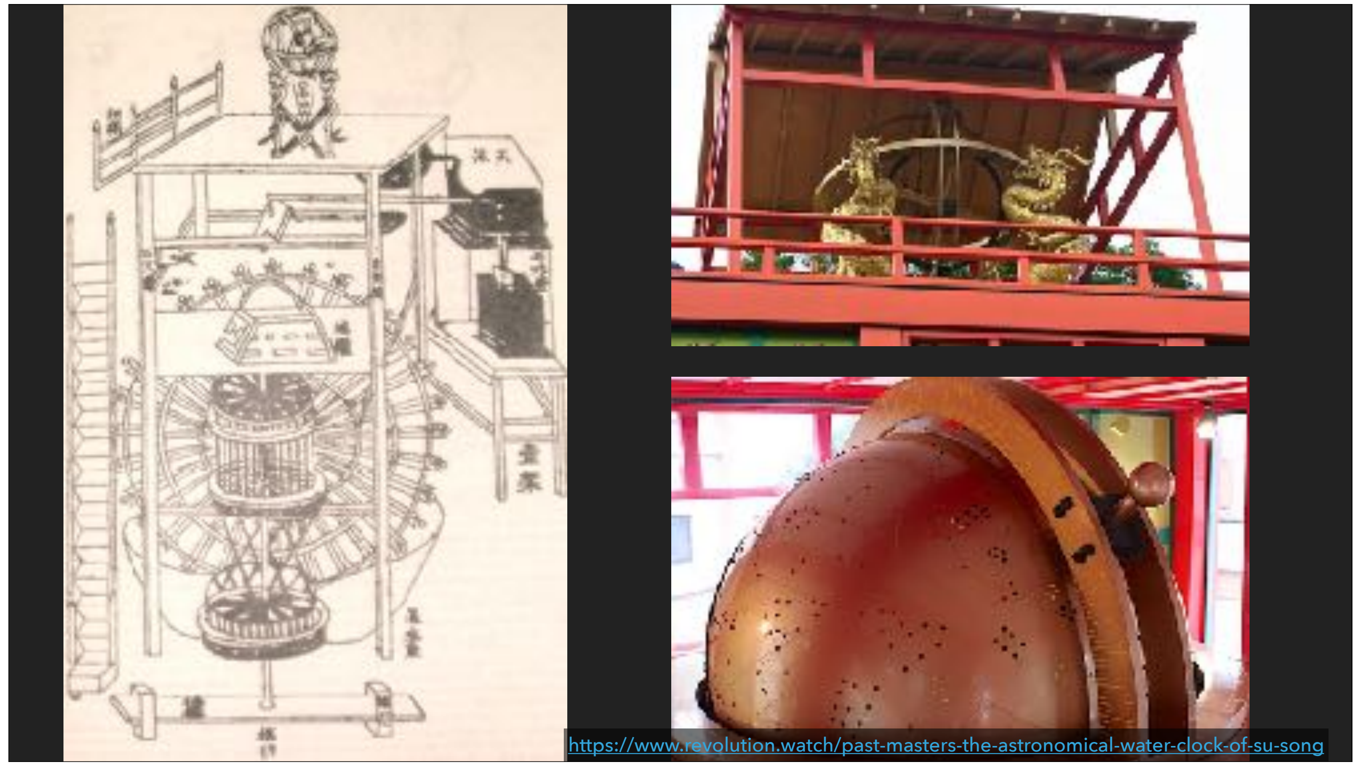


We can associate dates, zodiac signs, and solstice/equinox points.



This chart shows all the signs and dates.

(PHEW X 3)



So - why all this astronomy? Because people have forever, everywhere looked up at the sky and tried to find patterns in the movements of the sun, moon, planets and stars. Because of the particular nature of our Earth, how it rotates, how that rotation is tilted relative to the sun, how it orbits the sun, etc… we have a symphony of overlapping patterns and periods. How many rotations of the Earth in one orbit around the sun? How many orbits of the moon in the same? As the planets also orbit the orbiting rotating Earth, they will sometimes seem to advance East to West against the firmament, and sometimes move “backwards” from West to East in apparent retrograde motion. Thus the planets are called the “wandering stars” or the “wanderers”. The artifacts and maps people have made to keep track of these patters are beautiful. Here are a few.

SU SONG ASTRONOMICAL WATER CLOCK

01094 CE, FIRST ESCAPEMENT

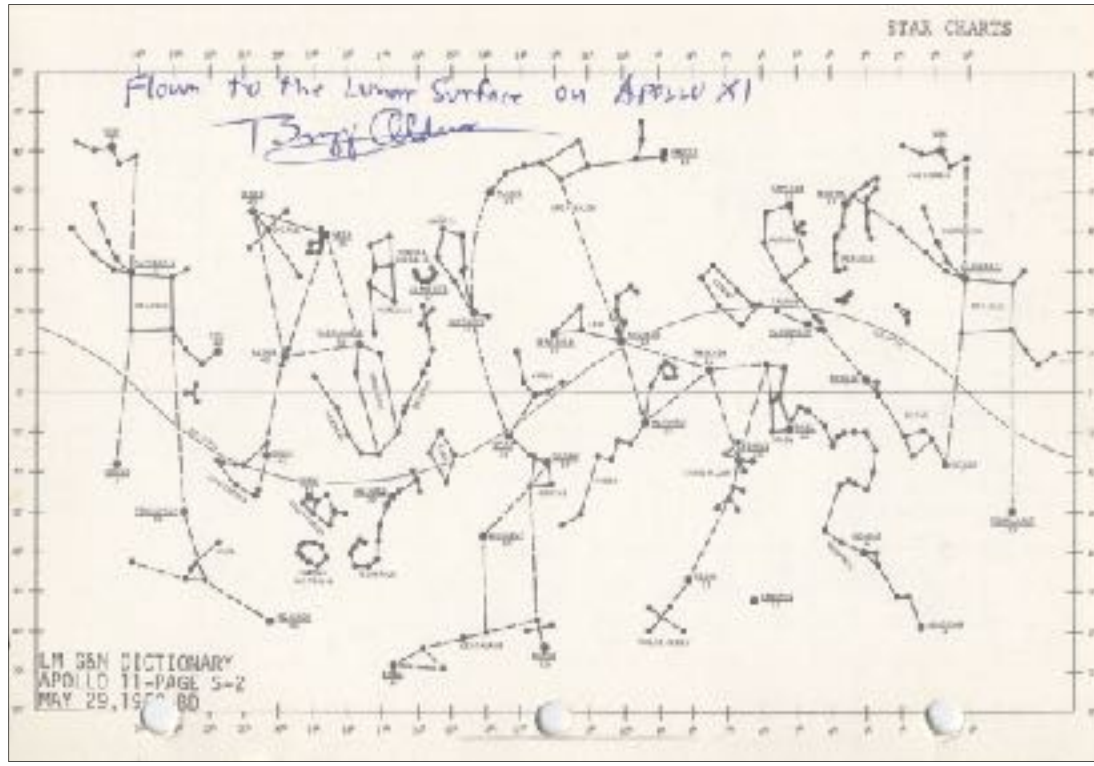
"Thus if the water is made to pour with perfect evenness, then the comparison of the rotary movements (of the heavens and the machine) will show no discrepancy or contradiction; **for the unresting follows the unceasing**."

ARMILLARY SPHERE MADE BY GIROLAMO DELLA VOLPAIA, FLORENCE, ITALY, 01554

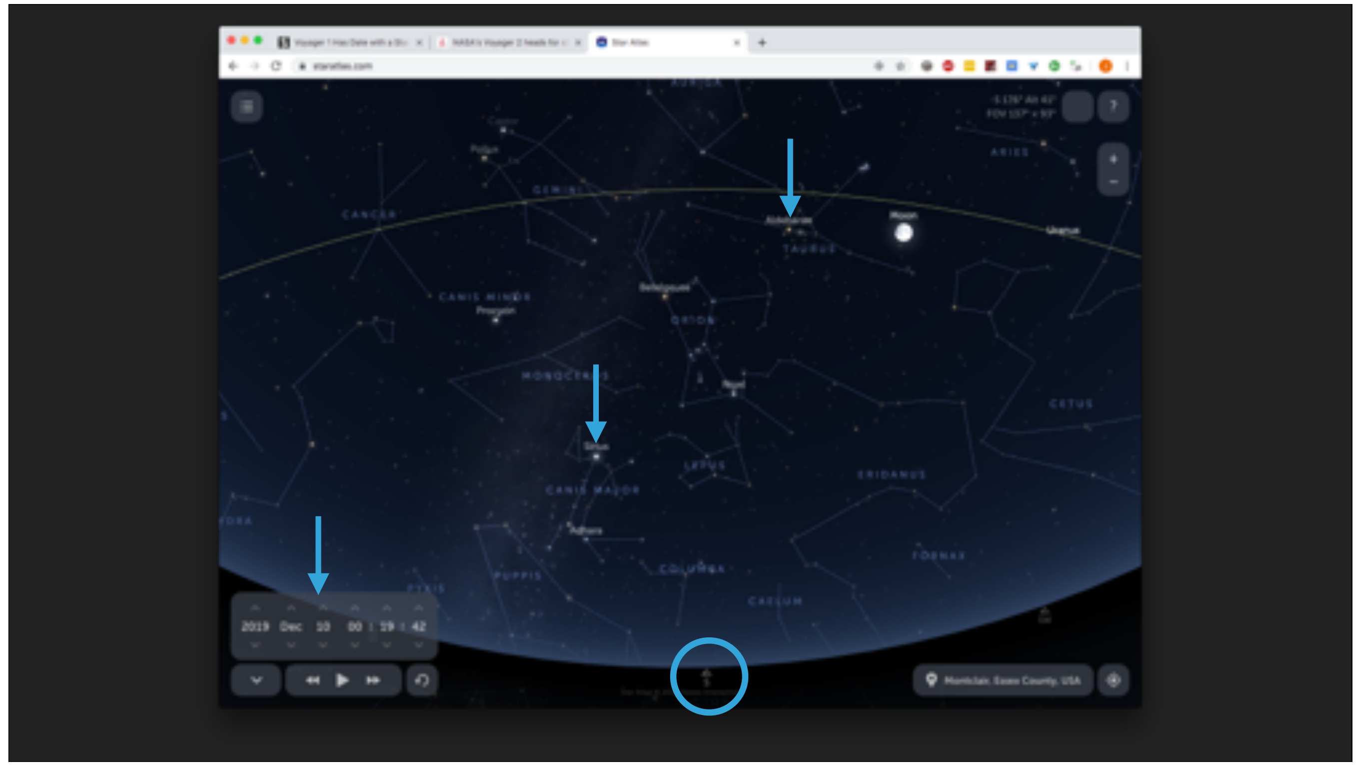
London Science Museum

AUGHRA'S ORRERY

Dark Crystal


STAR CHARTS
Flown to the Lunar Surface on Apollo XI
Buzz Aldrin
LM G&N DICTIONARY
APOLLO 11-PAGE S-2
MAY 29,19 BD

NASA



CANCER
GEMINI
TAURUS
ARIES
Moon
Uranus
CANIS MINOR
Procyon
ORION
MONOCEROS
CETUS
Sirius
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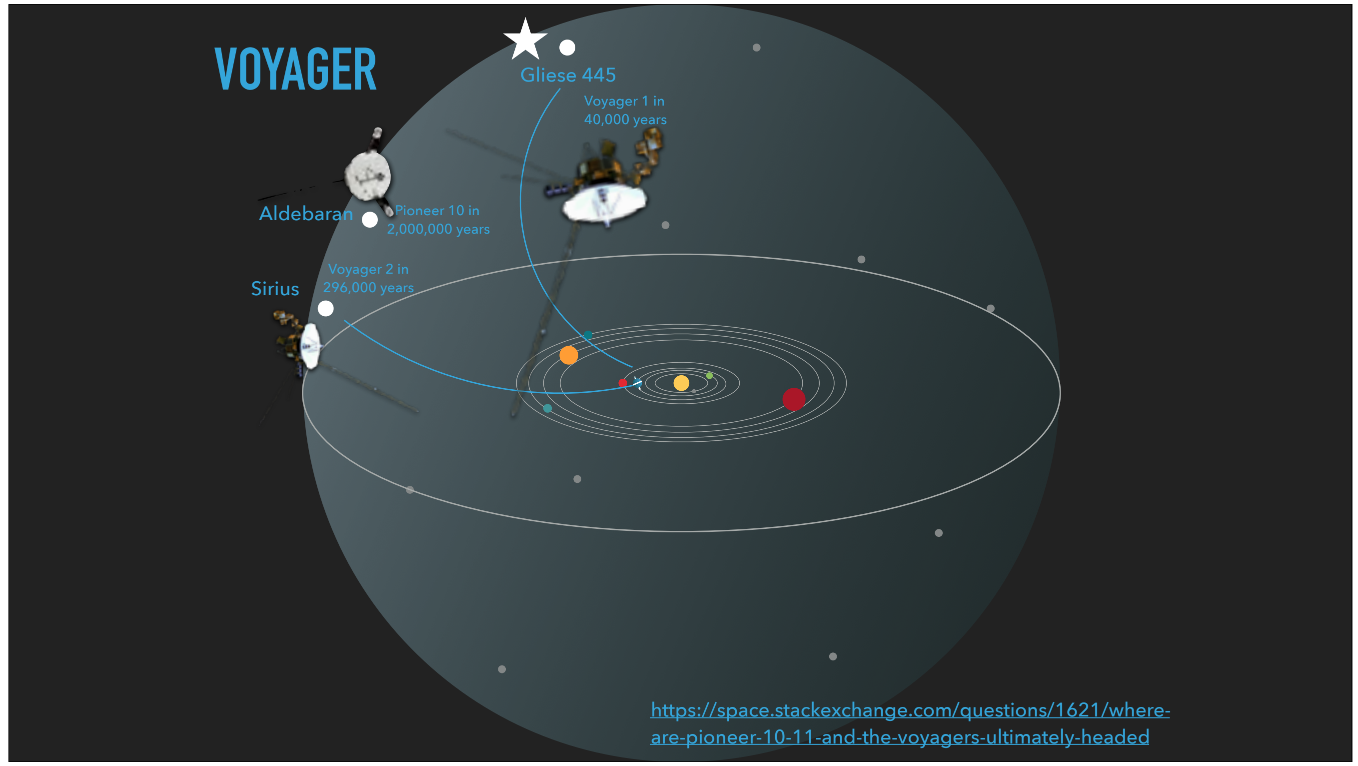
VOYAGER
Gliese 445
Voyager 1 in
40,000 years
Aldebaran
Pioneer 10 in
2,000,000 years
Sirius
Voyager 2 in
296,000 years
https://space.stackexchange.com/questions/1621/where-are-pioneer-10-11-and-the-voyagers-ultimately-headed