Observing the Night Sky: Locating Objects

As I left the house this morning, there was a bright *bluish* light above and to the left of my neighbors house (approximately East) and a big very bright object to my right over the hills (approximately South). I wonder what those objects are?

We can use a variety of reference materials to determine what those objects were if we know *where* they were *when* we saw them (Did I see you?). In order to determine *where* we will need to define a coordinate system(s)

Locating Objects

A coordinate system is defined so that we may use a set of numbers to locate an object

The Coordinate System is defined by specifying an origin and the nature (direction) of the coordinates.

Locating Objects

To locate an object on a flat (two-dimensional) surface (classroom arrangement, surface of the earth) two coordinates are necessary.

To locate an object in space (three-dimensions) three coordinates are necessary.

Locating Objects on Earth

Two angular coordinates, Latitude and Longitude, are used to locate objects on the surface of the Earth

The Earth rotates about an imaginary axis the passes through the North and South geographic poles. The Equator is an imaginary circle on the surface of the Earth located midway between the North and South poles. It is a Great Circle in that the plane containing it divides the Earth into two *equal* halves, the Northern and Southern hemispheres.

Latitude

The Equator is the origin (or zero point) for the Latitude coordinate.

Latitude: is the angle between the equator and any geographical location

Longitude

Latitude: is the angle around the equator to the point nearest the object to be located.

Where do we begin? The longitude line passing through Greenwich, England is the origin (zero point) of the longitude coordinate and is called the Prime Meridian. (direction, East or West is usually specified)

Angle Units

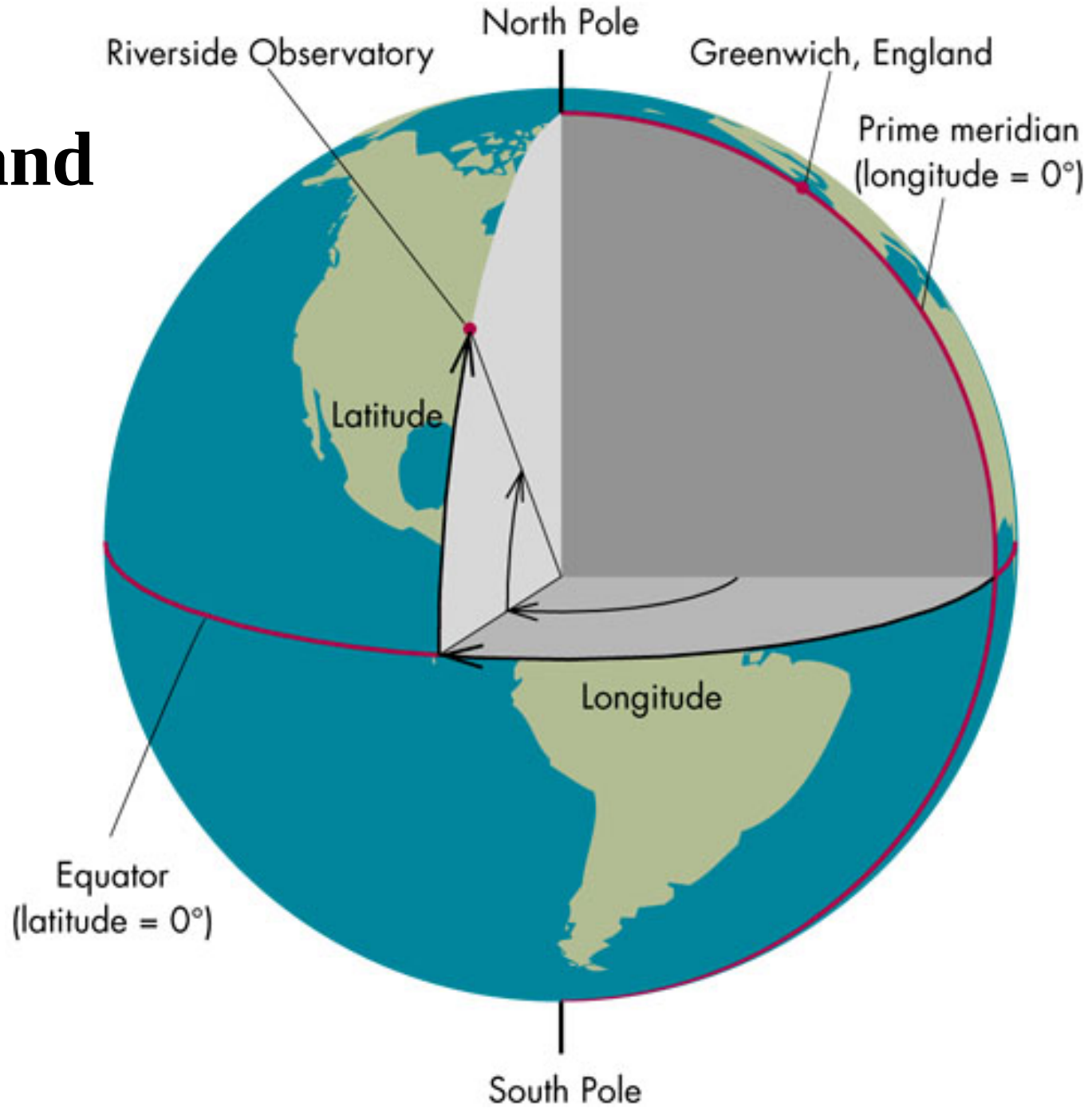
Latitude and Longitude are angular coordinates and are measured in:

Degrees

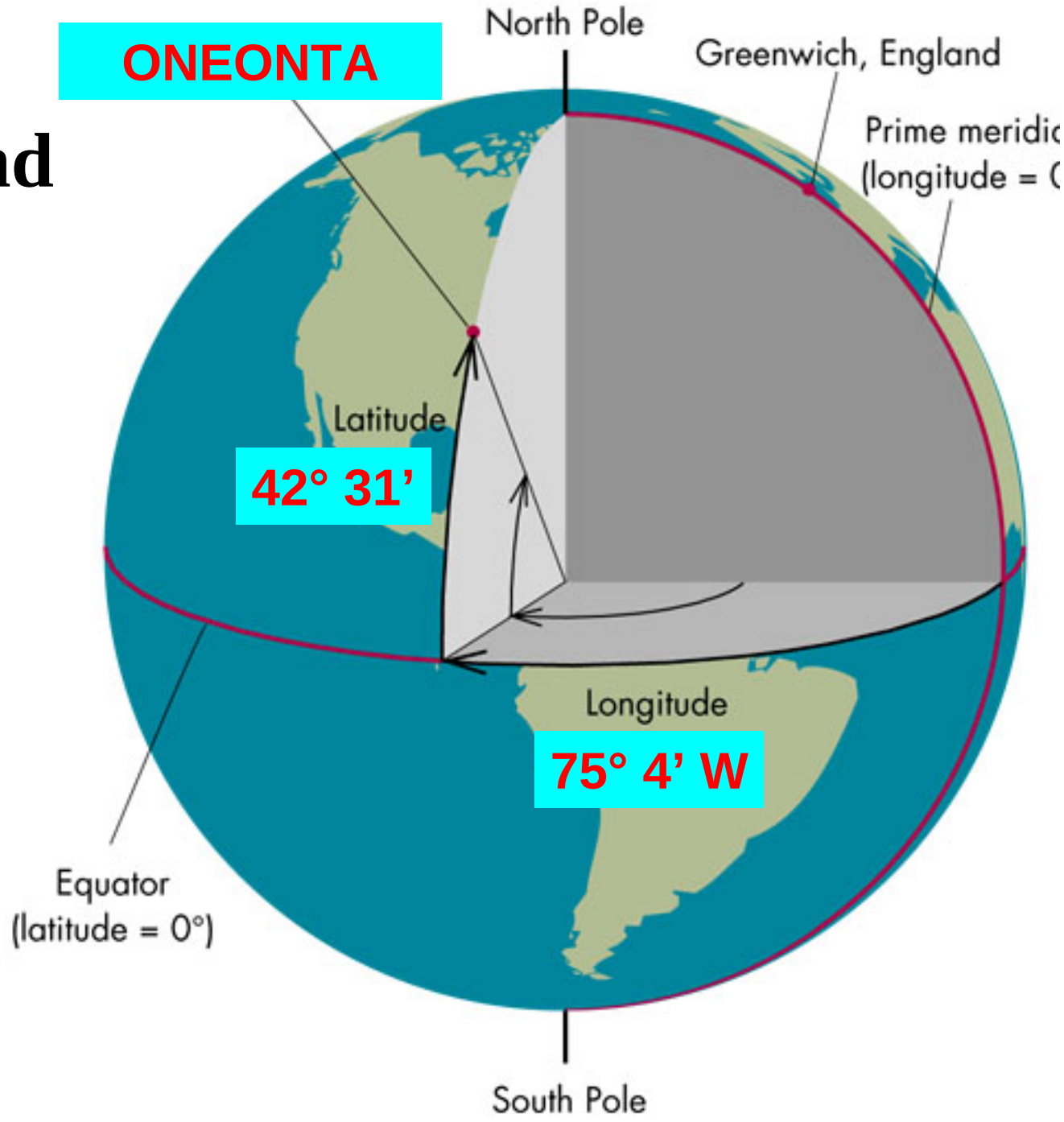
Minute of Arc is 1/60th of a degree

Second of Arc is 1/60th a minute of arc

Longitude and Latitude



Longitude and Latitude



Locating Objects: Horizon System

We can identify objects in the local sky using a coordinate system that is analogous to the latitude-longitude system.

In our local sky, the stars appear as lights on a dome (half of the Celestial Sphere). If we imagine that the do exist on a imaginary dome then two angular coordinates are needed to specify the position of any object

Zenith is the point directly over head in the celestial sphere

The Celestial Horizon is a circle consisting of all points 90 degrees from zenith.

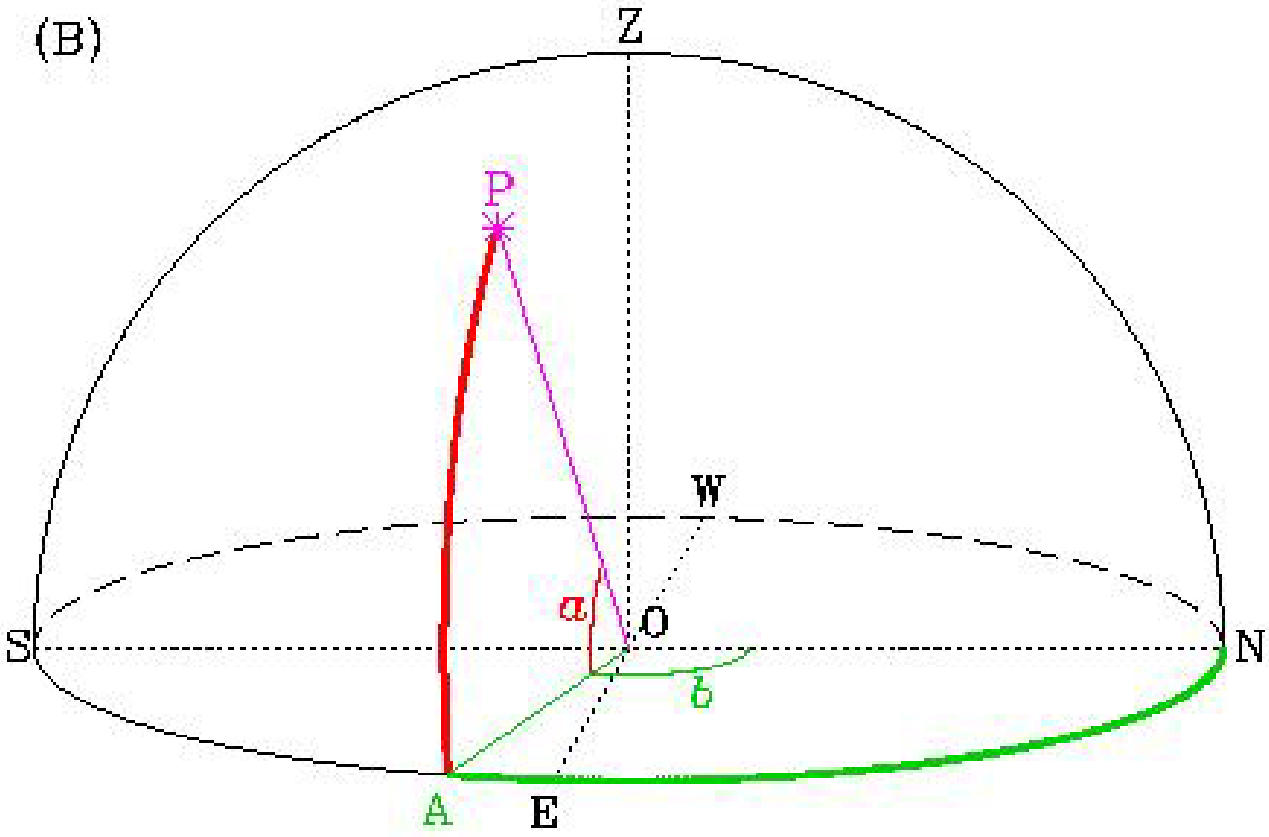
Altitude and Azimuth are the coordinates used to locate objects in the local sky.

Locating Objects: Horizon System

Altitude is the angular distance above the celestial horizon (analogous to latitude)

Azimuth is the angular distance measured eastward from north along the celestial horizon to a point closest to the object (analogous to longitude)

Horizon Coordinate System



Local Sky: Altitude Azimuth Plot

- http://www.tecepe.com.br/cgi-win/cgiasvis.exe
- City:
  Date: 24/1/2008
  Time: 03:00:00 GMT
  Latitude: 42°50.0'N
  Longitude: 75°00.0'W

- http://www.fourmilab.ch/cgi-bin/uncgi/Yoursky

Night Sky: Motion of Objects

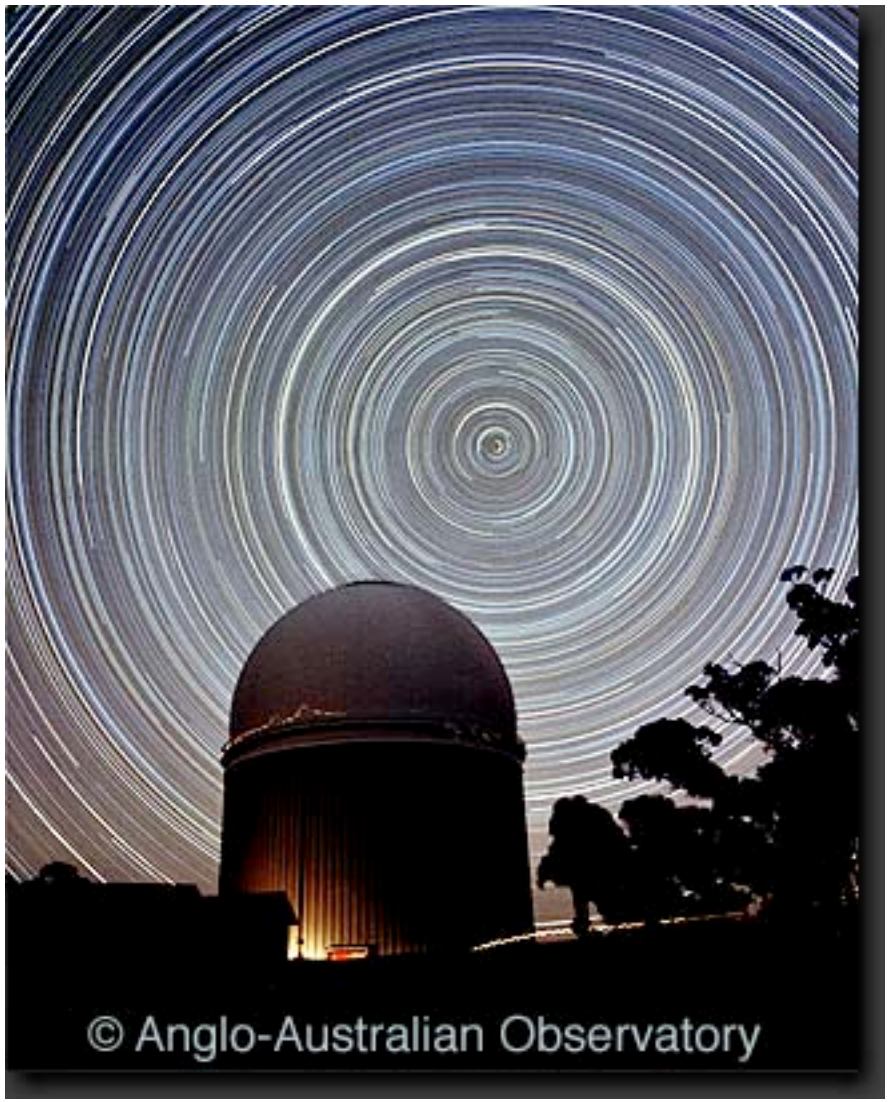
Through history, patterns in the motion of objects in the sky have been observed and recorded most notably:

The diurnal motion of the sun and stars

The annual motion of the sun and stars. (This could be observed by noting how the location of an object at set time changes from night to night)

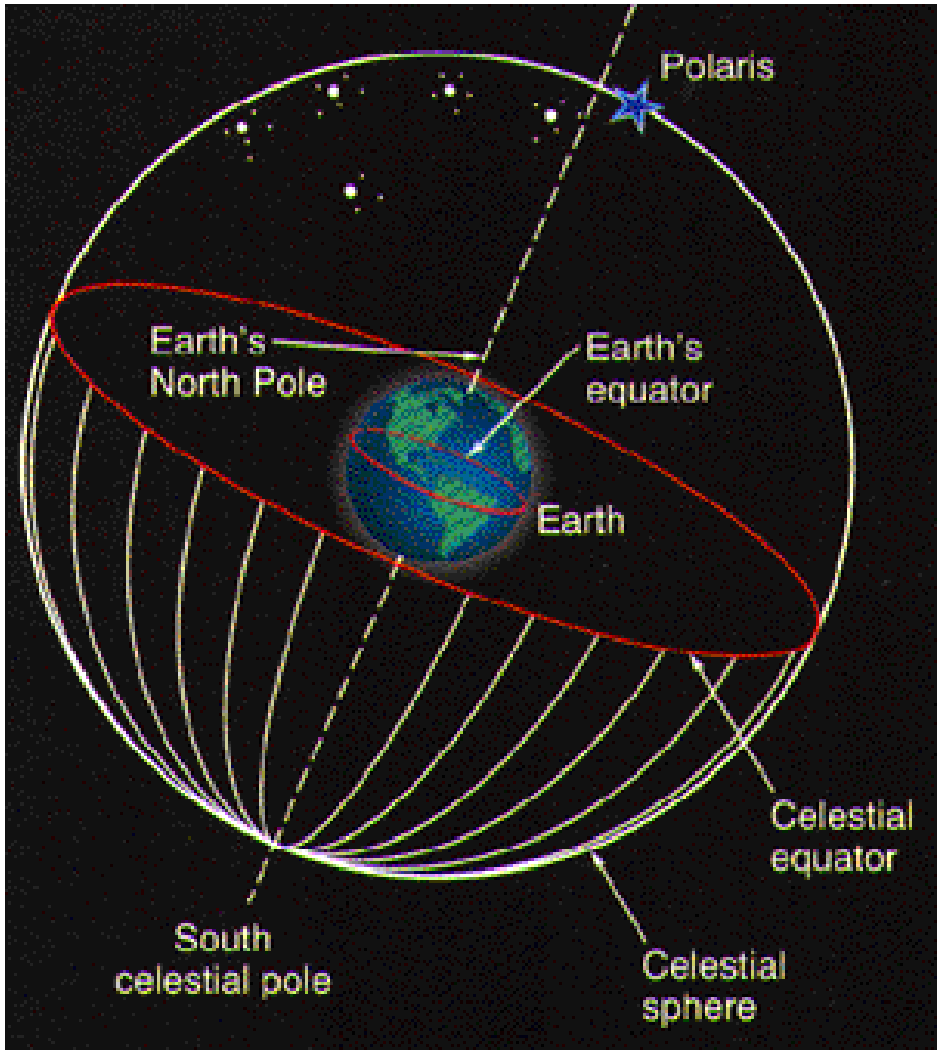
Features (phases, retrograde motion) of planetary motion.

Circumpolar Stars



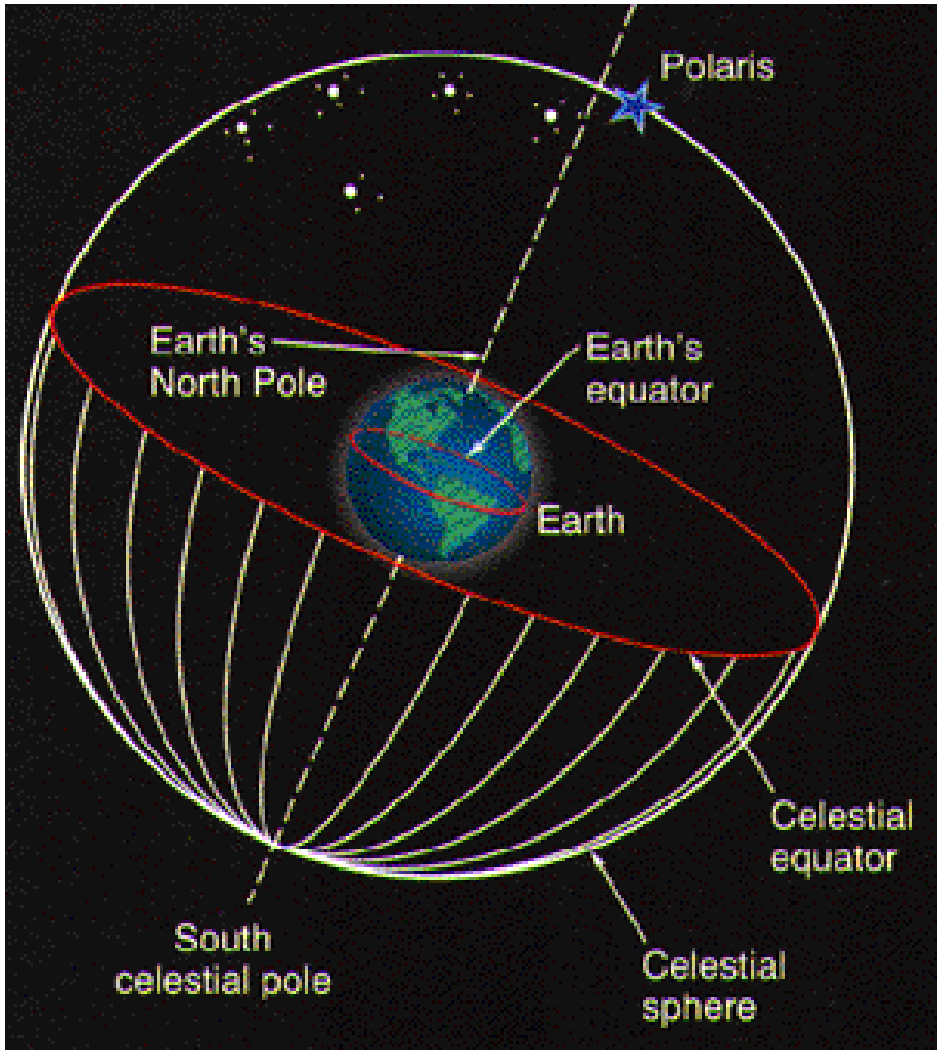
Day long exposure shows the paths traveled by the stars during the day (diurnal motion)

Celestial Sphere



•The stars may be thought of as residing on a large spherical dome known as the celestial sphere.

Celestial Sphere



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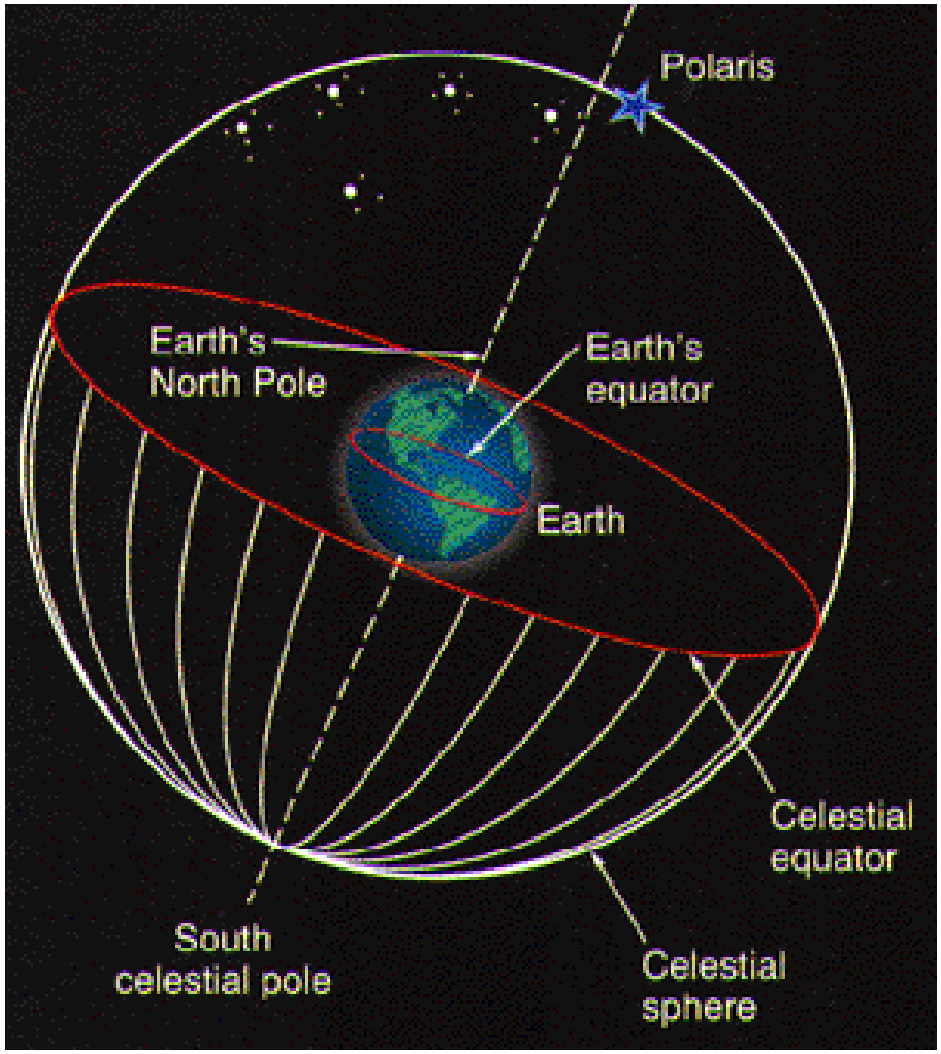
- The line coinciding with the Earth's rotational axis intersects the celestial sphere at the north and south celestial poles.

Celestial Sphere



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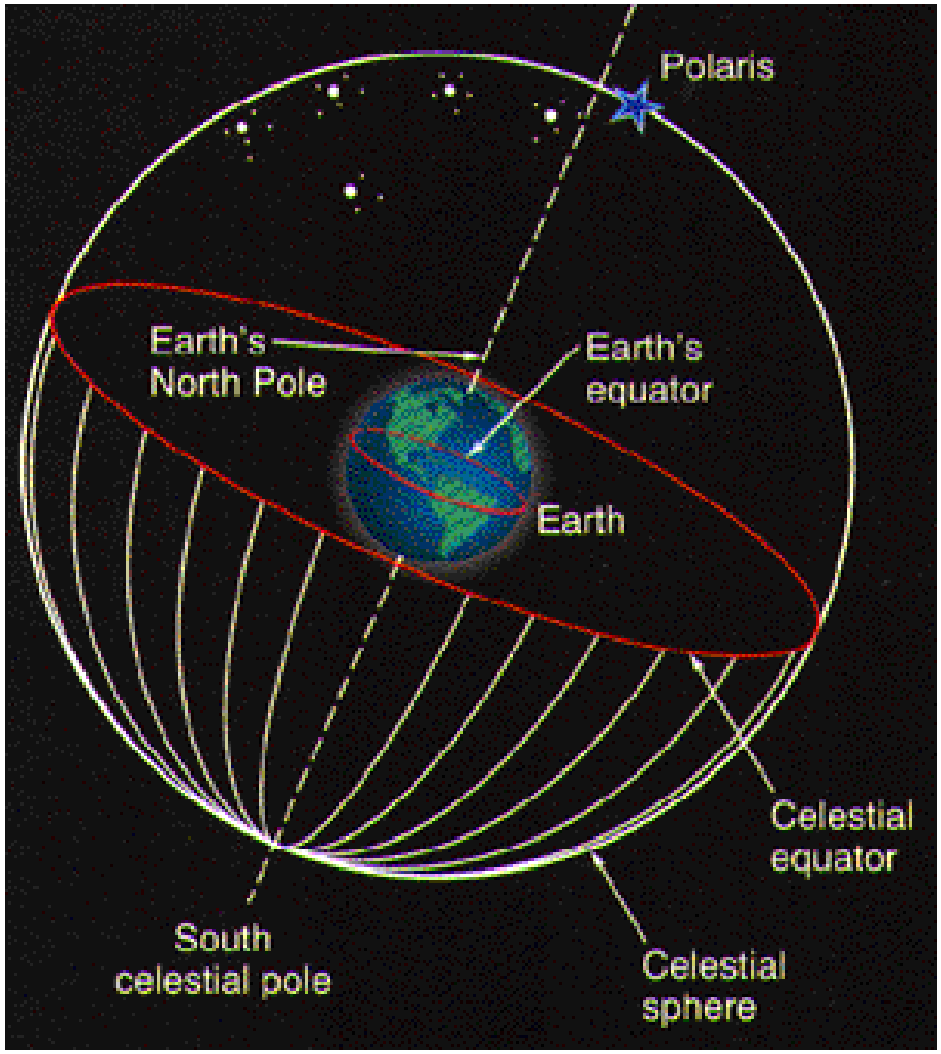
- The line coinciding with the Earth's rotational axis intersects the celestial sphere at the north and south celestial poles.
- An infinite plane containing the equator of the Earth intersects the celestial sphere in great circle known as the celestial equator.

Celestial Sphere



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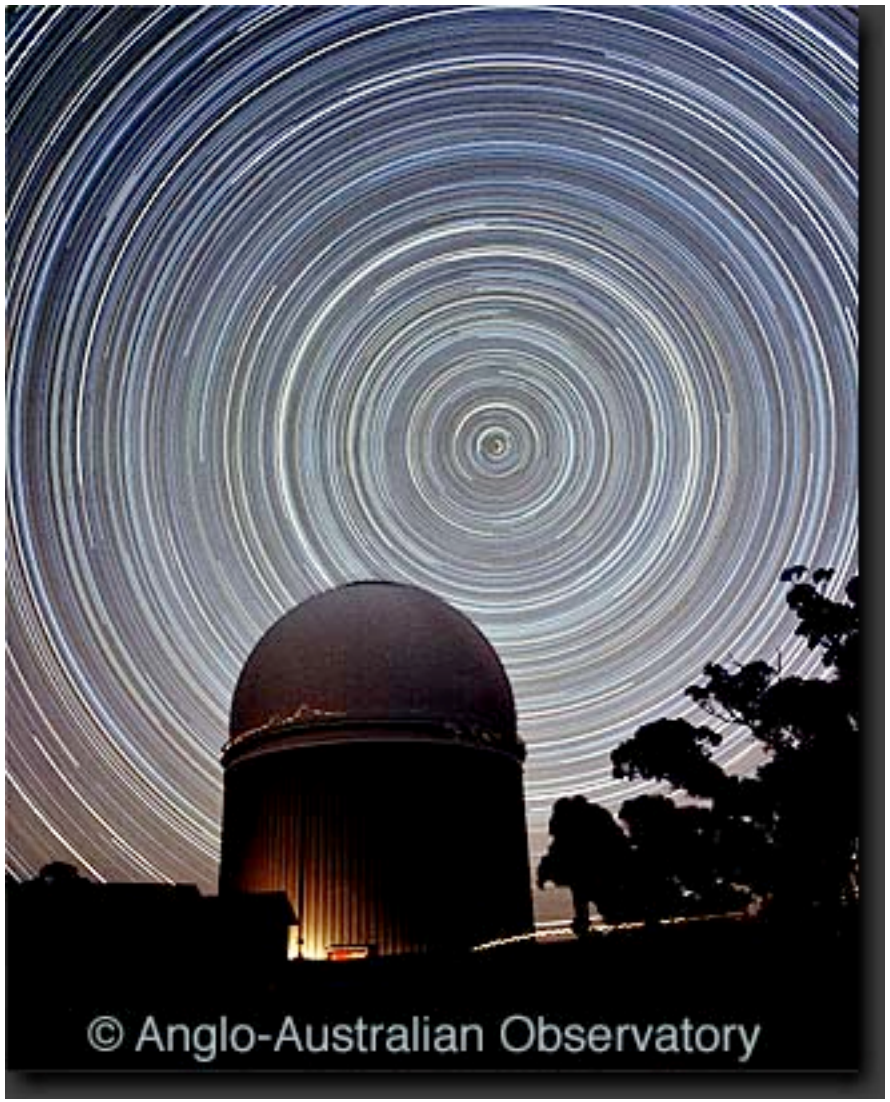
- Counterclockwise rotation of the Earth produces the same effect as clockwise rotation of the celestial sphere

- As observed from Earth, what is the daily (diurnal) motion of the stars?
- How does this apparent motion change with latitude?

Circumpolar Stars



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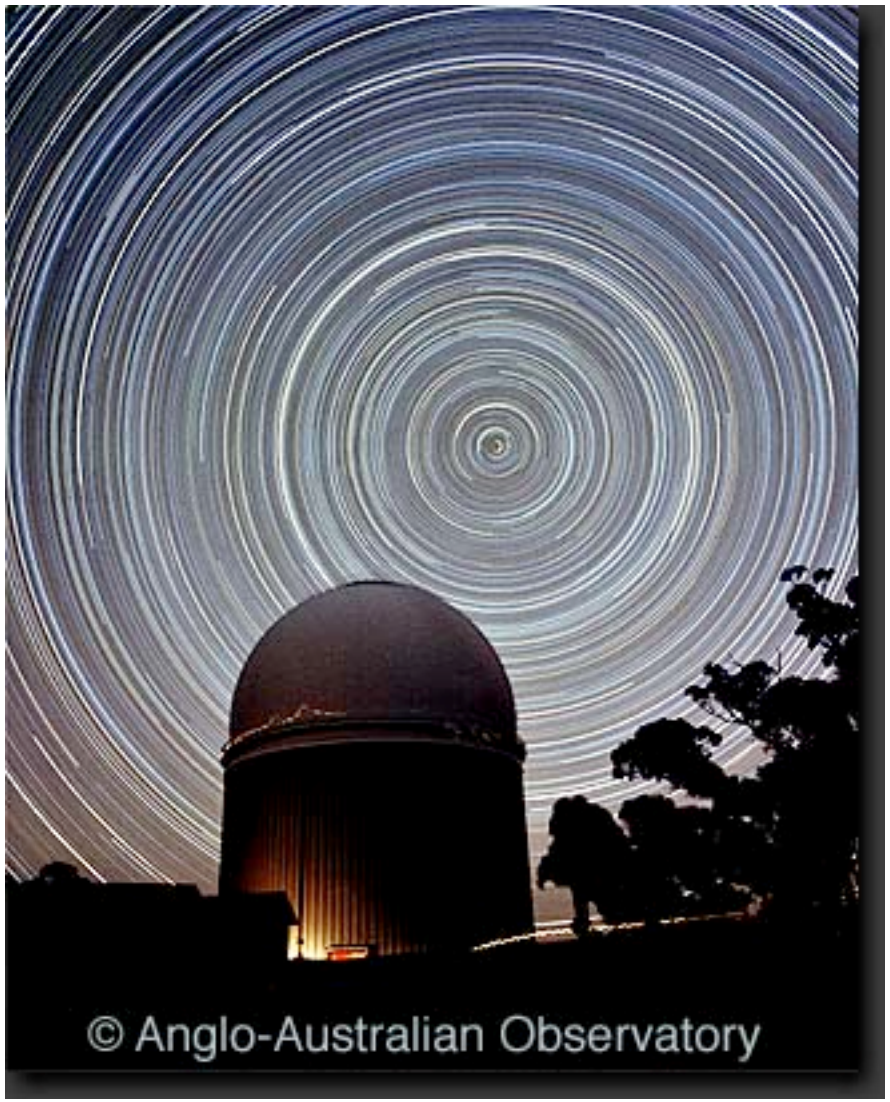
The stars appear to move in a circle about the celestial pole (in the northern hemisphere circles are centered approximately on Polaris, The North Star)

Circumpolar Stars



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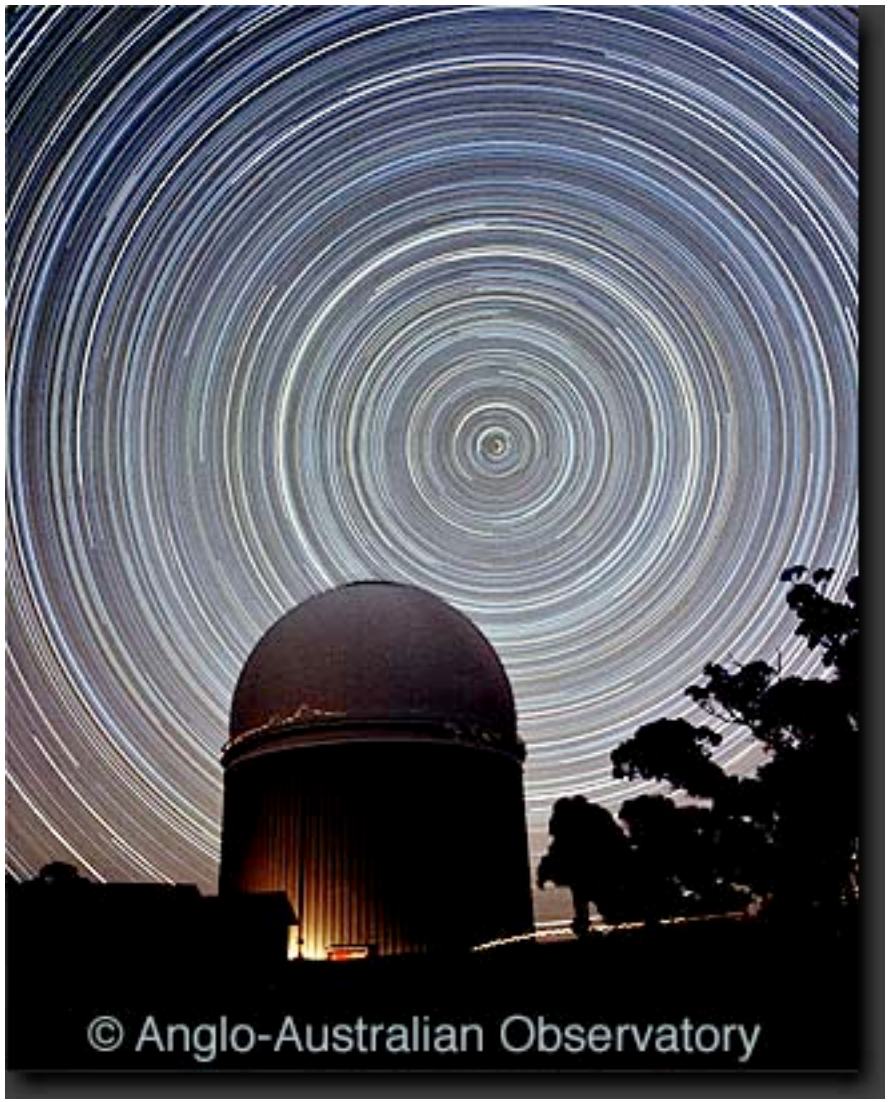
The altitude of the North Celestial Pole is Equal to the latitude of the observer.

Circumpolar Stars



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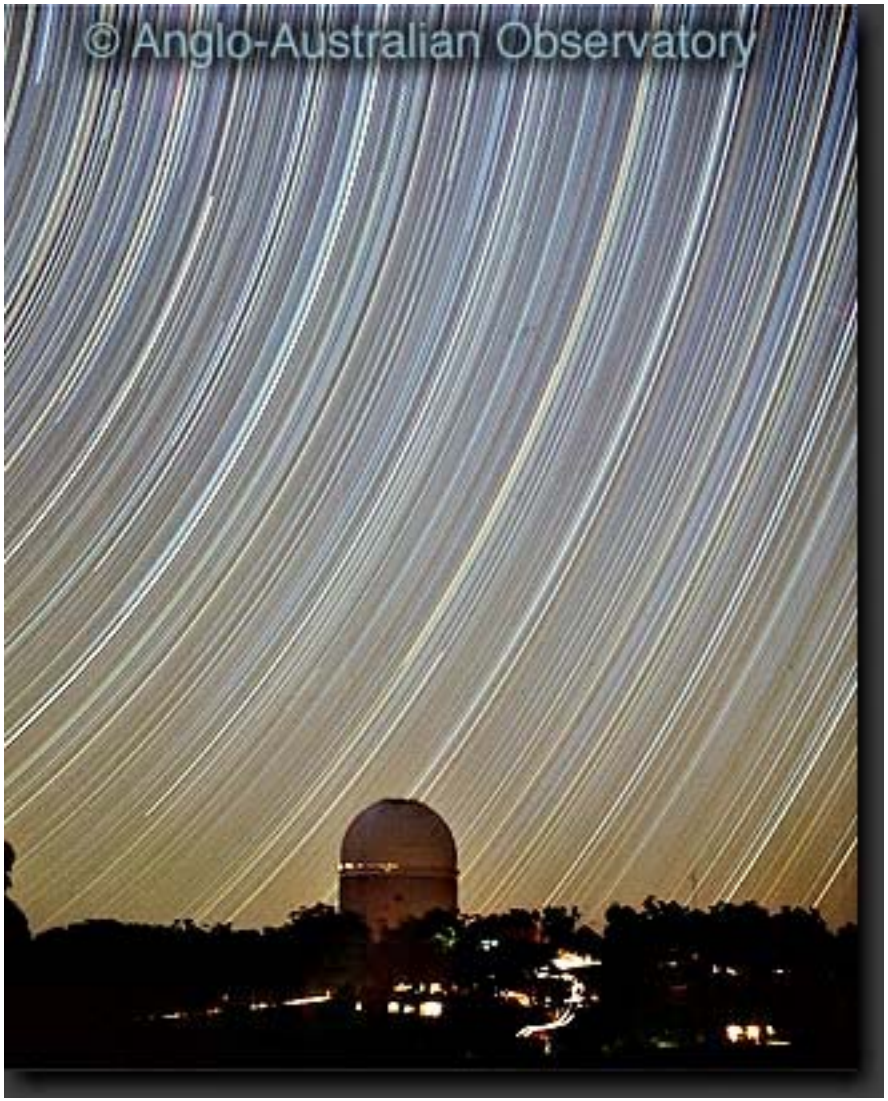
The altitude of the North Celestial Pole is Equal to the latitude of the observer.

Stars that never go below the horizon are known as Circumpolar Stars

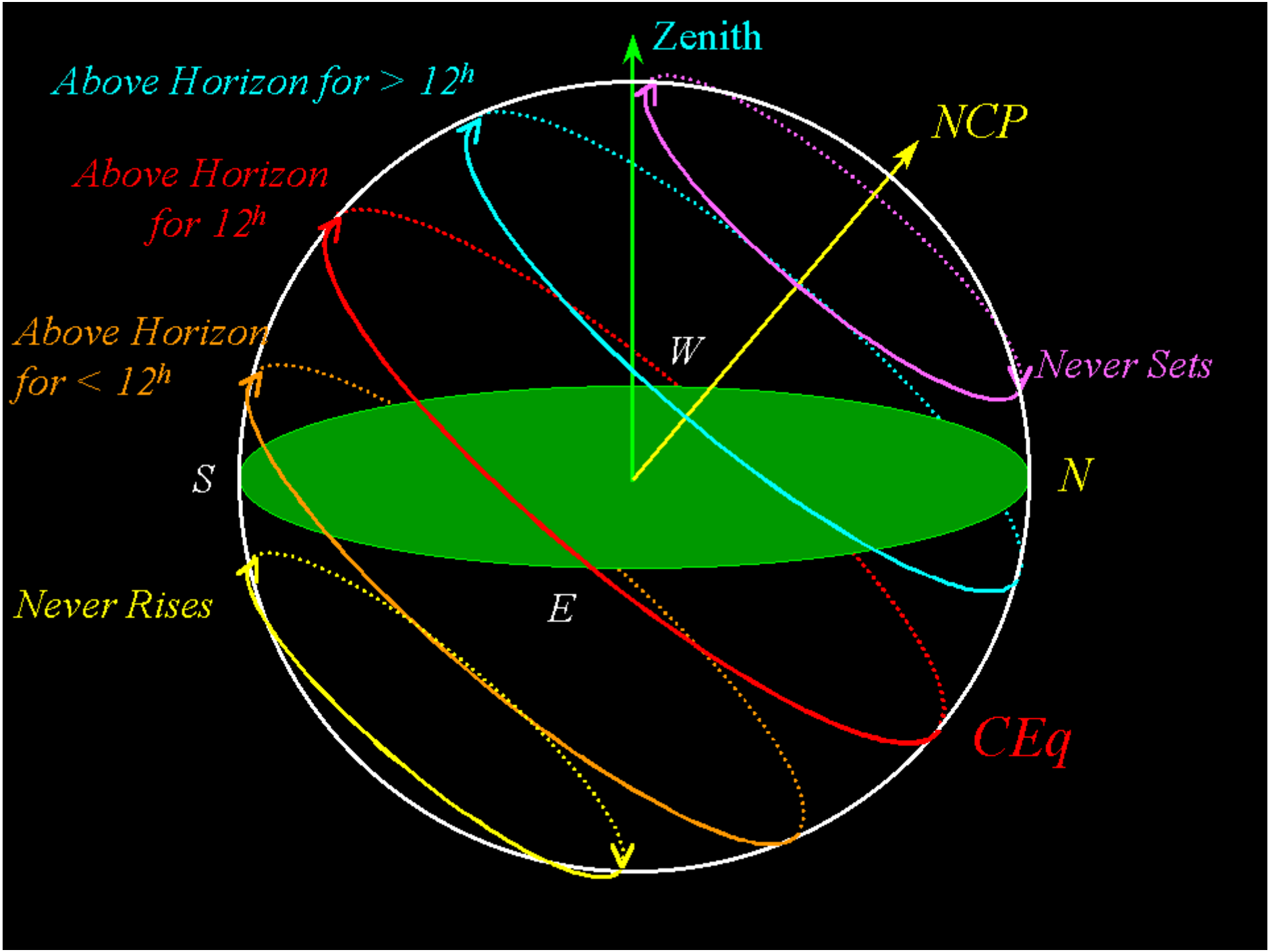
Circumpolar Stars

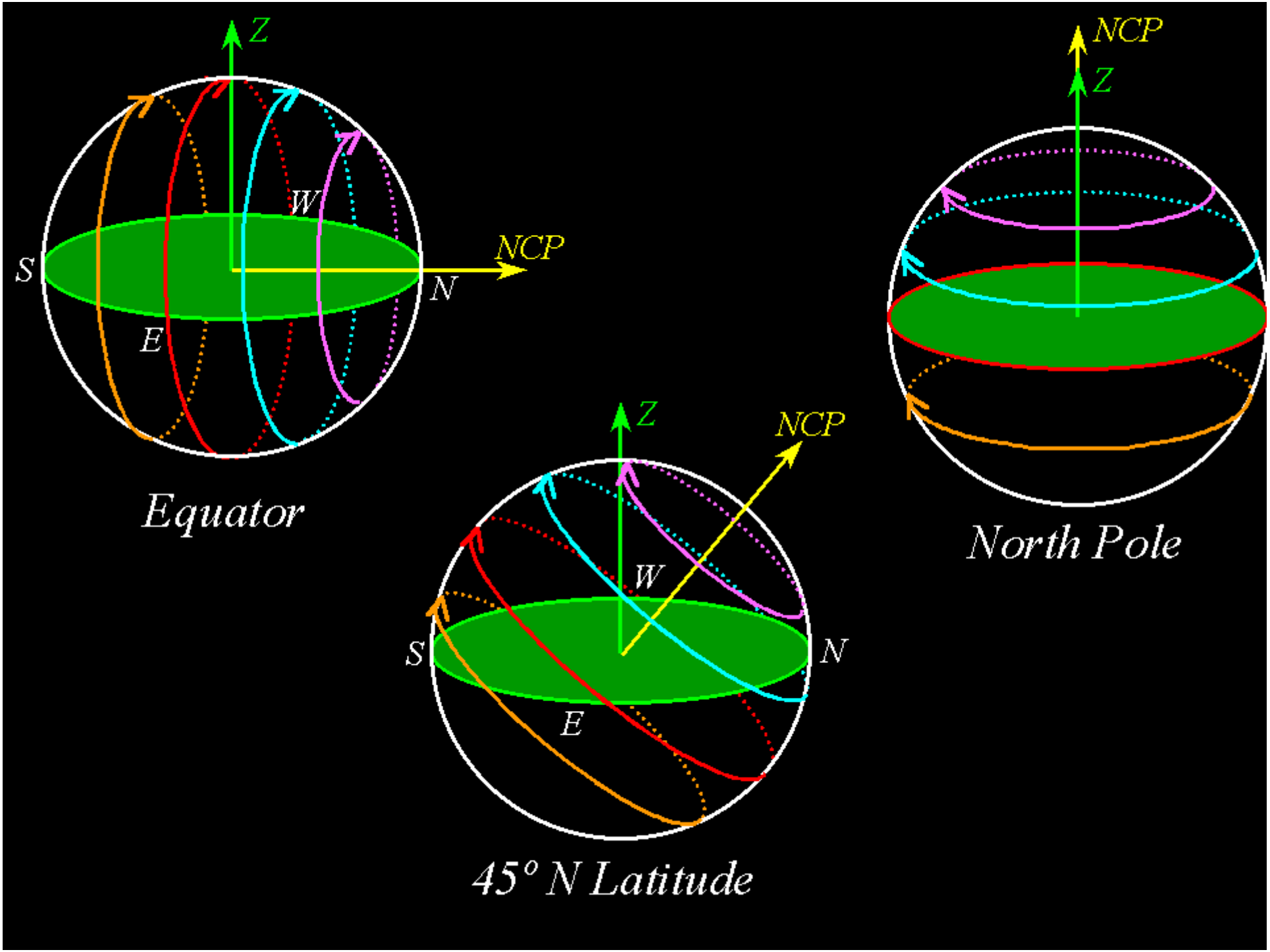


As one moves towards the equator, the altitude of the north (or south) celestial pole decreases.

The number of circumpolar stars decreases (more stars are rising and setting).

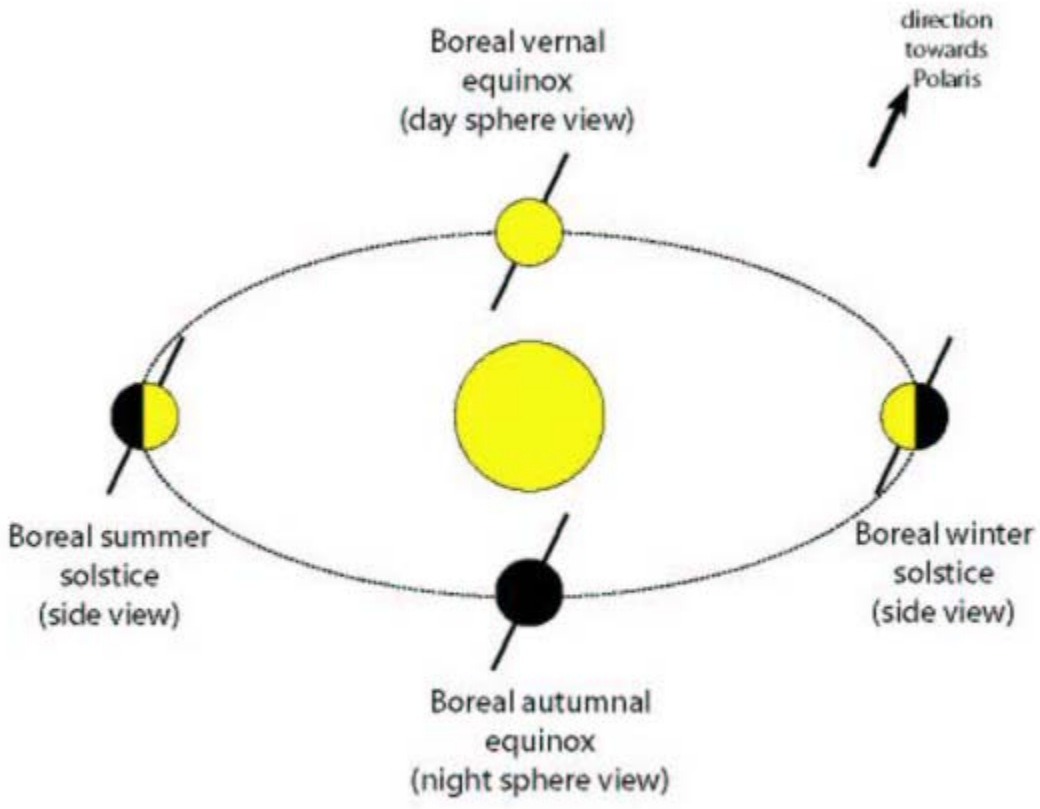
The stellar paths are more like straight lines.

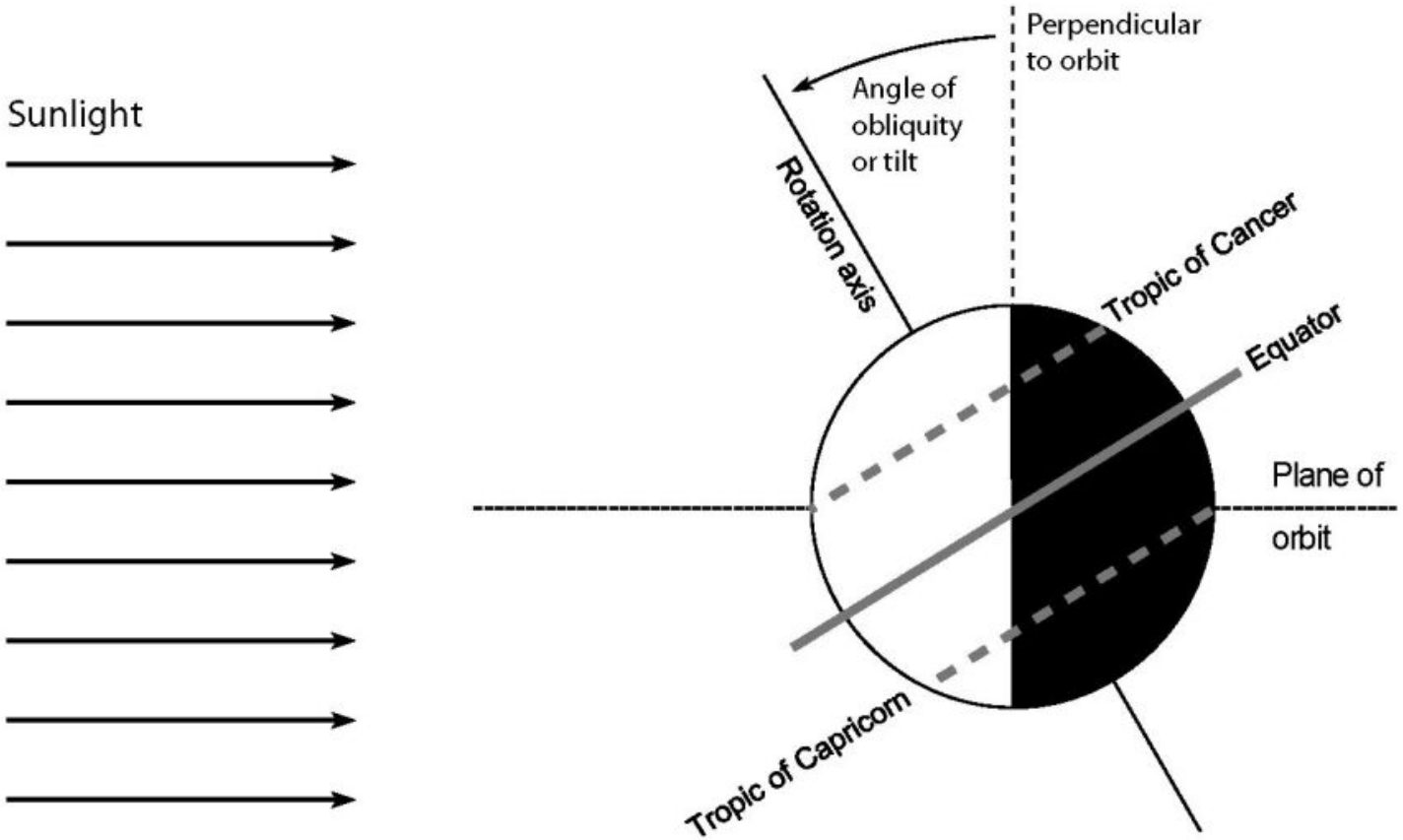

Zenith
Above Horizon for > 12h
NCP
Above Horizon for 12h
Above Horizon for < 12h
W
Never Sets
S
N
Never Rises
E
CEq

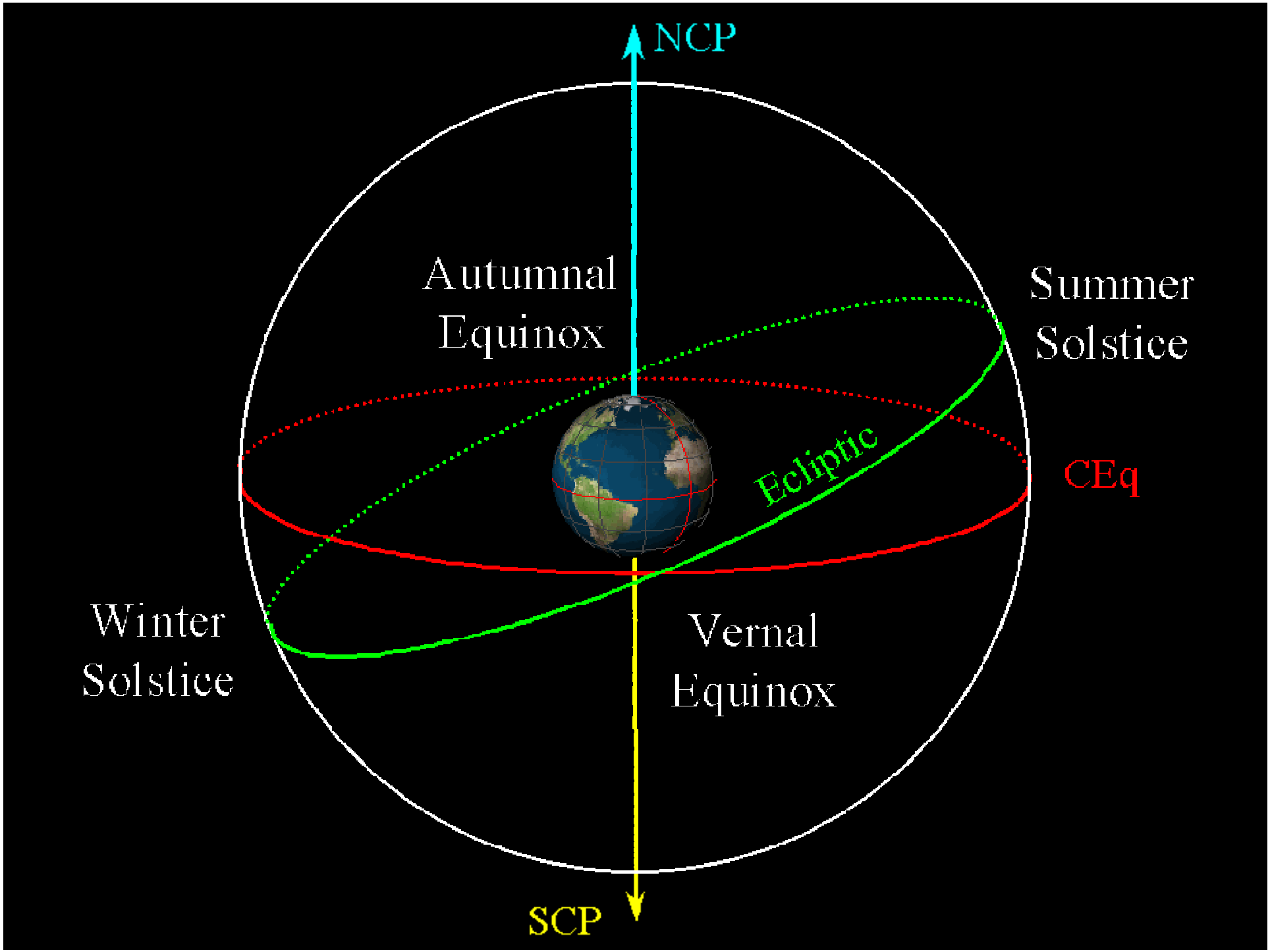

Z
W
NCP
S
N
E
Equator
NCP
Z
North Pole
Z
NCP
W
S
N
E
45° N Latitude

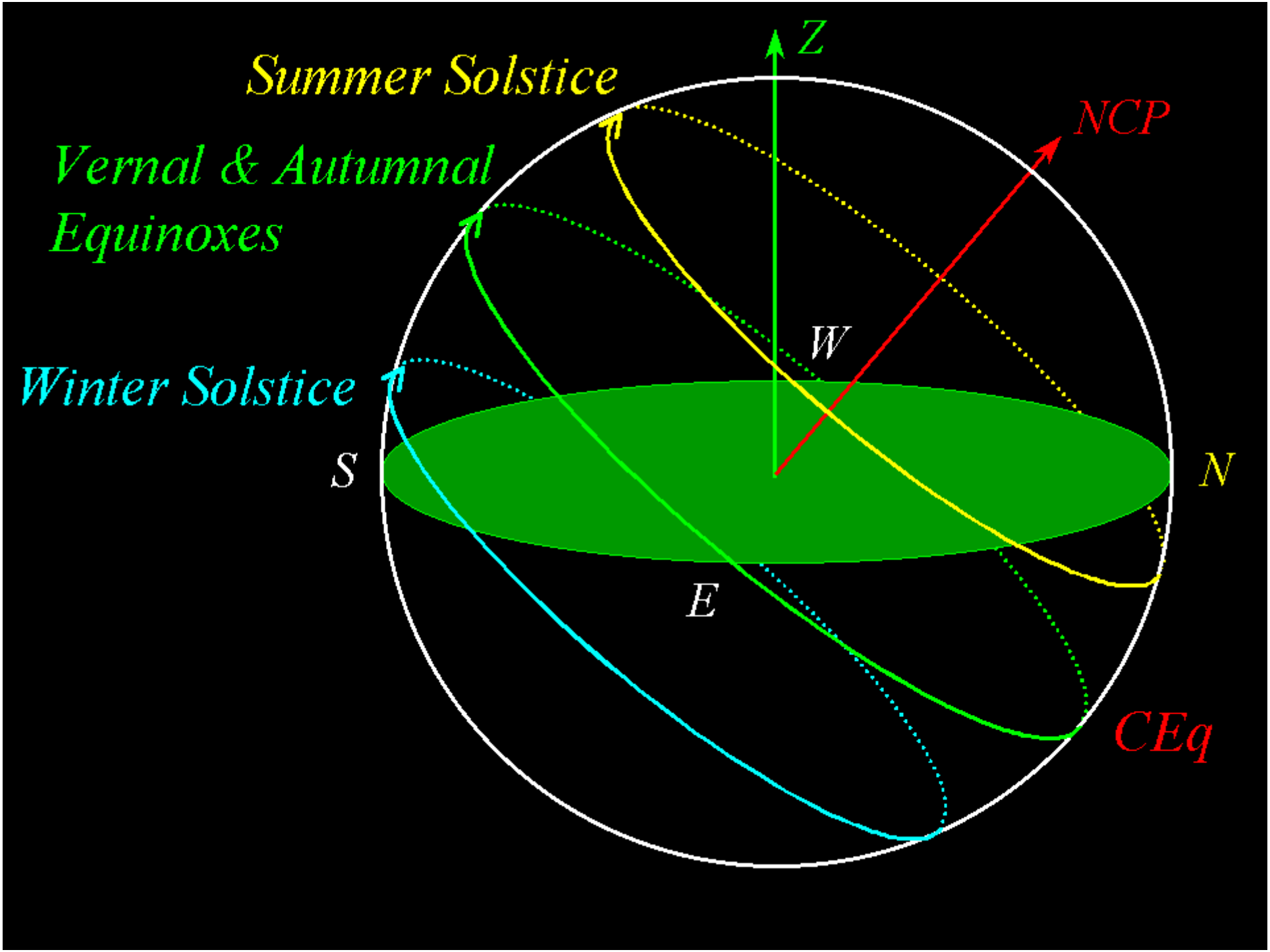
- How does the Sun appear to move through out the year?
- How is this apparent motion of the Sun (caused by the 23.5° tilt of the earth's rotational axis) related to the seasons?

Earth Rotational Axis Tilt in Annual Revolution About the Sun




Sunlight
Perpendicular to orbit
Angle of obliquity or tilt
Rotation axis
Tropic of Cancer
Equator
Plane of orbit
Tropic of Capricorn


NCP
Autumnal
Equinox
Summer
Solstice
Ecliptic
CEq
Winter
Solstice
Vernal
Equinox
SCP


Summer Solstice
Vernal & Autumnal Equinoxes
Winter Solstice
Z
NCP
W
S
N
E
CEq

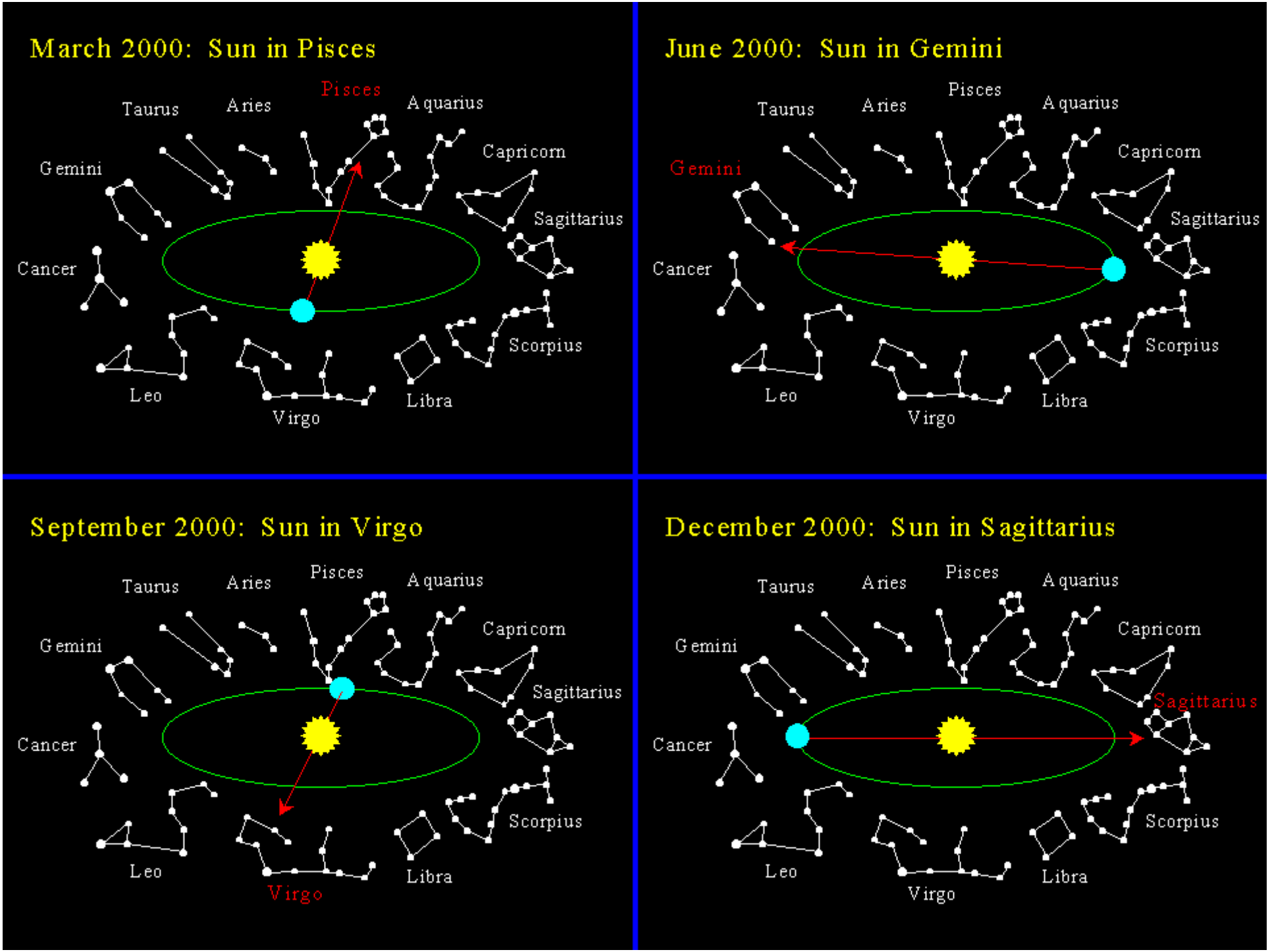
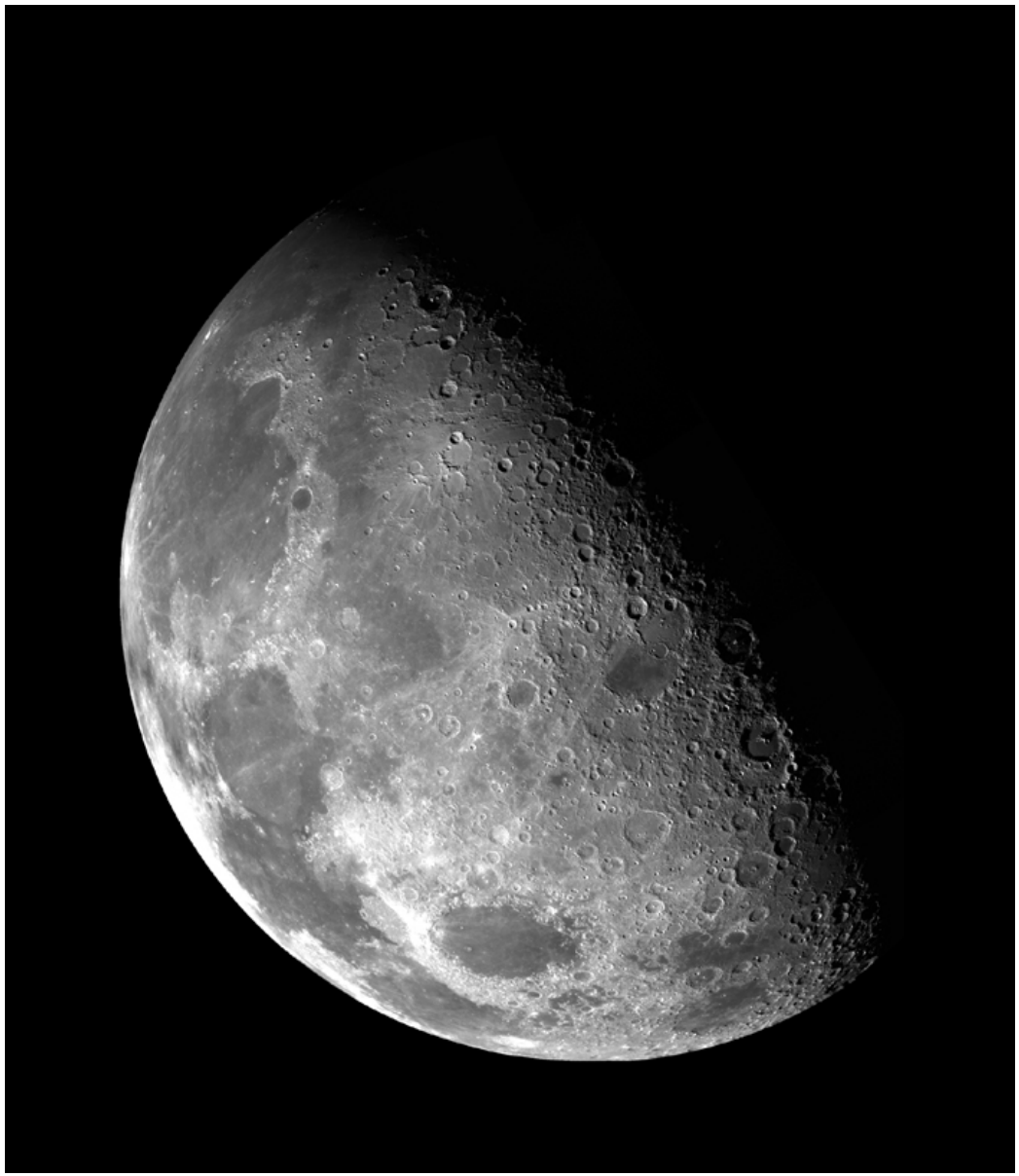

March 2000: Sun in Pisces
Taurus
Aries
Pisces
Aquarius
Capricorn
Gemini
Sagittarius
Cancer
Scorpius
Leo
Virgo
Libra
June 2000: Sun in Gemini
Taurus
Aries
Pisces
Aquarius
Capricorn
Gemini
Sagittarius
Cancer
Scorpius
Leo
Virgo
Libra
September 2000: Sun in Virgo
Taurus
Aries
Pisces
Aquarius
Capricorn
Gemini
Sagittarius
Cancer
Scorpius
Leo
Virgo
Libra
December 2000: Sun in Sagittarius
Taurus
Aries
Pisces
Aquarius
Capricorn
Gemini
Sagittarius
Cancer
Scorpius
Leo
Virgo
Libra

Image of the Moon from the Galileo Space Craft



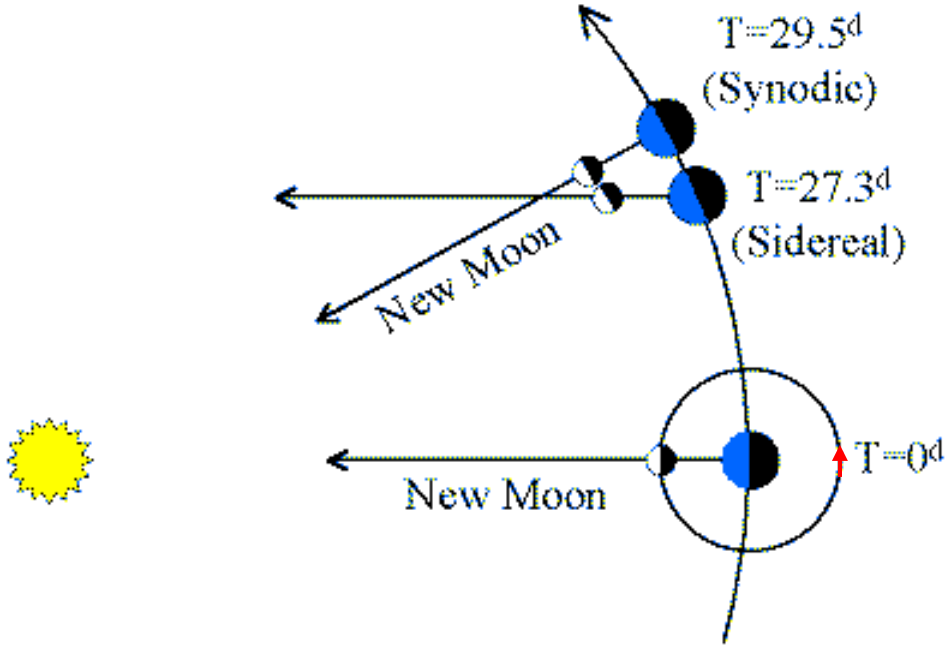
Moon: Overview

Due to its size (diameter 3476 km, Mercury's diameter is 4880 km) and composition, the moon is sometimes considered as a terrestrial planet along with Mercury, Venus, Earth and Mars.

In addition to being the only body visited by humans, it is also the only object from which physical sample have been brought back to Earth (Radioactive dating found the youngest rocks formed 3 .1 billion years ago and the oldest formed 4.4 billion years ago).

In addition to centuries of Earth bound observations, several space based missions have made observations of the Moon: Apollo (Dates), Clementine, Lunar Prospector

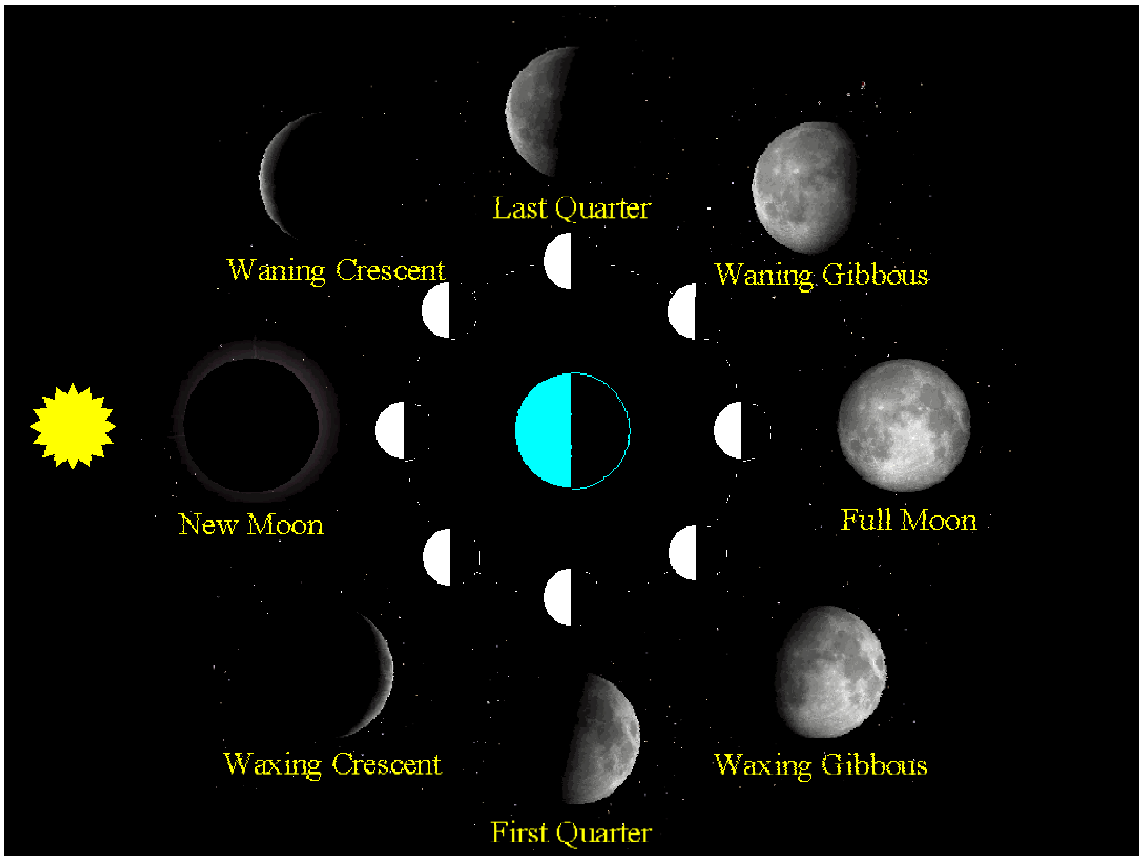
Moon: Revolution



The Moon revolves around the Earth in 27.3 days (Sidereal Period, revolution in the same sense as Earth about the Sun).

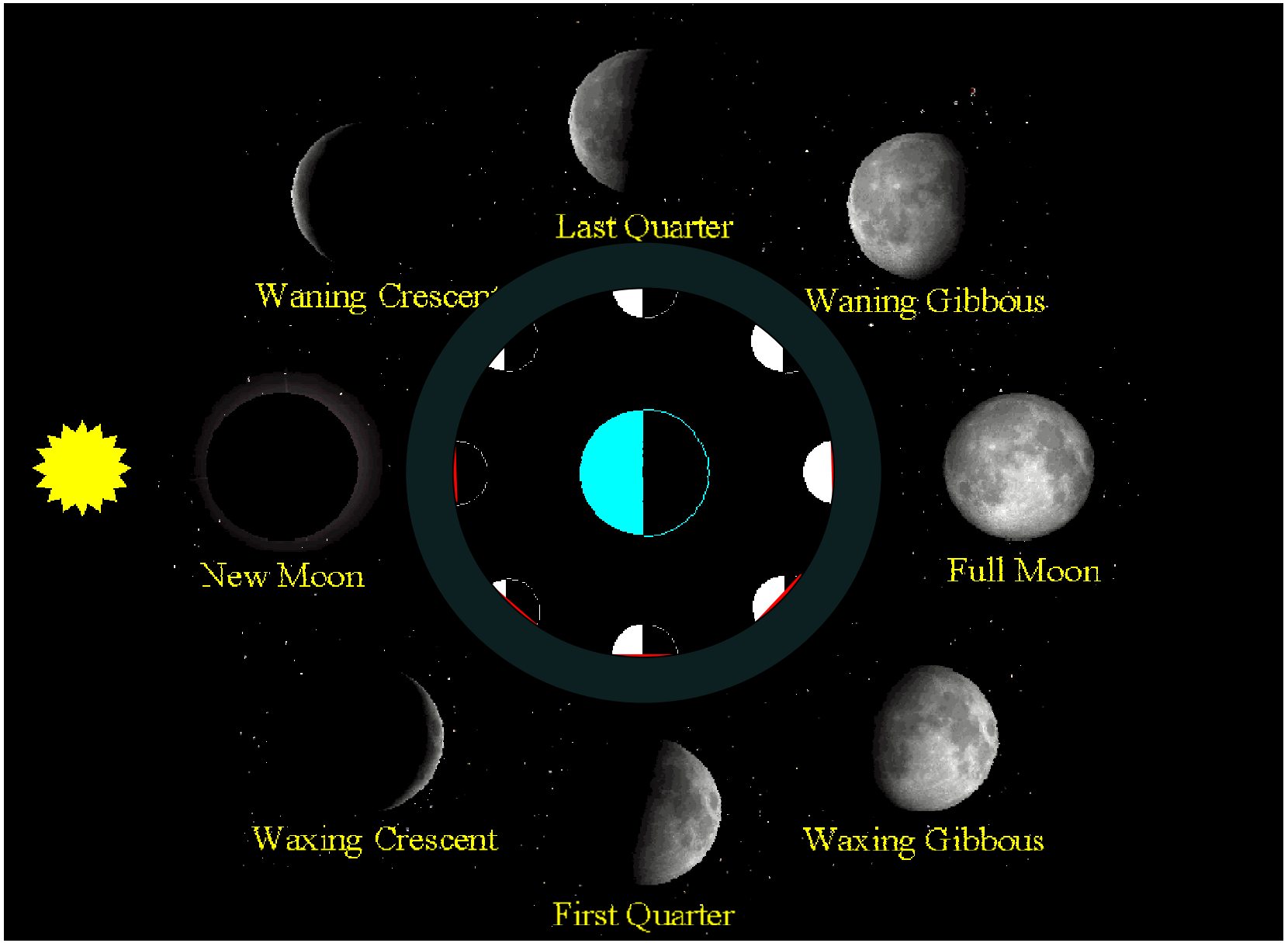
Since the Earth moves in its orbit about the Sun (~27° during this time) it takes about 2 more days for the moon to return to the same position relative to the Earth and Sun. Thus the Synodic Period is 29.5 days.

Moon: Revolution



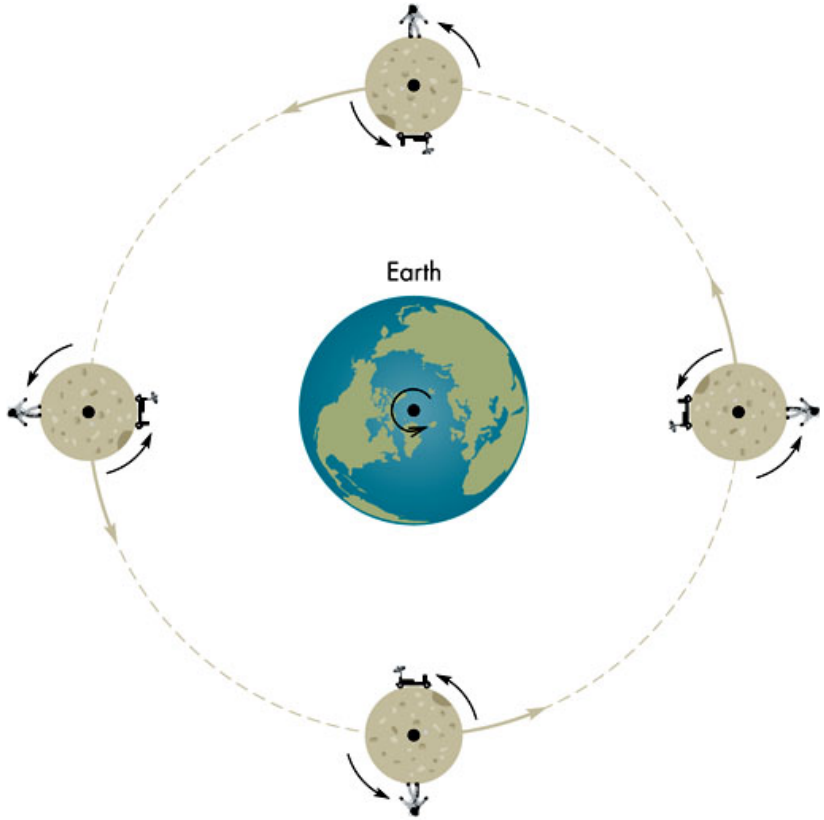
The revolution of the moon about the Earth produces the phases of the moon which complete one cycle during the synodic period.

Moon: Revolution



http://www.astronomy.ohio-state.edu/~pogge/Ast161/Unit2/lunation.gif

Moon: Rotation



B Synchronous rotation: Only one face visible from Earth

The moon rotates with a period of 27.3 days, which is the same as the sidereal period. When the period of rotation and revolution of an object are the same, it is in synchronous rotation. In synchronous rotation, the same side of the Moon (called the near side) always faces Earth.

Retrograde Motion

Most of the time, planets appear to move eastward against the background of stars. (Prograde Motion)

Retrograde Motion occurs when for a brief period of time a planet (Mars most dramatic example) appears to move backwards (westward) against the background of stars when observed from earth.

The planet appears brightest during retrograde motion.

Retrograde Motion

http://cygnus.colorado.edu/Animations/mars.mov

http://cygnus.colorado.edu/Animations/mars2.mov

http://alpha.lasalle.edu/~smithsc/Astronomy/retrograd.html

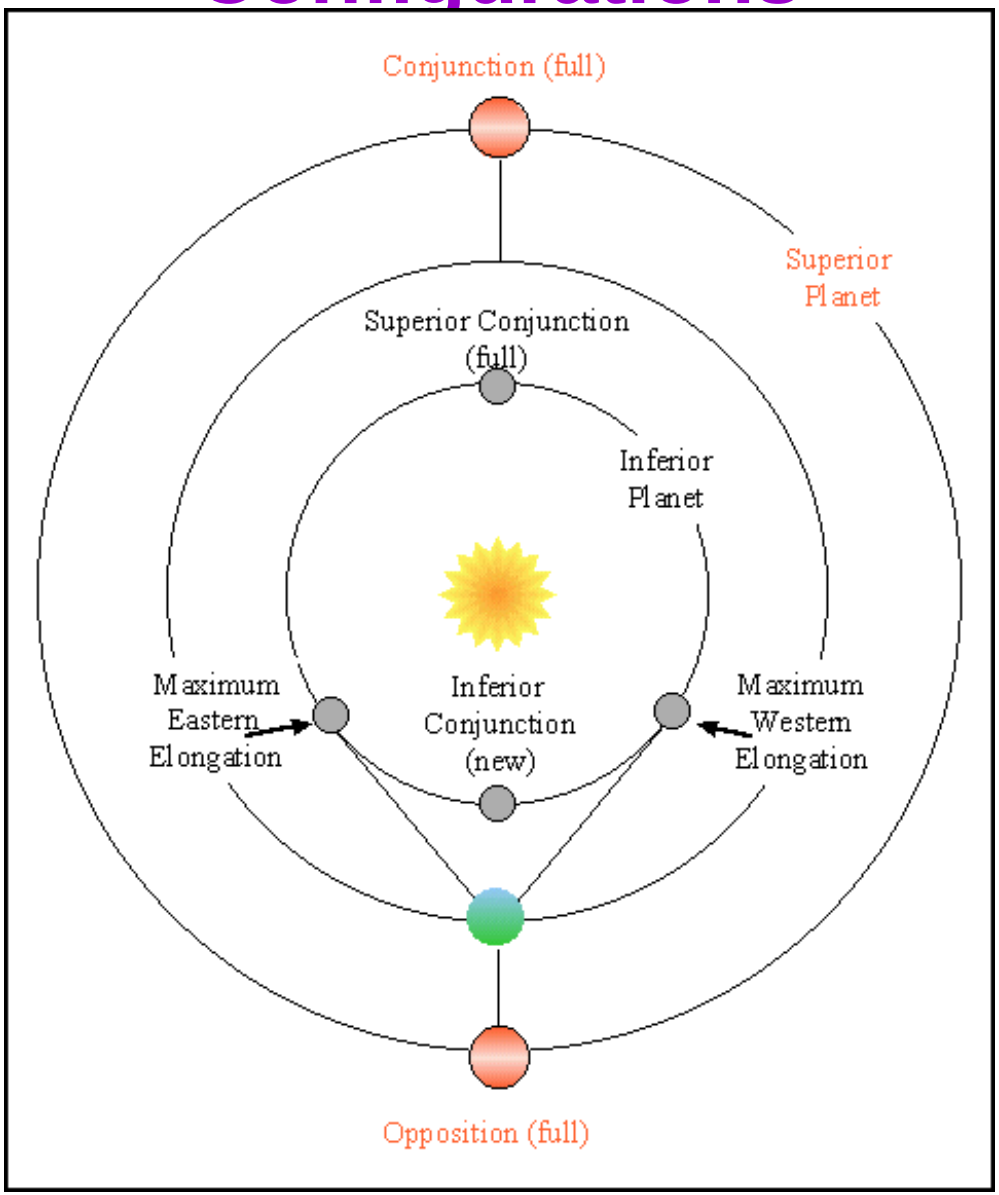
Special Earth-Sun-Planet Configurations

Inferior Conjunction: **Occurs when the planet and Sun are seen in the same direction from Earth and the planet is closest to Earth (Mercury and Venus).**

Superior Conjunction: **Occurs when the planet and sun are seen in the same direction from Earth and the Sun is closest to Earth.**

Opposition: **Occurs when the direction the planet and the Sun are seen from Earth is exactly on opposite.**

Special Earth-Sun-Planet Configurations



Retrograde Motion

Synodic Period: The time required for a planet to return to a particular configuration with the Sun and Earth. For example the time between oppositions (or conjunctions, or retrograde motion).

Mars (and the other outer planets) is brightest when it is closest at opposition. Therefore retrograde motion of the outer planets occurs at opposition.

Retrograde motion of Mercury and Venus takes place near conjunction.

Newton and Gravity

In Newton's 2nd Law of Motion we understand that a Force (push or pull) is required to change the velocity (motion, either speed or direction) of the object. [The change in the velocity of an object is also known as acceleration].

http://www.phys.virginia.edu/classes/109N/more_stuff/Applets/newt/newtmtn.html