Introduction to Astronomy and Astrophysics I

Lecture 3

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Solar Time

- Local time

Solar Time

- Local time
- Standard time

Solar Time

- Local time
- Standard time
- Greenwich time

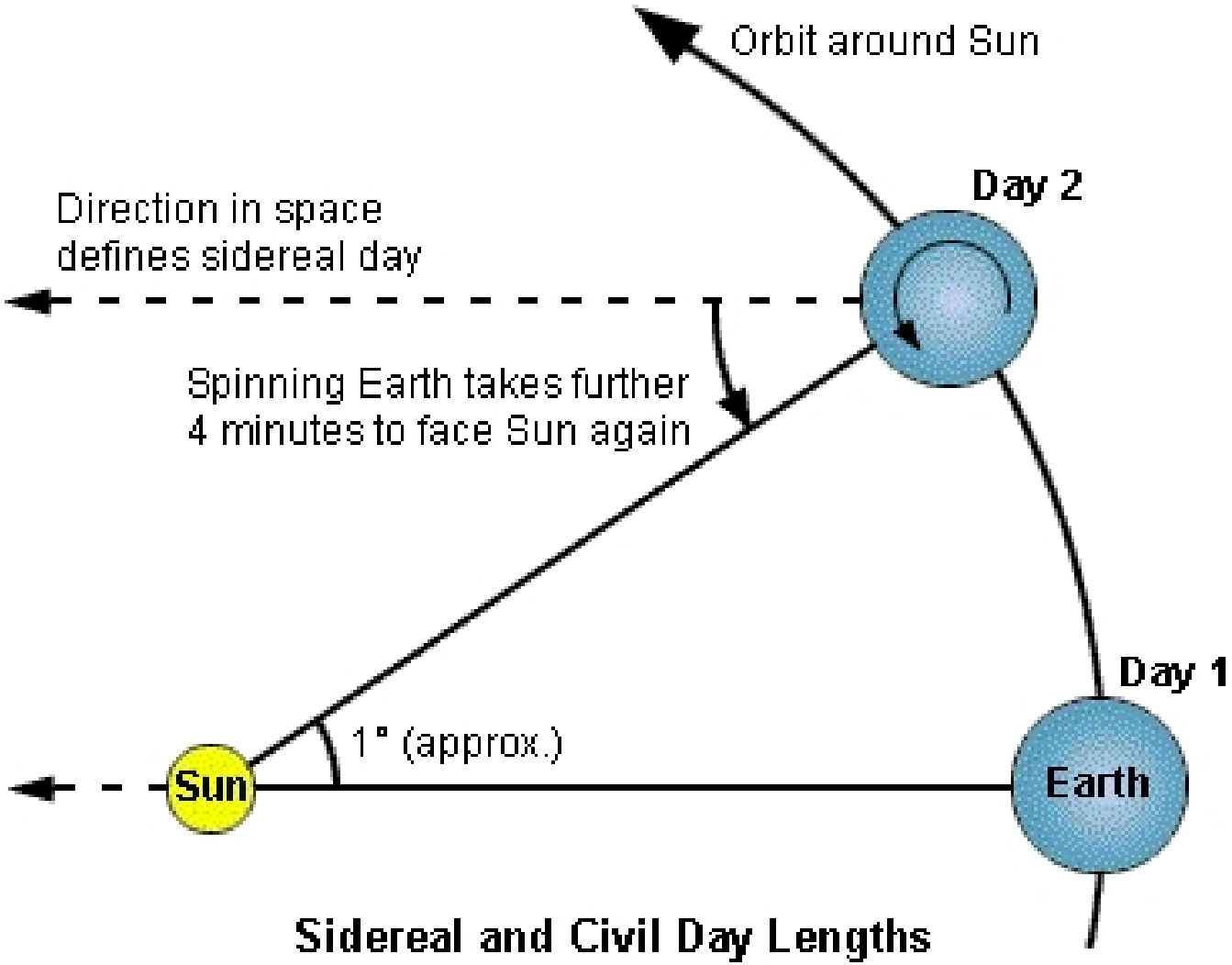
Solar Time

- Local time
- Standard time
- Greenwich time
- Universal time

Universal time

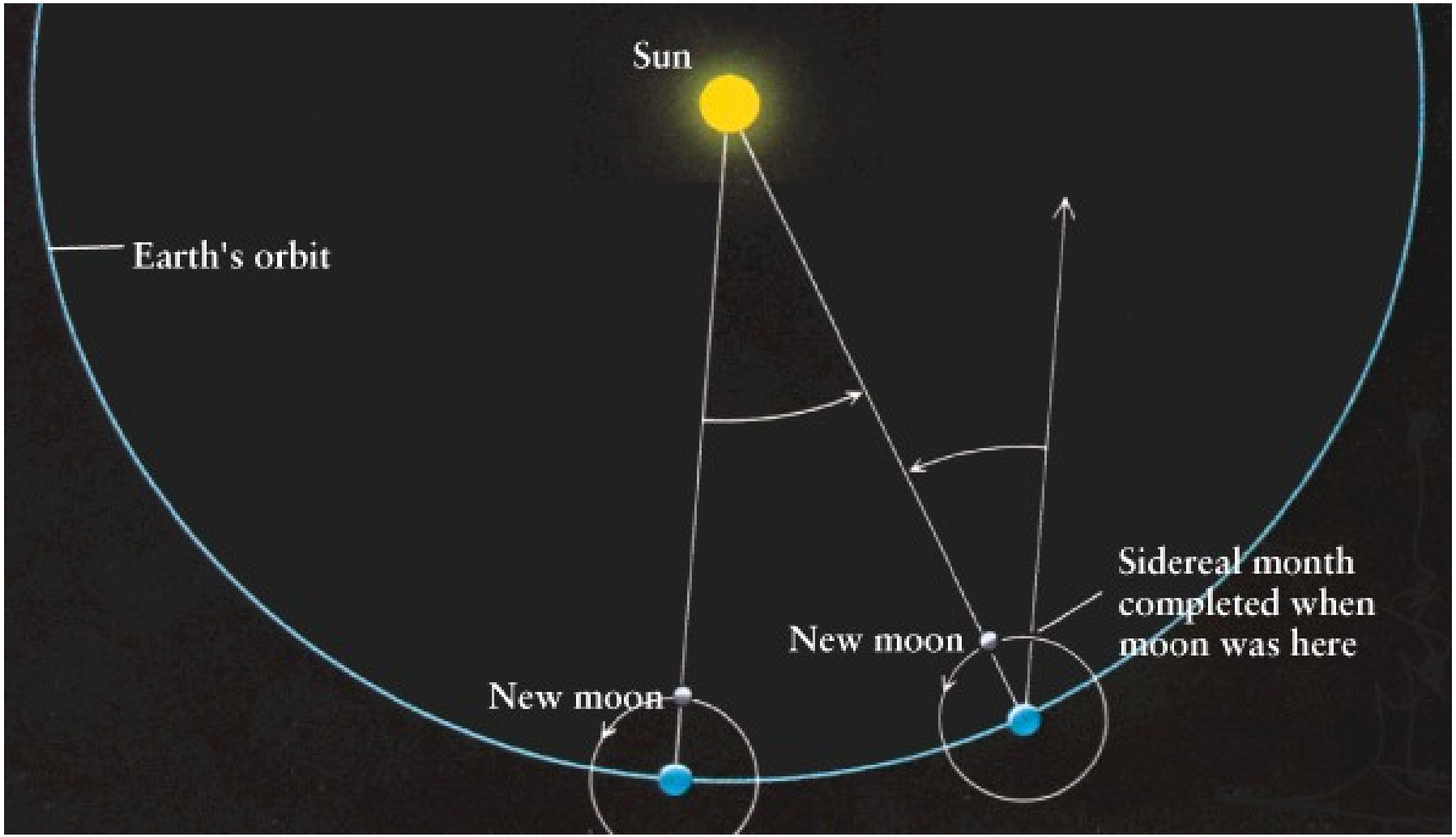
a generic reference to one of several time scales that approximate the mean diurnal motion of the Sun; loosely, mean solar time on the Greenwich meridian (previously referred to as Greenwich Mean Time). In current usage, UT refers either to a time scale called UT1 or to Coordinated Universal Time (UTC). UT1 is formally defined by a mathematical expression that relates it to sidereal time. Thus, UT1 is observationally determined by the apparent diurnal motions of celestial bodies, and is affected by irregularities in the Earths rate of rotation and needs correction. UTC is an atomic time scale but is maintained within 0s.9 of UT1 by the introduction of 1-second steps when necessary. Generally, leap seconds are added at the end of June or December as necessary, but may be inserted at the end of any month. Although it has never been utilized, it is possible to have a negative leap second in which case the 60th second of a minute would be removed.

Sidereal versus Solar Day



Could the sidereal day have been longer than a solar day?

Sidereal versus Synodic Month



Most lunar calendars use the Synodic month

Julian Day

- the interval of time in days and fractions of a day, since 4713 B.C. January 1, Greenwich noon.
- note that Julian day starts at noon. Why?
- Astronomers often use modified Julian day (MJD; starts at midnight!) or reduced Julian day (RJD)

Year

- **Tropical year** (or solar year): the period of revolution of the Earth around the Sun with respect to the *dynamical equinox*. The tropical year comprises a complete cycle of seasons, and its length is approximated in the long term by the civil (Gregorian) calendar. It is approximately 365 days, 5 hours, 48 minutes, 45 seconds (365.2422 days).
- **Sidereal year**: the period of revolution of the Earth around the Sun in a fixed reference frame. It is the mean period of the Earths revolution with respect to the background stars. The sidereal year is currently approximately 20 minutes longer than the tropical year. Will our night sky in January 10000 AD look very different? Will it still be winter in January?
- **Anomalistic Year**: the period between successive passages of the Earth through perihelion. The anomalistic year is approximately 25 minutes longer than the tropical year.

Gregorian calendar

- The calendar introduced by Pope Gregory XIII in 1582 to replace the Julian calendar. This calendar is now used as the civil calendar in most countries. In the Gregorian calendar, every year that is exactly divisible by four is a leap year, except for centurial years, which must be exactly divisible by 400 to be leap years. Thus 2000 was a leap year, but 1900 and 2100 are not leap years.
- (365 * 400 + 100 - 3)/400 = 365.2425

Equation of time

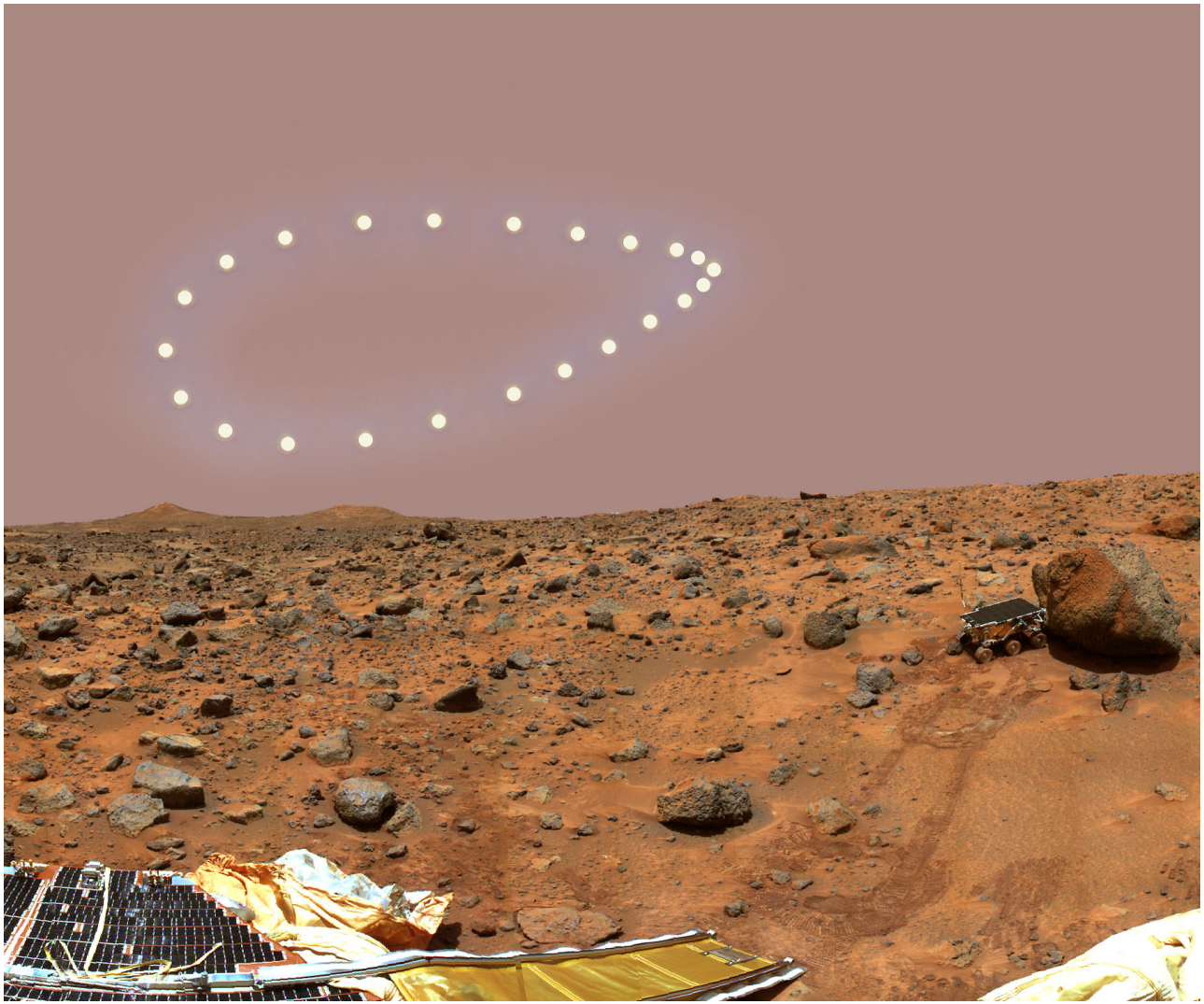
The equation of time describes the discrepancy between two kinds of solar time. These are apparent solar time, which directly tracks the motion of the sun, and mean solar time, which tracks a *fictitious mean sun* with noons 24 hours apart.
There seems to be no convention for the sign (+-) of the equation of time.

Equation of time - the fictitious mean sun

Some questions to ponder

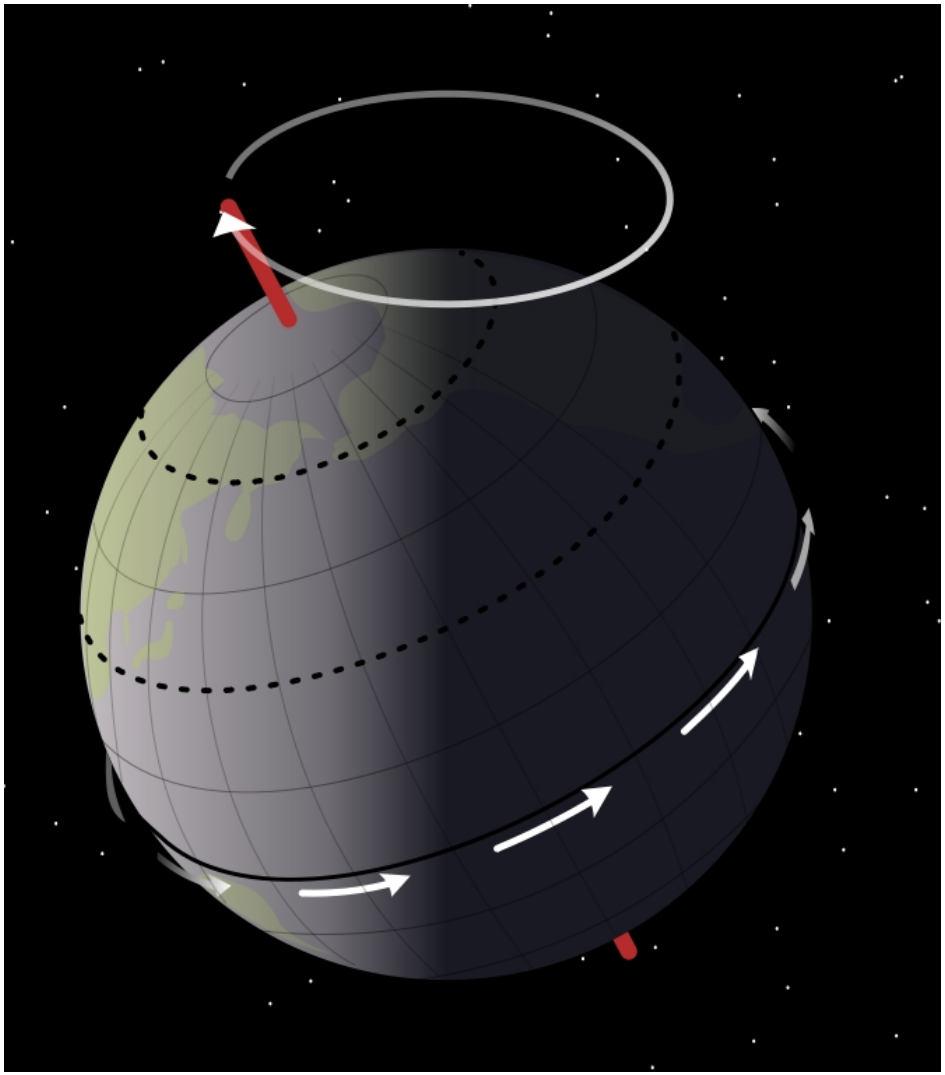
- What is the shortest day of the year?
- When is the earliest sunset?
- When is the latest sunrise?
- Why are these 3 dates not coincident?
- And how is all this connected to the fact that the time shown by the Samrat Yantra at IUCAA needs a correction that depends on the time of year?

Mars analemma



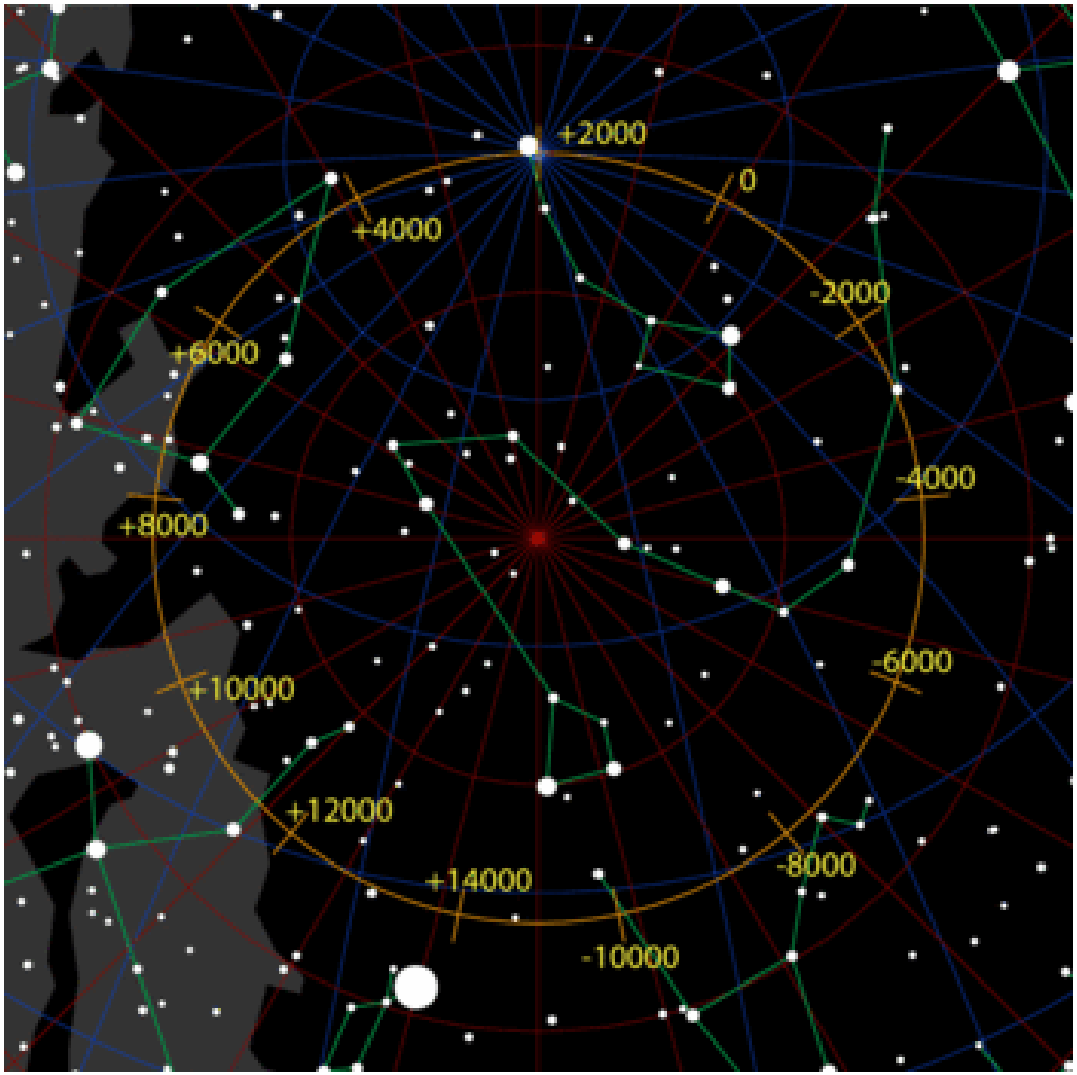
Read: `http://scienceblogs.com/startswithabang/2009/08/26/why-our-analemma-looks-like-a/`

Earth precession - 25800 year cycle

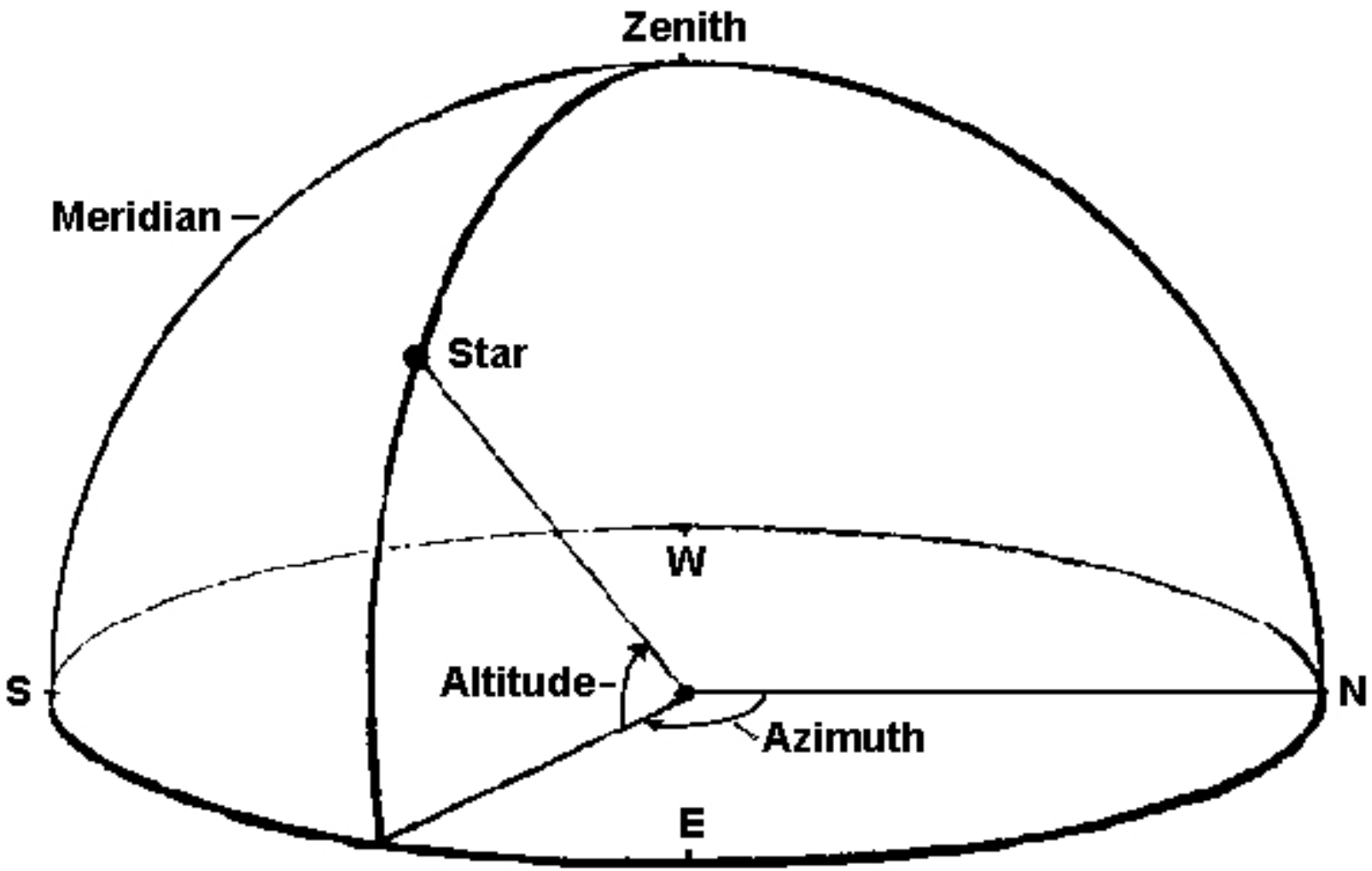


Note direction of precession

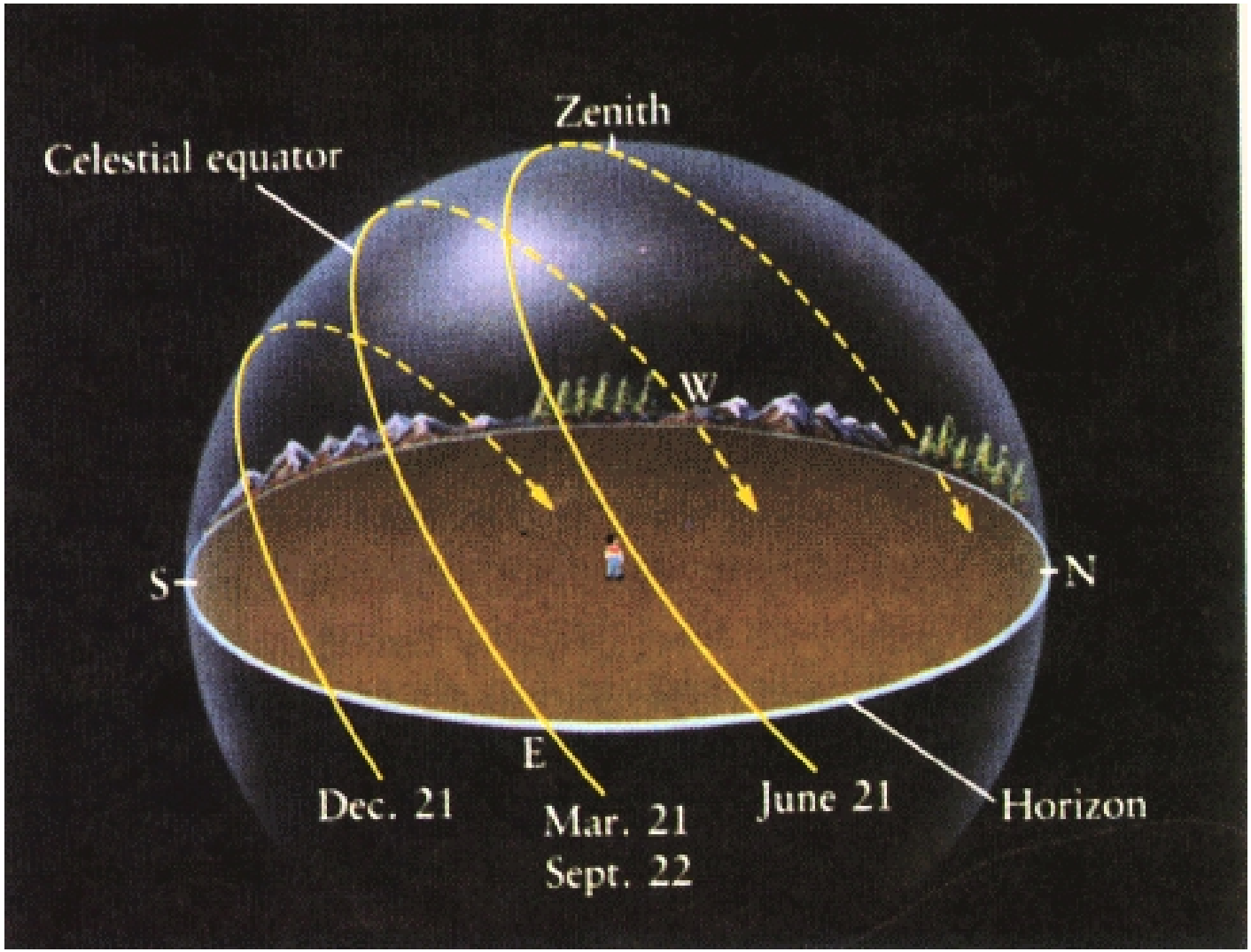
Earth precession changes the pole star



Altazimuth coordinates

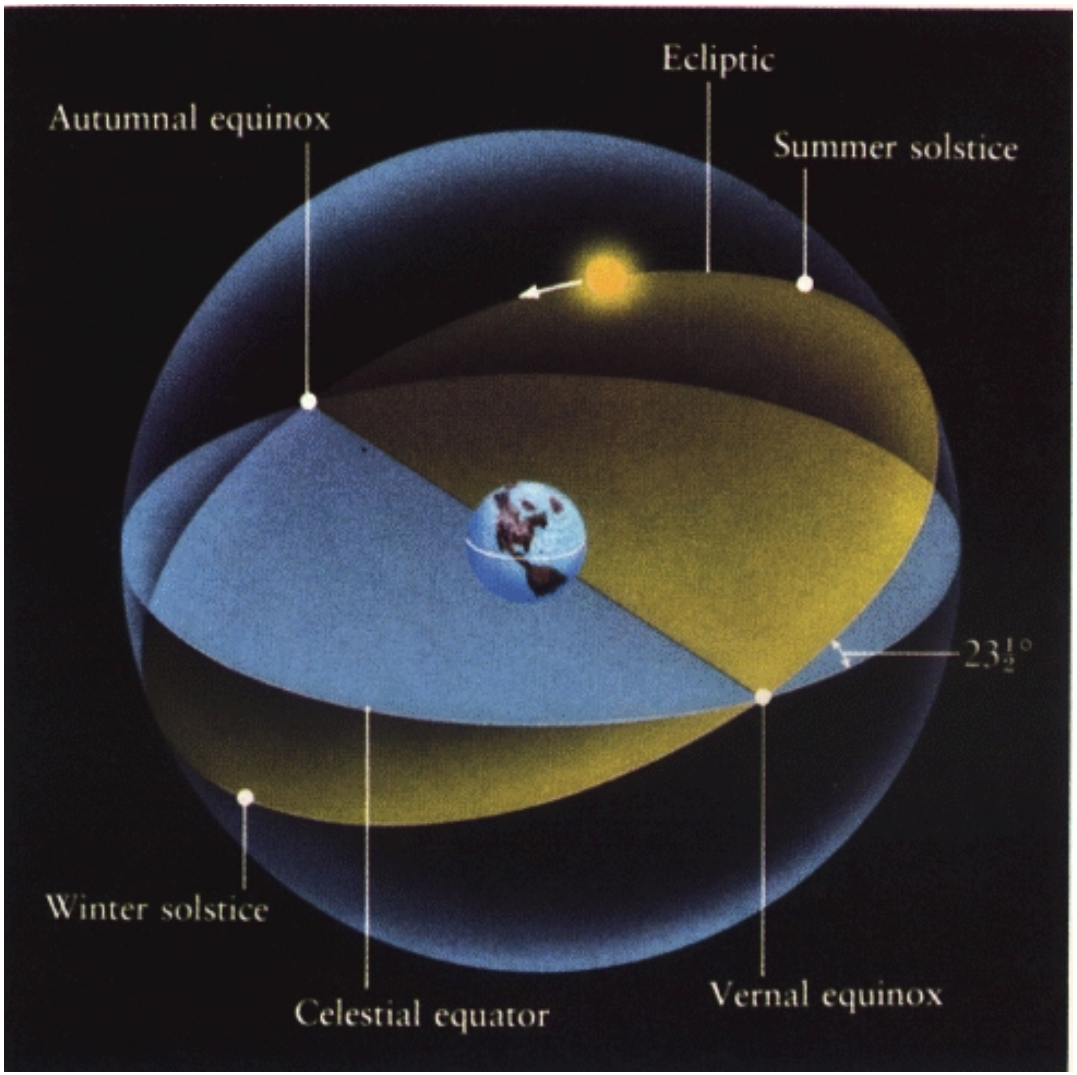


How does the sun move?

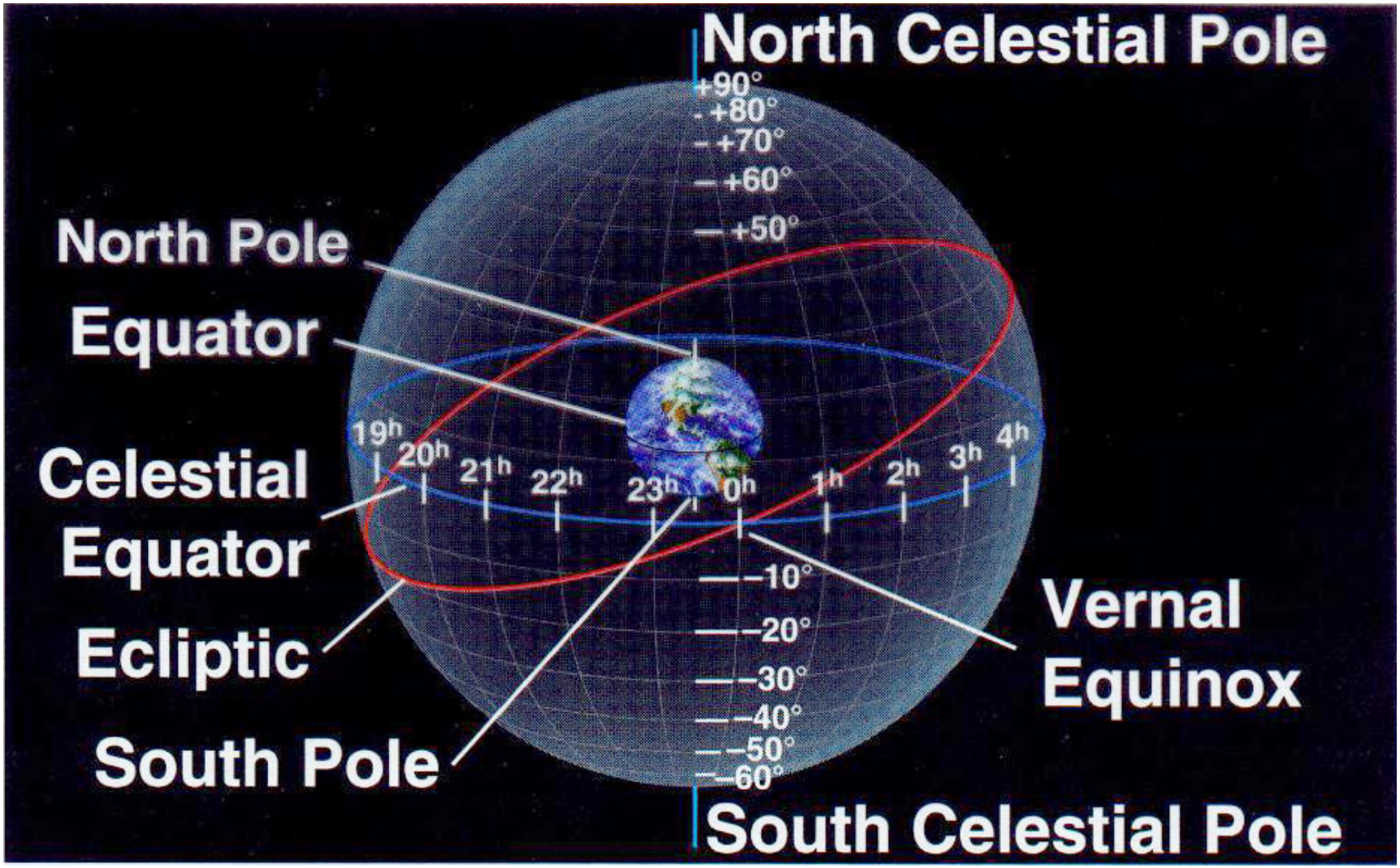


How do stars move in the sky?

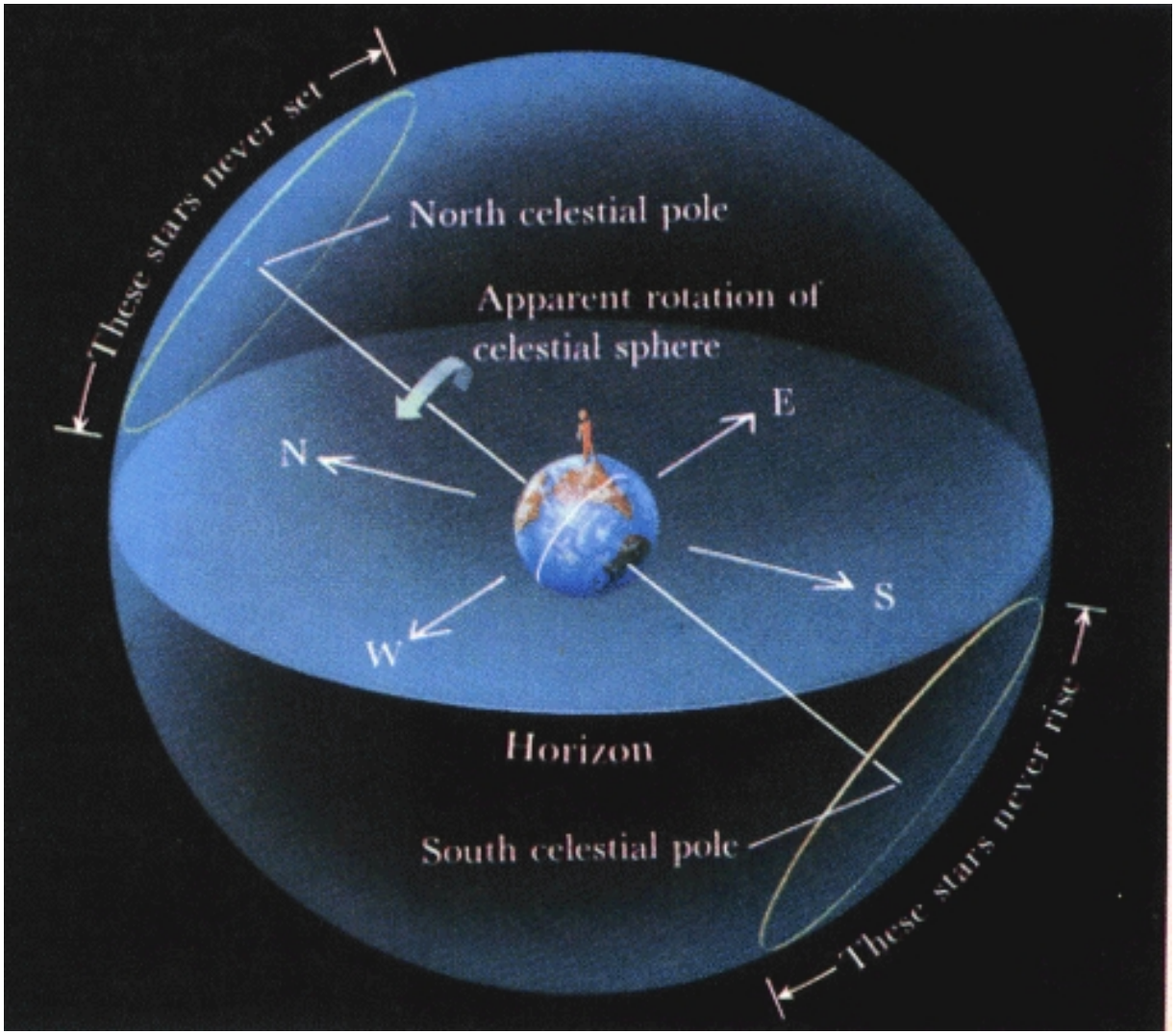
Celestial sphere



Celestial sphere - definitions

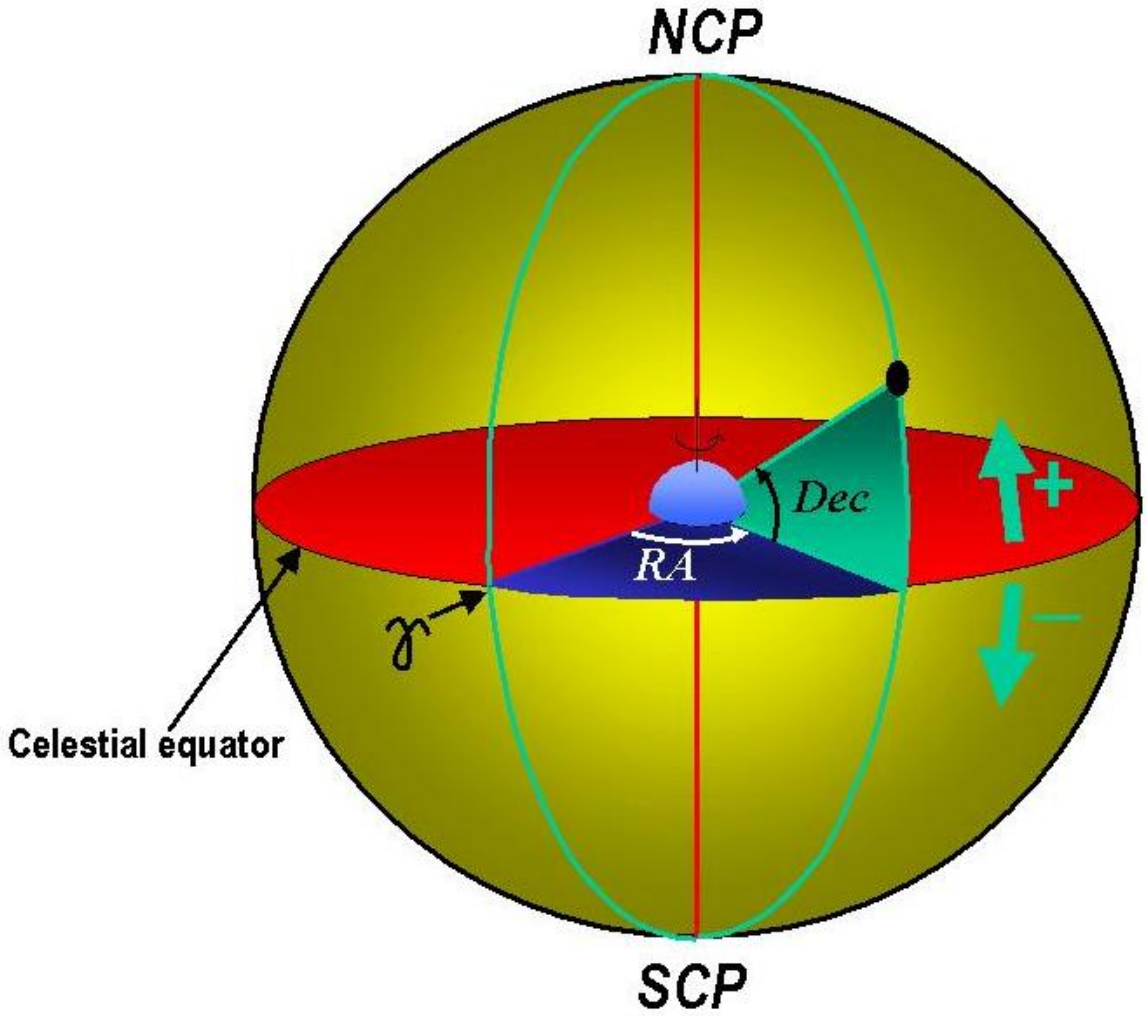


Circumpolar stars



Circumpolar stars

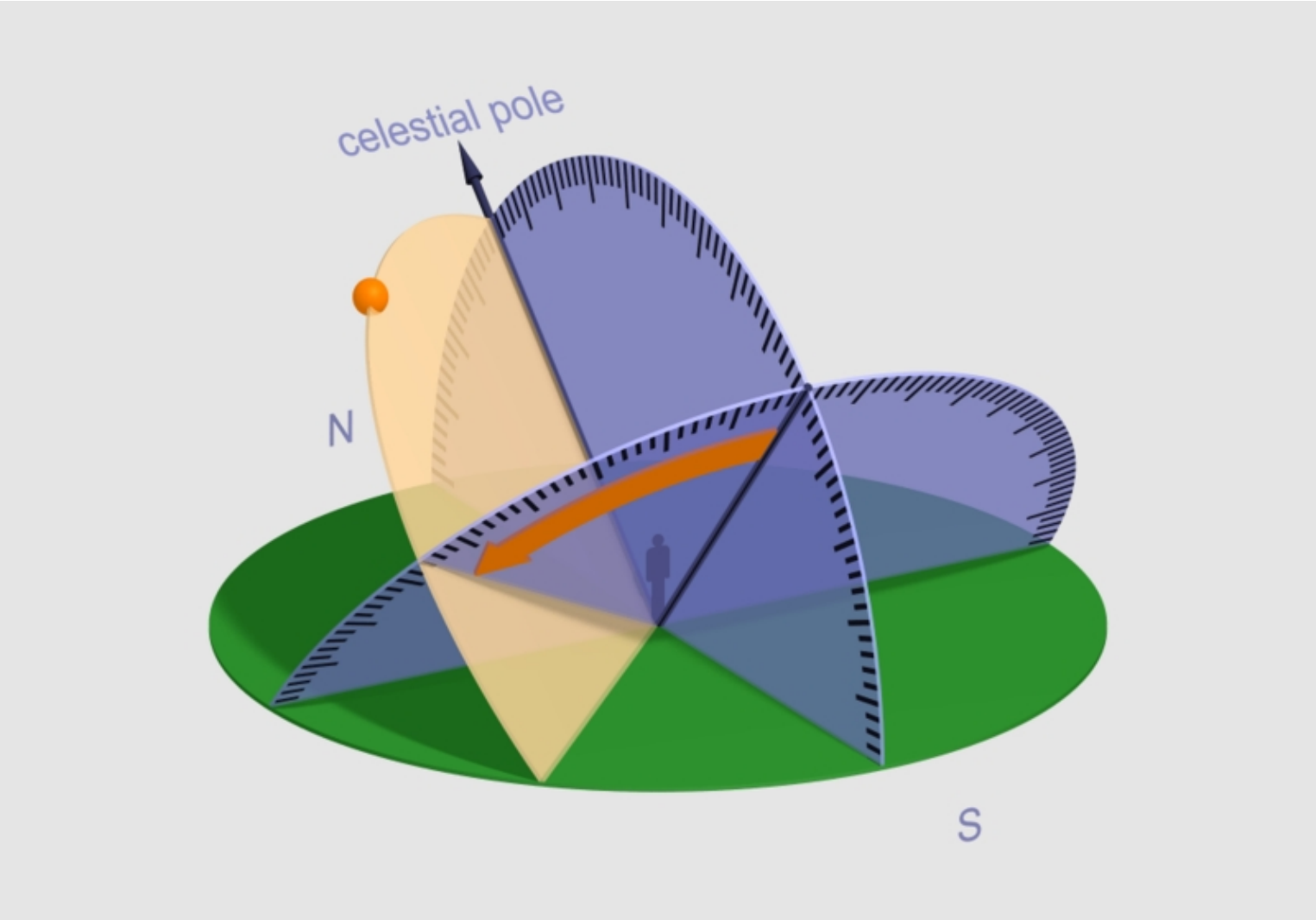
Right ascension (α) and Declination (δ)



Right ascension (α) and Declination (δ)

- RA measured in hours, minutes and seconds or decimal degrees.
- Dec measured in degrees, minutes and seconds or decimal degrees.

Hour angle (HA)



Local sidereal time (LST)

is the hour angle of the vernal equinox. It can also be defined as the right ascension of the meridian.

Do sidereal time clocks run slower or faster depending on whether the earth is closer or further from the sun in its elliptical orbit?

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Compute the local sidereal time at 6 pm local time on 22 December (winter solstice)?

Computing HA

HA = LST - α

What is the hour angle of an object at RA=23:00:00 at 6 pm local time on 22 December (winter solstice)?