Part 3

- Celestial coordinate systems
  - Equatorial coordinate system

Equatorial coordinate system

- The equatorial coordinate system is based on the celestial equator and the vernal equinox.

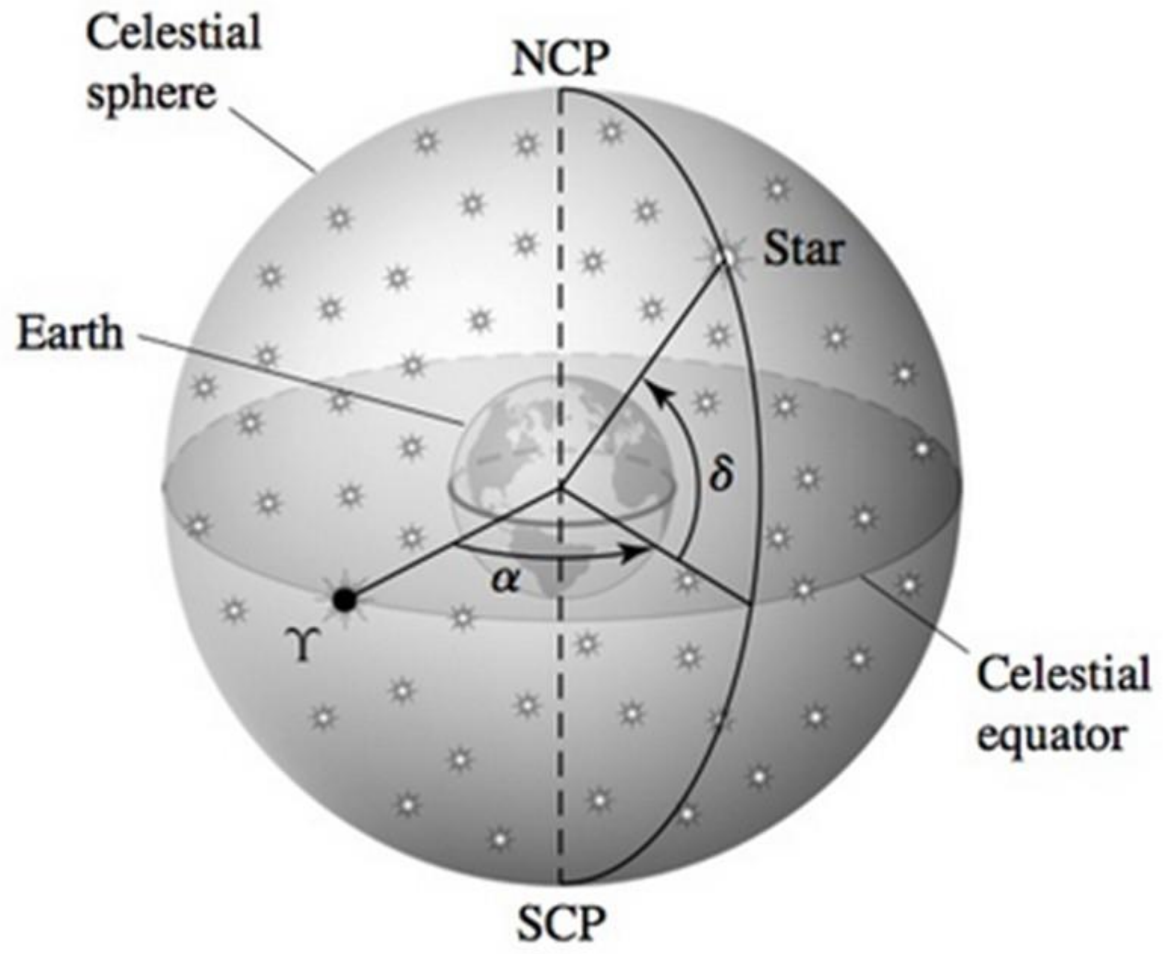


FIGURE 13 The equatorial coordinate system. α, δ, and Υ designate right ascension, declination, and the position of the vernal equinox, respectively.

Declination

- Declination δ is measured in degrees north (positive) or south (negative) of the celestial equator.
- For example, the NCP has a declination of $+90^\circ$.

Right ascension

- The hour circle of the object being considered is the great circle passing through the object and through the NCP.
- Right ascension α is measured eastward along the celestial equator from the vernal equinox (Υ) to its intersection with the object's hour circle.

Hours, minutes, & seconds

- Right ascension is traditionally measured in hours, minutes, and seconds; 24 hours of right ascension is equivalent to 360°, or 1 hour = 15°.

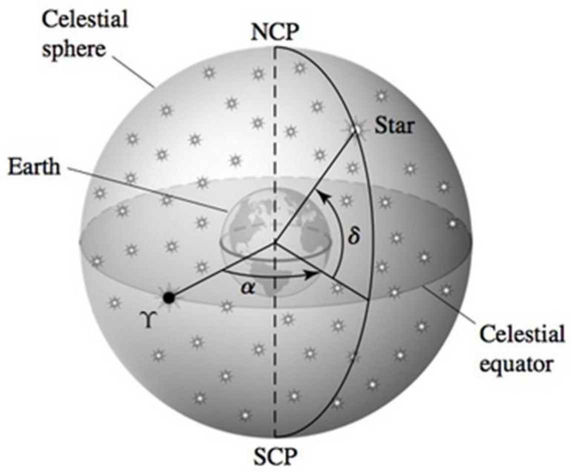


FIGURE 13 The equatorial coordinate system. α, δ, and Υ designate right ascension, declination, and the position of the vernal equinox, respectively.

Measurement of a star location

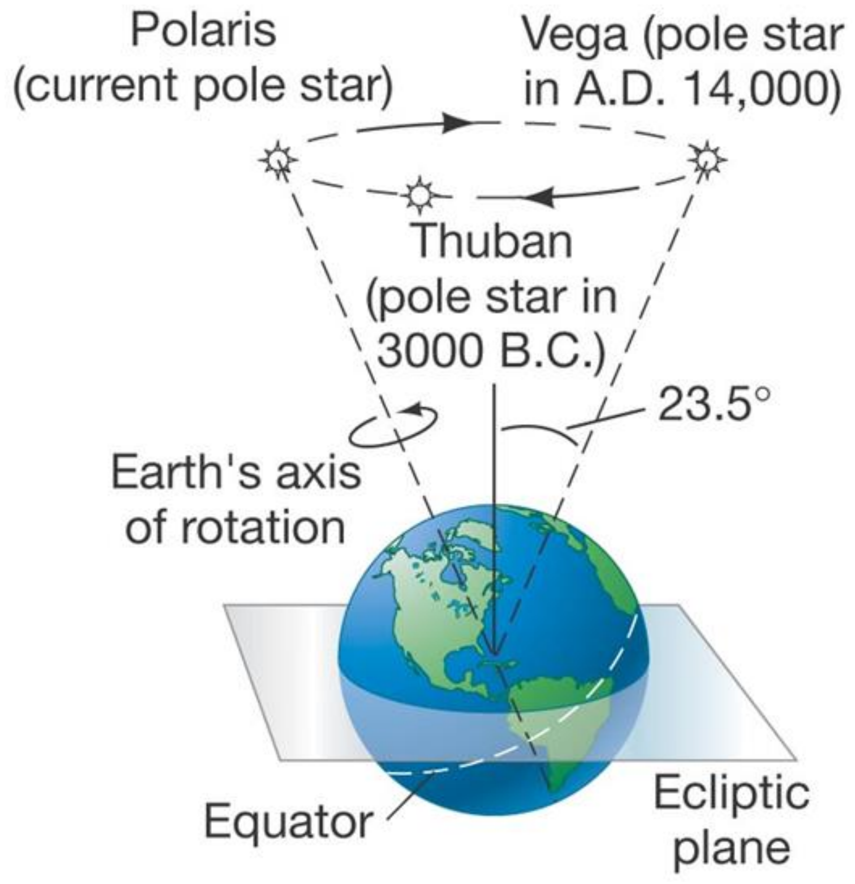
- Astronomers have chosen this unit to measure right ascension because they measure a star’s location by timing its passage through the meridian as Earth rotates.
  - E.g., if a star with α = 0 hour is at its meridian, then a star with α = 1 hour will be at its meridian 1 hour later.

Nearly constant values

- The equatorial coordinate system results in nearly constant values for the positions of celestial objects, despite the complexities of diurnal and annual motions.
  - Precession causes the right ascension and declination of celestial objects to change, albeit very slowly.
- Changes in the location of the observer do not affect the values of right ascension and declination.

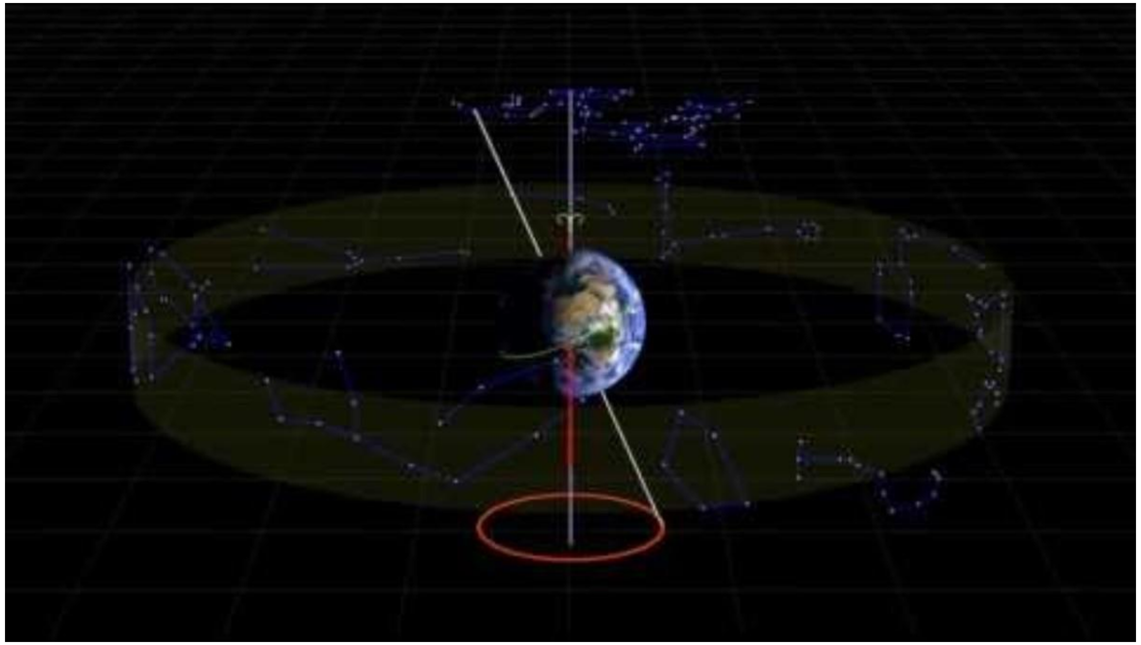
Precession

- Precession is the slow wobble of Earth's rotation axis due to our planet's nonspherical shape and its gravitational interaction with the Sun and the Moon.
- Earth's precession period is 26,000 years and causes the NCP to make a slow circle through the heavens.



Westward motion of the vernal equinox

- Earth's precession also causes an approximately 50″ yr^{-1} westward motion of the vernal equinox along the ecliptic.



https://www.youtube.com/watch?v=qlVgEoZDjok&t=29s

Epoch J2000.0

- Because precession alters the position of the vernal equinox along the ecliptic, it is necessary to refer to a specific epoch (or reference date) when listing the right ascension and declination of a celestial object.
- The epoch commonly used today for astronomical catalogs refers to an object’s position at noon in Greenwich, England (universal time, UT) on January 1, 2000. A catalog using this reference date is designated as J2000.0.

Angular distance between two points

- Figure 17 shows two points on the celestial sphere, A and B.
- The angular distance is $\Delta\theta$.
- The coordinates at point A and point B are (α, δ) and ($\alpha + \Delta\alpha$, $\delta + \Delta\delta$), respectively.
- The laws of spherical trigonometry can be employed to find $\Delta\theta$.

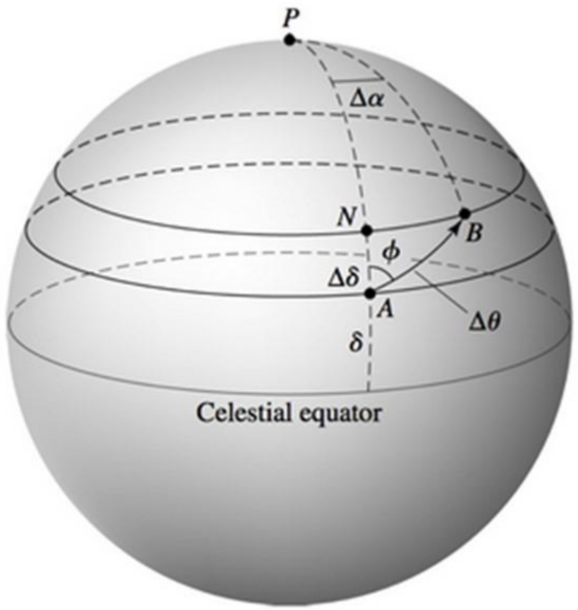


FIGURE 17 The proper motion of a star across the celestial sphere. The star is assumed to be moving from *A* to *B* along the position angle ϕ.

Laws of spherical trigonometry

Law of sines

$$\frac{\sin a}{\sin A} = \frac{\sin b}{\sin B} = \frac{\sin c}{\sin C}$$

Law of cosines for sides

$$\cos a = \cos b \cos c + \sin b \sin c \cos A$$

Law of cosines for angles

$$\cos A = -\cos B \cos C + \sin B \sin C \cos a.$$

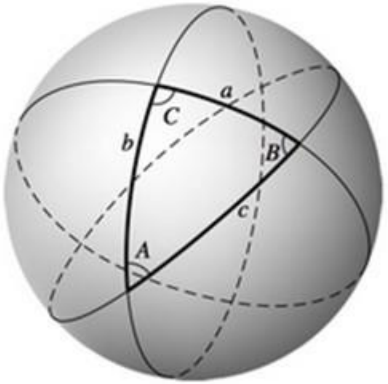


FIGURE 16 A spherical triangle. Each leg is a segment of a great circle on the surface of a sphere, and all angles are less than 180°. a, b, and c are in angular units (e.g., degrees).

Summary

- Celestial coordinate systems
  - Equatorial coordinate system

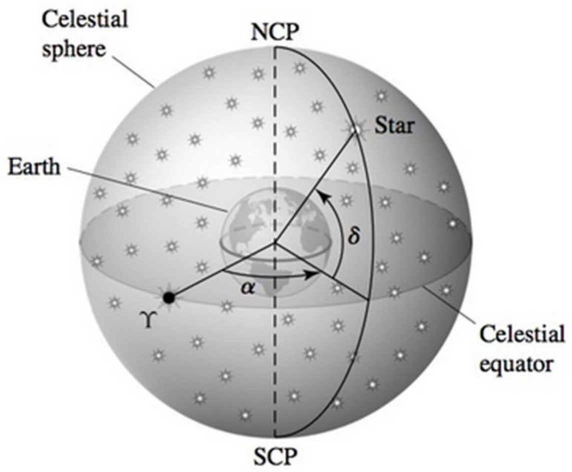


FIGURE 13 The equatorial coordinate system. α, δ, and Υ designate right ascension, declination, and the position of the vernal equinox, respectively.