33-777

Jan 14, 2020

Today

- introduction
- celestial coordinates

Celestial Coordinates

The "celestial sphere" is an anachronistic concept that is still useful for defining a coordinate system for celestial objects. Because most astrophysical objects are so distant, their apparent positions on the inside surface of this very large with the Earth rotating at its center.

Solar system objects (the planets, Sun, Moon, etc.) are an exception to this rule. These objects tend to wander (the origin of the word "planet" from the Greek) across the celestial sphere.

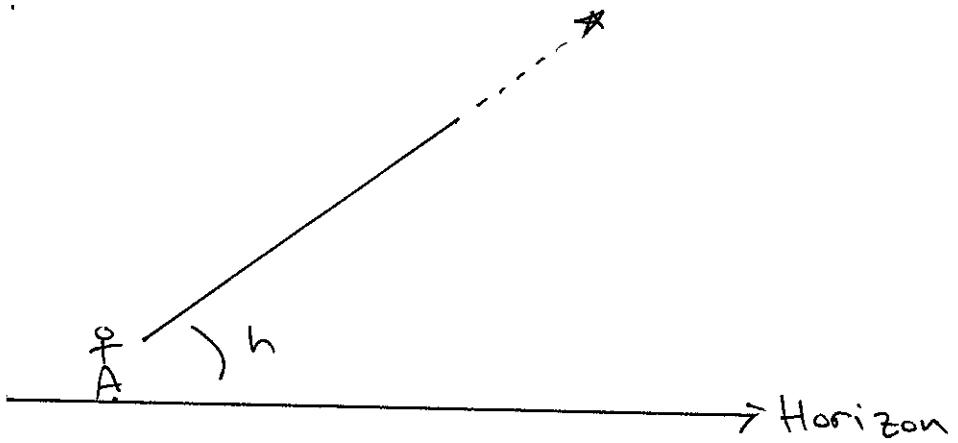
Understanding these objects was the backbone of the Scientific Revolution and ushered in our modern understanding of physics, astronomy, and cosmology. We will not review this in this course, but I highly recomend reviewing this material yourself.

To pinpoint the location of objects on the celestial sphere, astronomers use two systems:

① "Alt-Az" (Altitude, Azimuth)

② "Equtorial" (Right Ascension, Declination)

The first is the simplist to describe. The Altitude, h, is the angle between the direction towards an object and the horizon.



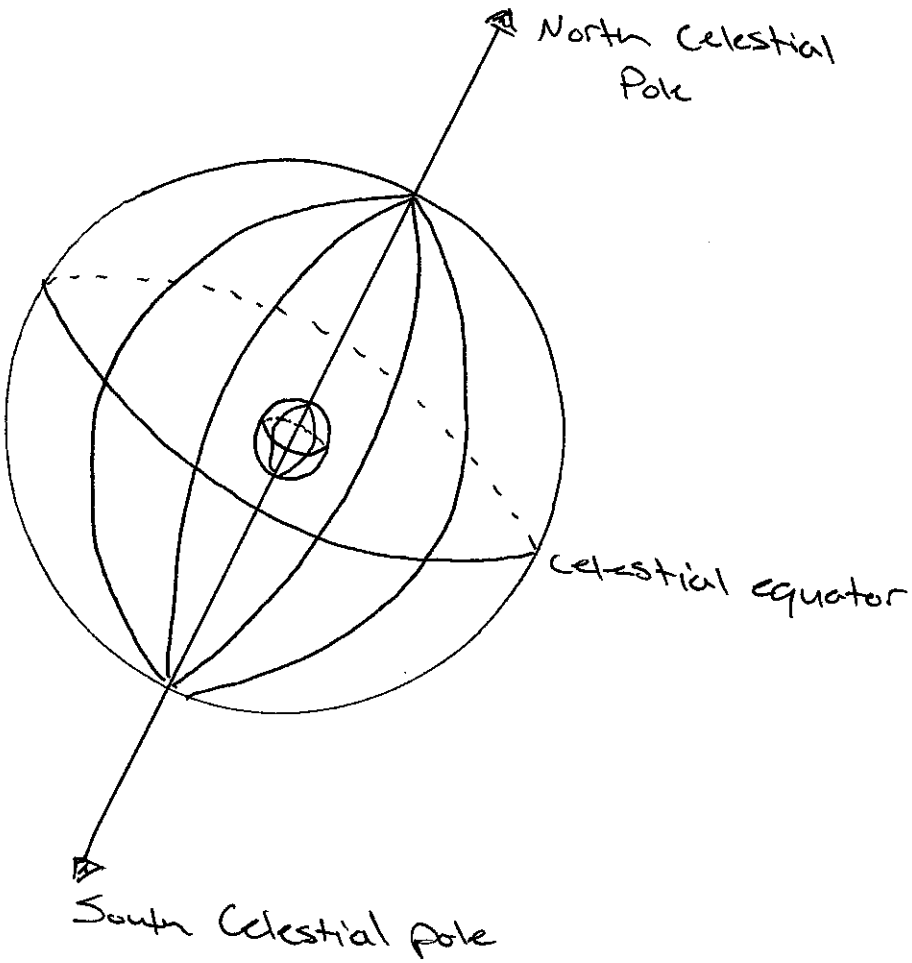
The Azimuth, A, is the angle along the horizon between the Northward direction and the direction towards the object (measured in the Eastward direction).

Unfortunatly, due to the Earth's rotation, the coordinates for most objects changes throughout the day. The only other concepts from this observer-centric system you should be aware of are

- Zenith (direction overhead)
- Meridian (great circle that passes through the Zenith and intersects the horizon at due North and South)

Fixed objects achieve their maximum altitude as they pass the Meridian.

A more useful system is the equitorial system. This system is analogous to the system of longitude and latitude on Earth. The celestial equator is simply the projection of the Earth's equator onto the celestial sphere. Right ascension is analogous to longitude, α, while declination is analogous to latitude, δ.



A quick diversion to units. Right ascension is often given in units of hours, minutes, and seconds

$$1 \text{ hour} = \frac{360^\circ}{24} = 15^\circ$$

$$1 \text{ min} = \frac{1 \text{ hour}}{60} = \frac{1}{4}^\circ = 15'$$

$$1 \text{ sec} = \frac{1 \text{ min}}{60} = \frac{1}{240}^\circ = 15''$$

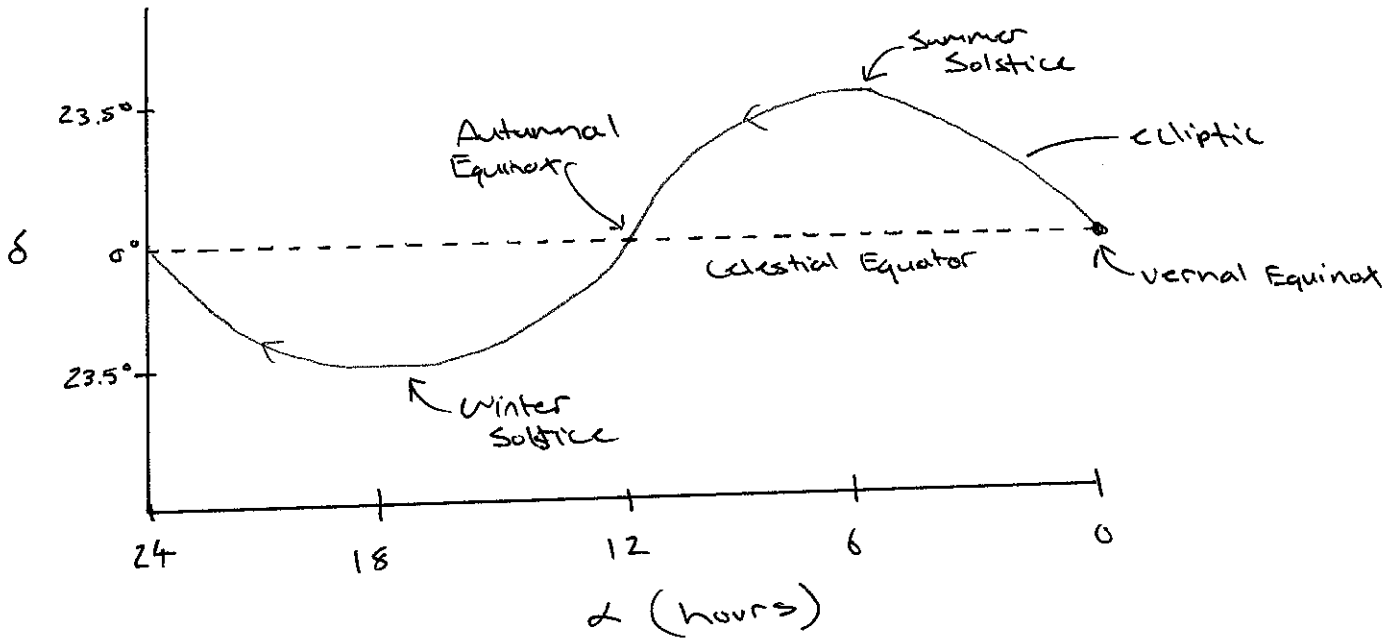
Declination is specified in degrees, minutes of arc, and seconds of arc.

$$1 \text{ arcmin} = 1' = \frac{1}{60}^\circ$$

$$1 \text{ arcsec} = 1'' = \frac{1}{3600}^\circ$$

Generally, $\delta = 0$ at the celestial equator, and is > 0 northward and < 0 southward. Right ascension is defined to be 0 at the Vernal (spring) equinox.

Because the Earth's axis of rotation is tilted wrt the plane of the Earth's orbit around the Sun, the Sun does <u>not</u> have a constant declination. The path the Sun takes over the celestial sphere is called the <u>ecliptic</u>.



- Vernal Equinox : March 19-21
- autumnal Equinox : Sep 21-24

There are two important measures of time in astronomy:

① Sidereal time

② Solar time

Sidereal time is measured wrt the "fixed" stars. One day is the interval between successive crossings of the meridian for distant stars. Solar time is instead measured wrt the Sun. A solar day is slightly longer than a sidereal day (~4 min).

Finally, because the Earth's axis of rotation precesses with a ~26,000 year period, the location of the vernal equinox (and celestial poles) changes slowly. For precise observations, the epoch of observation must be noted.

Also note that while there is a reasonably bright star near the celestial North pole right now (Polaris) there has/will not always been. In 3,000 B.C.E. Thuban was the pole star. In 14,000 C.E. Vega will be the pole star. There is no bright star near the South celestial pole right now.