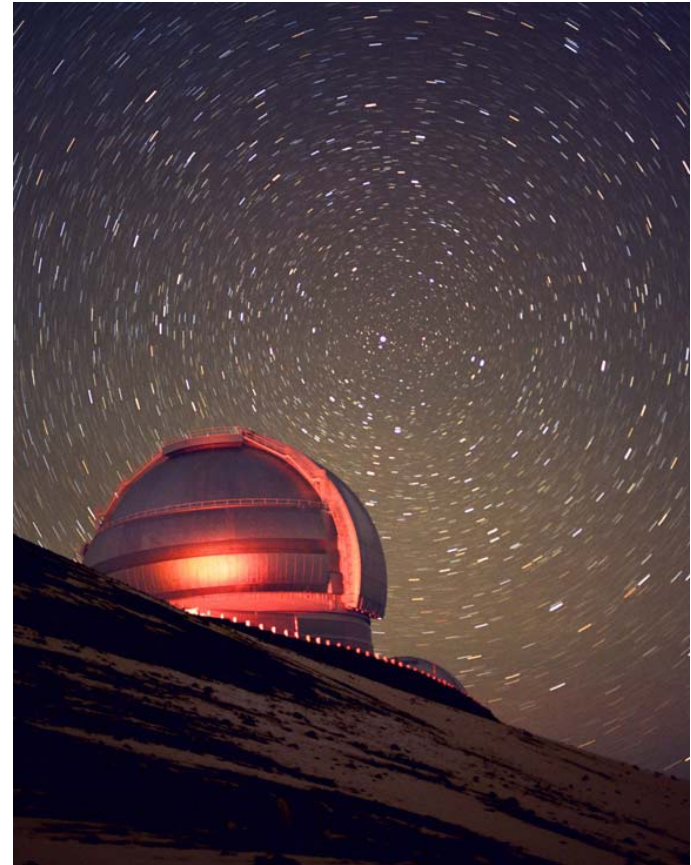


The Night Sky

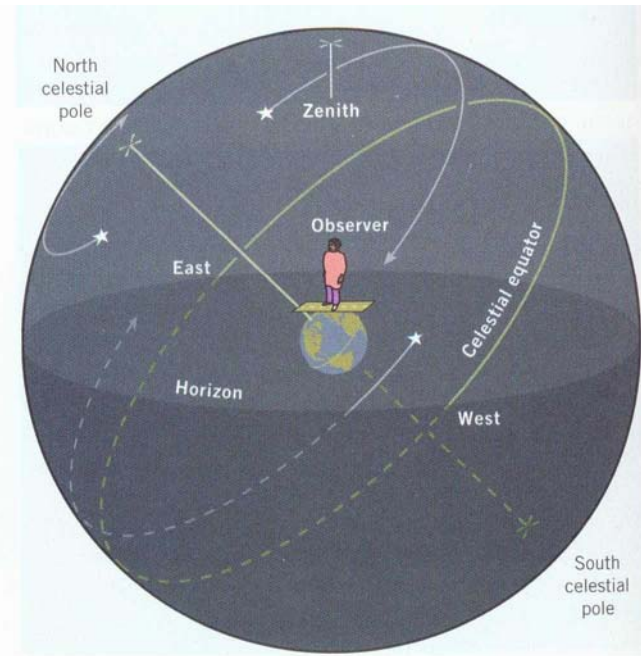
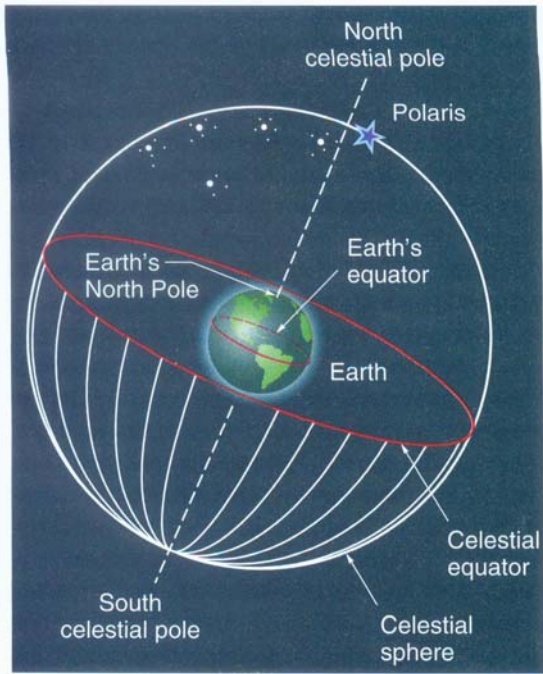
Stars

- “fixed” positions relative to one another
- absolute positions move east to west with diurnal rotation of the whole sky
- which stars are visible depends on the time, season, and position on Earth
- can imagine stars are fixed to surface of a celestial sphere



A view to the north above the new Gemini telescope.

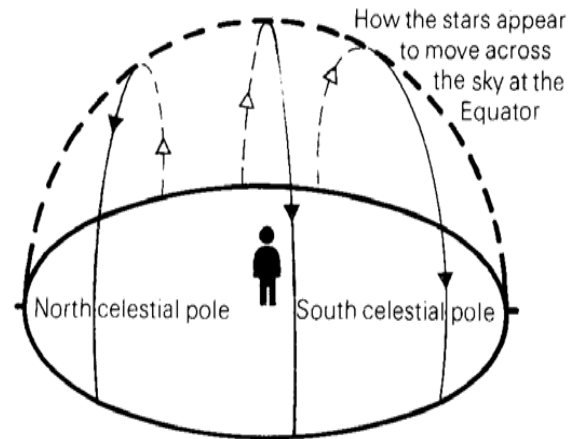
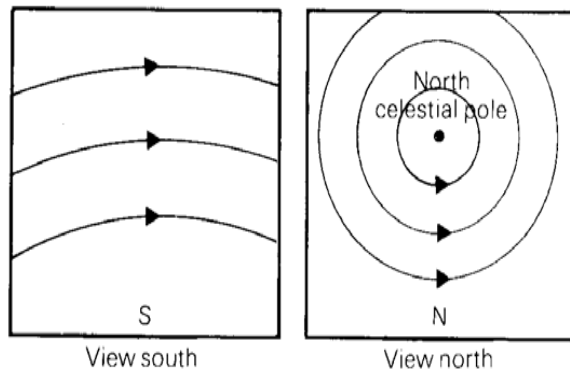
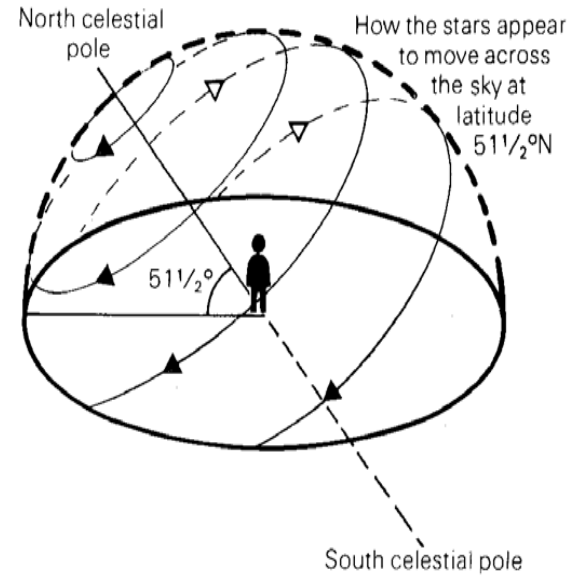
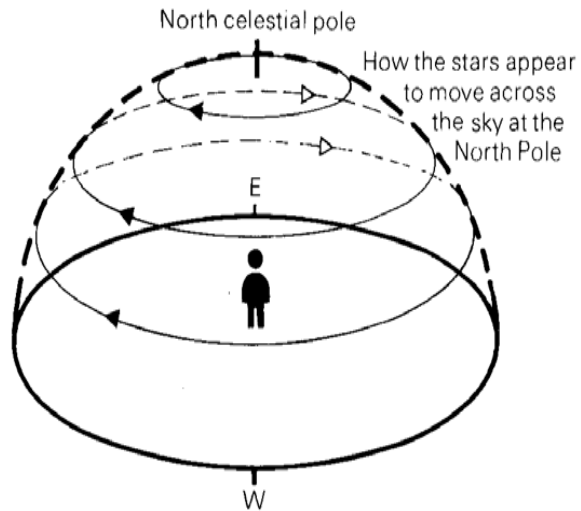
The Celestial Sphere



Diurnal motions of objects in the sky imply they may be on a sphere surrounding the Earth. The location on Earth determines the local horizon, which along with the location of the Sun determines which stars are visible at any time.

Motion of the Stars

STARGAZING



Constellations

- apparent groupings of stars in the sky
- aid in tracking position and motion of stars
- useful for keeping track of time, location, and seasons



Orion and Taurus, the hunter and the bull.

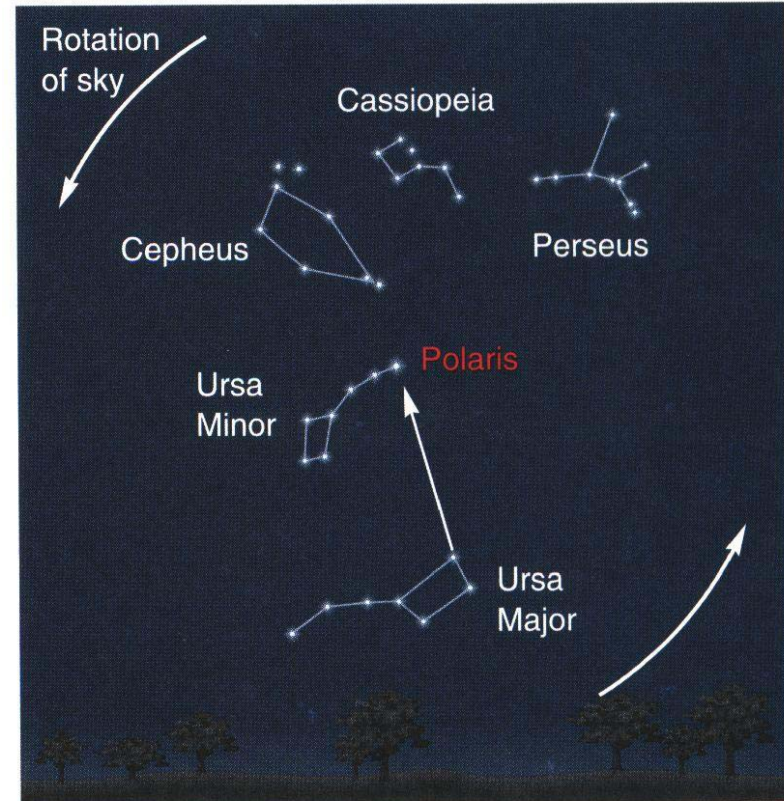
There are 88 officially designated constellations.

Constellations



a

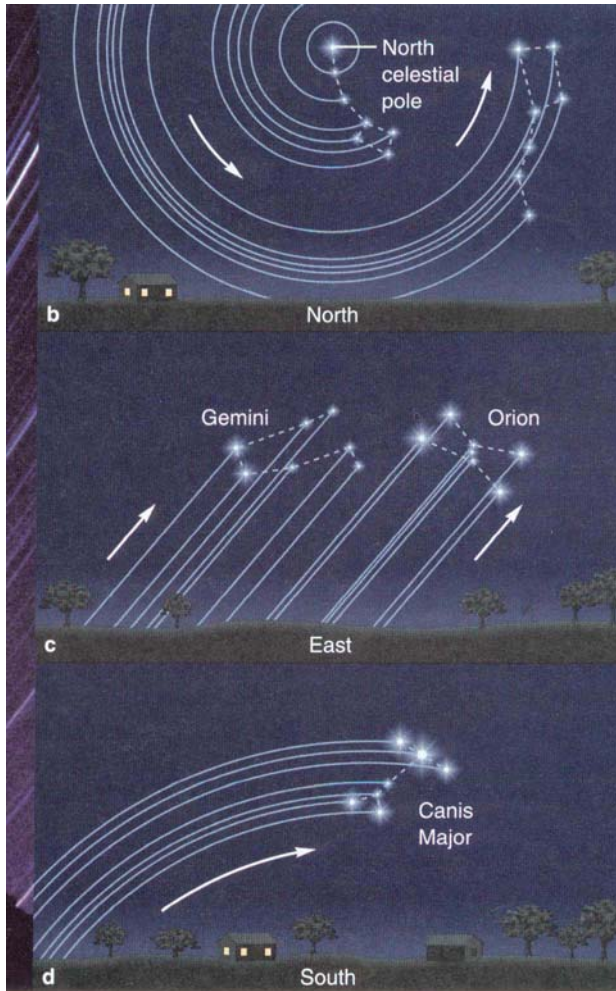
Orion. The stars are designated by Greek letters, usually in order of brightness.



Some constellations always visible in the northern hemisphere. Polaris = pole star.

Constellations

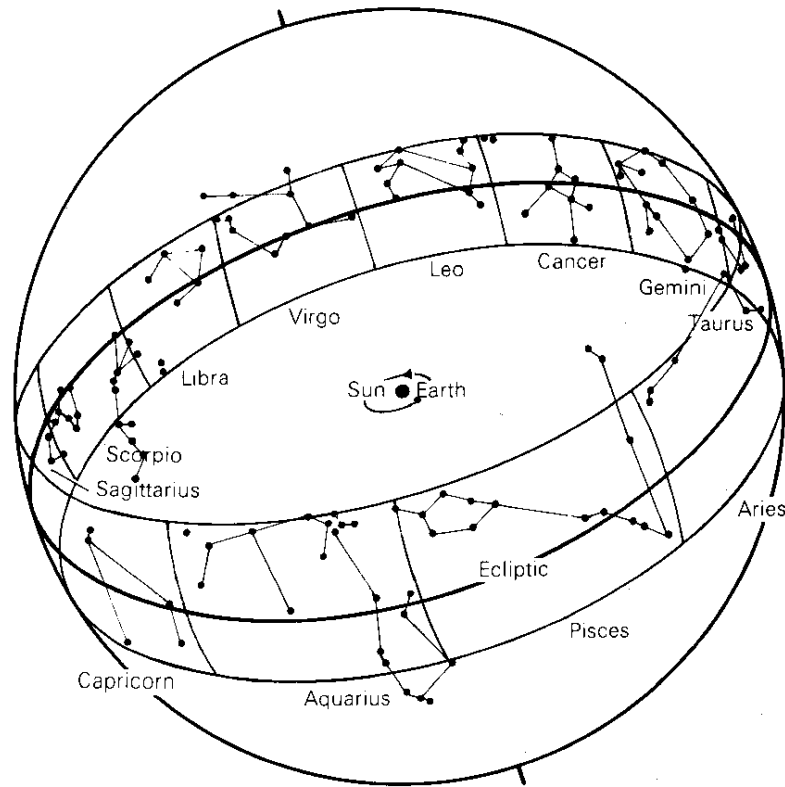
Motion of stars and constellations across the northern sky.



Sun and Planets

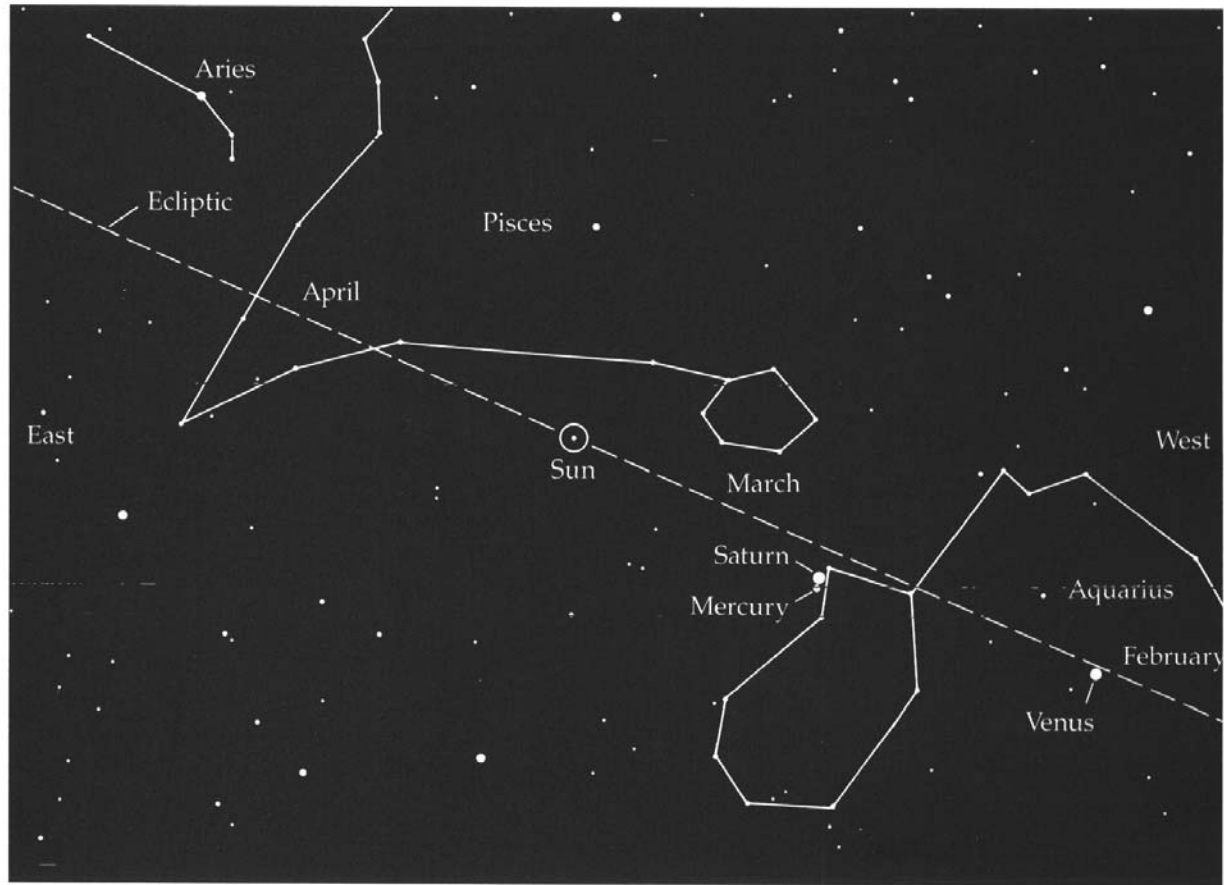
- wander relative to fixed stars
- “planetes” is Greek for wanderers
- seven known historically: Sun, Moon, Mercury, Venus, Mars, Jupiter, and Saturn - form basis of 7-day week - Babylonians
- generally move west to east relative to stars, but retrograde motions also occur for some planets
- the 12 Zodiac constellations are special since the Sun moves through them - planets also remain near these constellations
- the annual path of the Sun through the fixed stars is called the ecliptic - Zodiac constellations lie nearly along the ecliptic
- how can we make sense of all these motions?

The Ecliptic and the Zodiac Constellations



The Earth-Sun line rotates through 360° in the course of a year. Other planets lie approximately within the Earth-Sun plane. The Sun (and planets) appear to migrate across the CS through the year. Intersection of Earth-Sun plane with CS is the ecliptic.

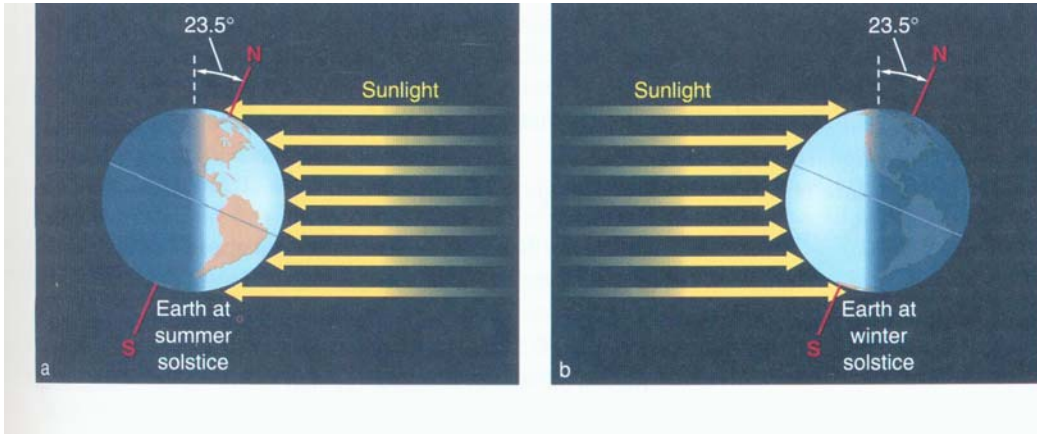
Sun and Planets



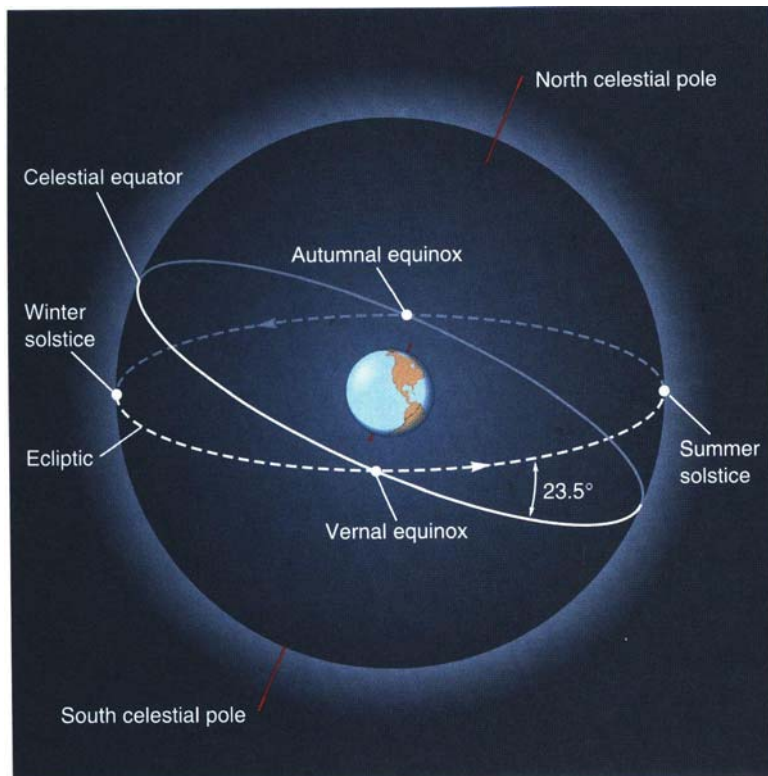
(A)

Sun on the ecliptic with nearby Zodiac constellations and some planets - a daytime view.

The Yearly Motion of the Sun



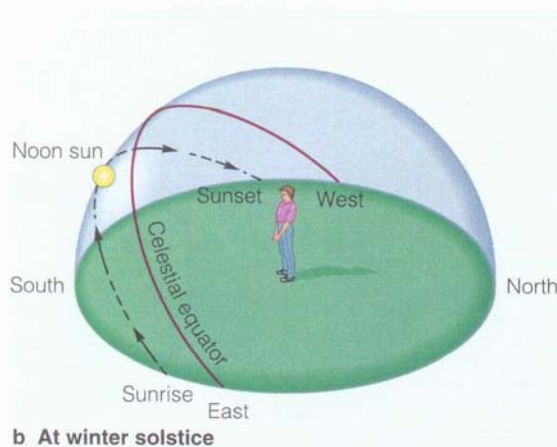
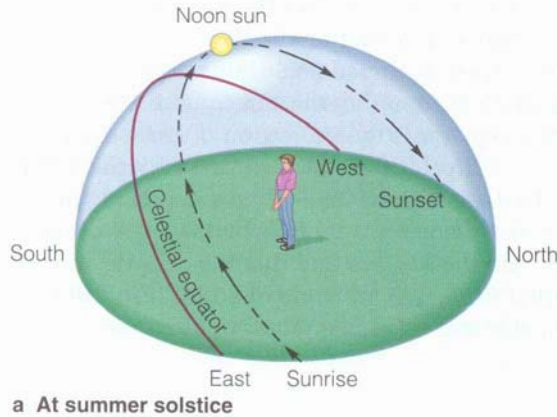
View from outside Earth:
inclination of equator to Earth-Sun plane causes yearly migration of Sun from north to south on CS.



View from within the CS: the Sun completes a 360° motion due to Earth-Sun orbit, but this path (the ecliptic) is offset from the celestial equator by 23.5° .

The Daily Motion of the Sun

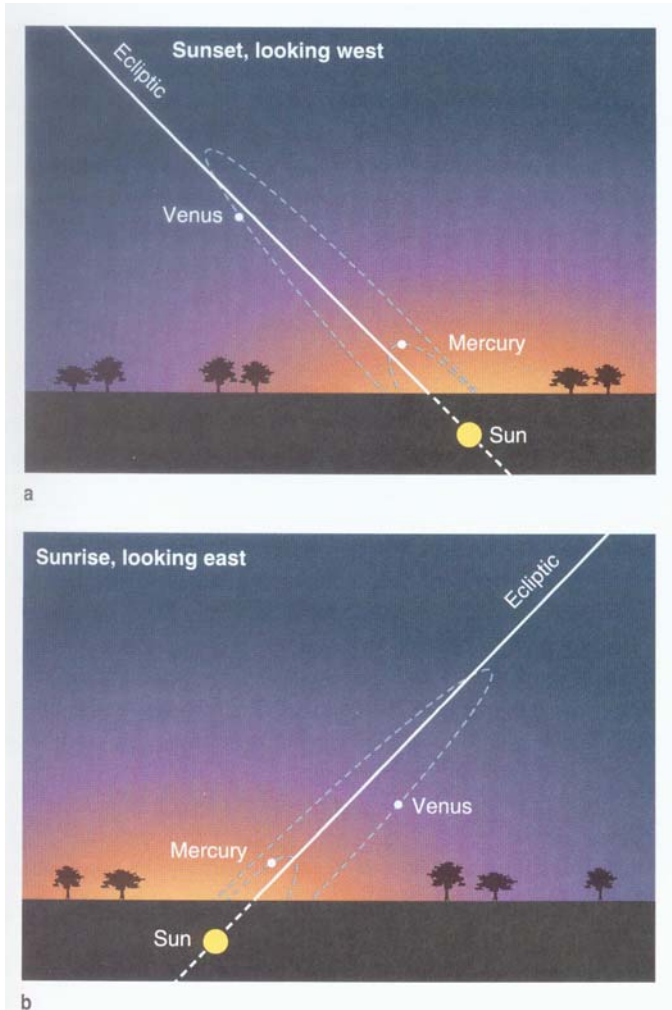
Like the stars, the Sun undergoes a diurnal motion due to the Earth's rotation. This is independent of the slow yearly movement across the CS.



The daily paths of the Sun at latitude 40°N. Notice the person's shadows.

The summer (winter) Sun is above the horizon for more than (less than) 12 hours. The summer Sun stands higher in the sky at mid-day. However, note that it remains below the zenith at all times.

Motion of the Planets

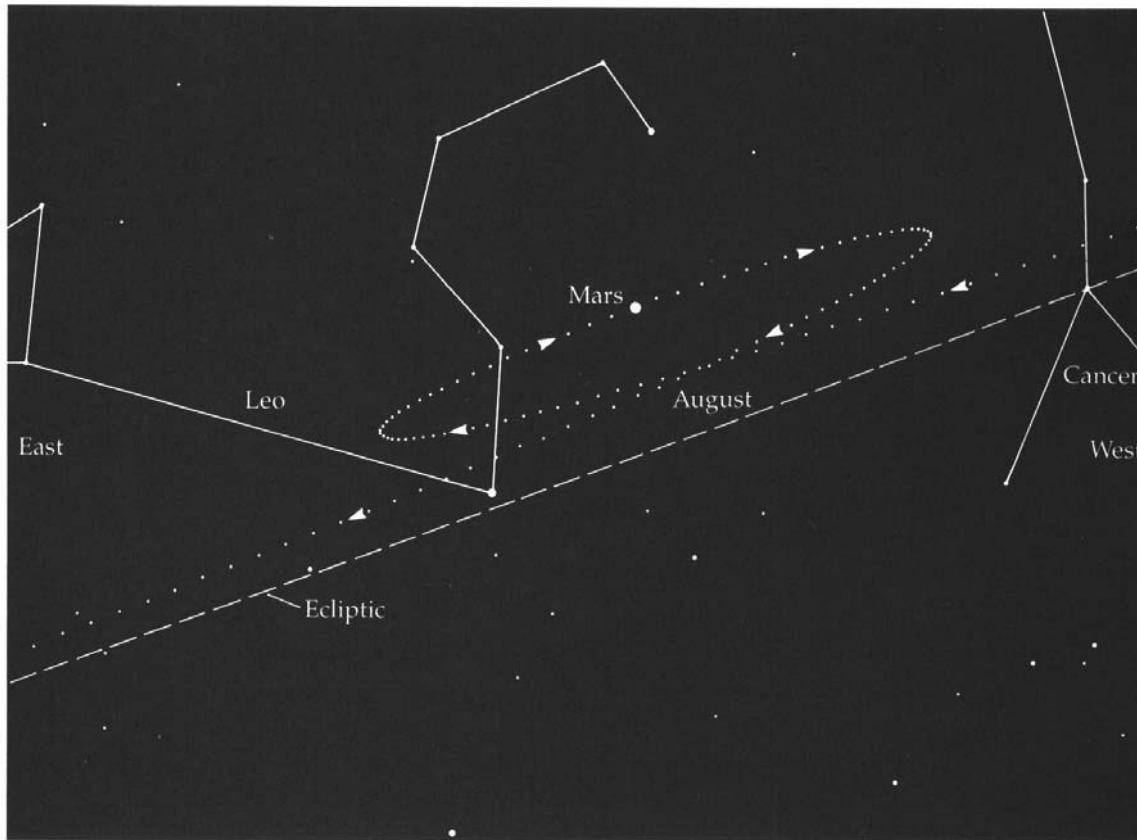


Mercury and Venus are often visible just after sunset in the western sky or just before sunrise in the eastern sky.

They are the only planets to always remain within a fixed angular distance from the Sun. Why?

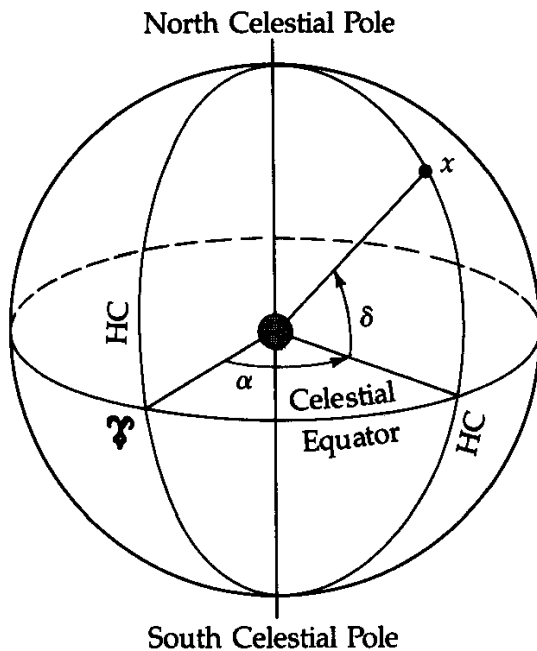
Motion of the Planets

Other planets remain near the ecliptic, but may not be near the Sun. Some exhibit retrograde motion.



Retrograde motion of Mars in 1993-1995.

Celestial Sphere coordinates



Coordinates rotate westward around Earth once/day. Stars have fixed δ , α .

δ = Declination, angular distance above celestial equator, -90^0 to $+90^0$

α = RA = Right Ascension, angle eastward of vernal equinox measured in hrs,min, sec ($24 \text{ h} = 360^0$, $1 \text{ h} = 15^0$, $4 \text{ min} = 1^0$).

The Sun's position undergoes a small daily shift in δ and α . Path along CS traces out the ecliptic.

Important points in Sun's path: (1) vernal equinox ($\delta = 0, \alpha = 0$) - March 21. (2) summer solstice ($\delta = 23.5^0, \alpha = 6\text{h}$) - June 21. (3) autumnal equinox ($\delta = 0, \alpha = 12\text{h}$) - Sep. 21. (4) winter solstice ($\delta = -23.5^0, \alpha = 18\text{h}$) - Dec. 21.

Horizon coordinate system

Relative to observer's position. No object has fixed position.

zenith - vertically overhead

nadir - directly underfoot

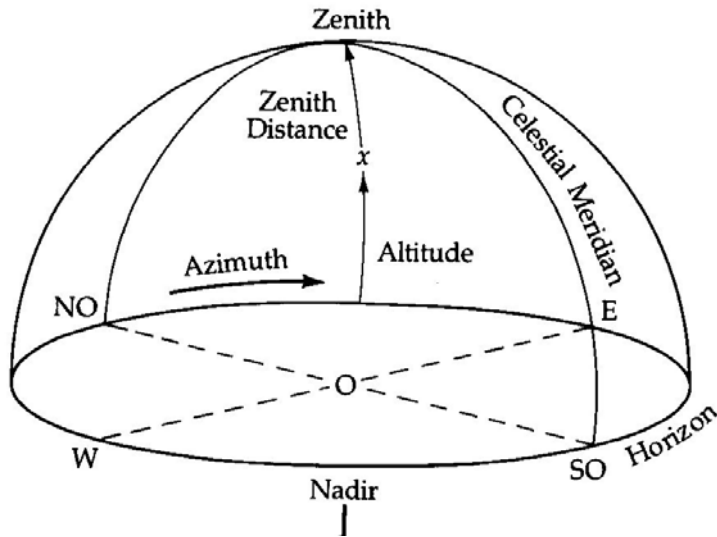
meridian - vertical circle which includes zenith and north and south points on horizon

azimuth - angular distance along horizon measured eastward from north point

altitude - angular distance upward from horizon

hour angle - angular distance parallel to celestial equator measured westward from the meridian ($360^0 = 24\text{hr}$)

upper transit - the event that a celestial body crosses the meridian moving westward



Recap

Stars:

- fixed positions on CS
- diurnal motions observed from local horizon system
- path in sky depends on location on CS and latitude of observer
- some always above horizon, some always below, and some are above horizon for part of day; latter are observable during part of the year, when Sun's position on CS places it below the horizon while the star is above it

Recap

Sun:

- 360° motion around CS due to Earth-Sun motion
- moves around ecliptic rather than around celestial equator (CE), since Earth-Sun orbit plane offset from CE by 23.5°
- diurnal motion in horizon system according to daily position on CS

Planets:

- move along CS, and stay close to ecliptic
- Mercury and Venus stay close to Sun; others can be near any portion of the ecliptic; some exhibit retrograde motion
- diurnal motion in horizon system according to daily position on CS