Astronomical Coordinates

International Celestial Reference System (ICRS) - the standard celestial reference system adopted by the International Astronomical Union (IAU). Its origin is at the barycenter of the Solar System.

Declination (`DEC` or δ) is equivalent to terrestrial latitude. Points north of the celestial equator have positive declinations, while those to the south have negative declinations. Declination is expressed in degrees [$^\circ$], arc-minutes [$'$], and arc-seconds [$''$].

$1^\circ = 60' = 3600''$

Example: `DEC` $= +23^\circ\ 52'\ 12.12''$

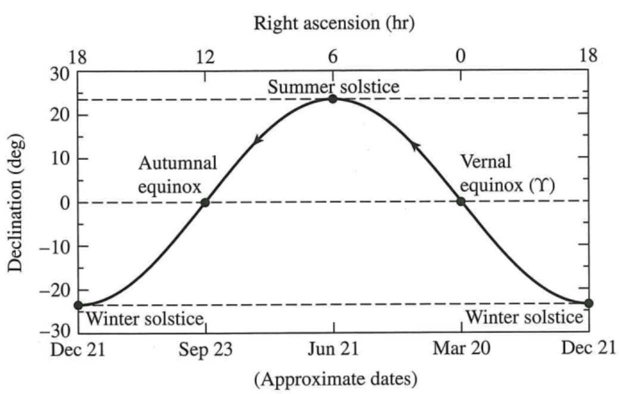
- The celestial equator has a `DEC` $= 0^\circ$
- The celestial north pole has a `DEC` $= +90^\circ$
- The celestial south pole has a `DEC` $= -90^\circ$

Right Ascension (`RA` or α) is roughly equivalent to terrestrial longitude. The units of right ascension are hours, minutes, seconds [hms].

1 hour in `RA` $= 15^\circ$, 24 hours in `RA` $= 360^\circ$.

Example: `RA` = 20h 23m 12.12s

The zero-point for right ascension is the position of the Sun on the first day of spring (Vernal Equinox). `RA` is measured eastward from the Vernal equinox. The position of the Sun at the beginning of each season is given in the table below.

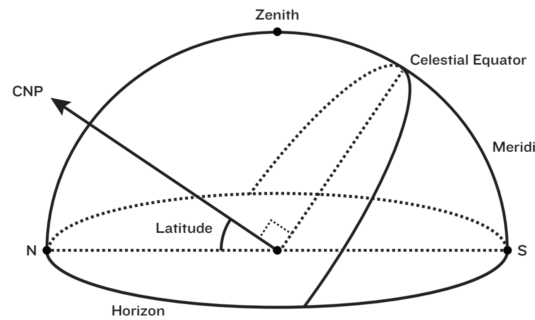


Season	Approx Date	`RA`	`DEC`
Vernal Equinox	Mar 20	0h	0°
Summer Solstice	Jun 21	6h	$+23.4^\circ$
Autumnal Equinox	Sep 23	12h	0°
Winter Solstice	Dec 21	18h	-23.4°

As you can see, the Sun moves about 1h in `RA` every 2 weeks.

Julian Date (JD) The elapsed time since Jan 1, 4713 BCE at noon. Notice the zero point is noon, not midnight. Measured in seconds. Sept 25, 2019 at noon (JD = 2458752.0)

Celestial Sphere



Meridian. The meridian is the great circle running from due north to south, passing through the celestial pole. The moment an object is on the meridian, that object will have a right ascension (`RA`) equal to the Local Sidereal Time (LST).

LST = `RA` of the meridian. Since the zero-point of right ascension is a fixed point in space, the value of the LST will constantly be changing (the Earth is rotating), and will be depend on your location on Earth.

Midnight The LST at any location at local midnight will be the `RA` of the Sun + 12 h

Zenith. This is the point on the celestial sphere directly above the observer's location. It is the point on the meridian with the highest altitude. An object at the zenith will have the coordinates: `RA` = LST, `DEC` = observer's latitude (θ).

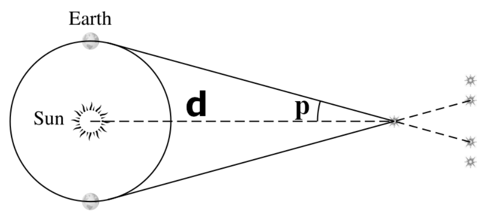
Visibility. The ability of an observer to see an object in the sky depends on the observer's latitude and longitude (θ, ϕ), the time of the observation (LST), and the coordinates of the object (`RA`, `DEC`).

Some objects may always be above the observer's horizon. These objects are called **circumpolar** objects. Of course you may not be able to see these objects if the Sun is in the sky. Conversely, some objects may never rise above the observer's horizon.

Visibility	Northern Observer ($\theta > 0$)	Southern Observer ($\theta < 0$)
Circumpolar	`DEC` $> 90^\circ - \theta$	`DEC` $< -90^\circ - \theta$
Never Visible	`DEC` $< -90^\circ + \theta$	`DEC` $> 90^\circ + \theta$
Best Visibility	`RA` = LST at midnight	

Star Stuff

Parallax (p) Stellar parallax is the apparent shift of position of any nearby star (or other object) against the background of distant objects. The more distant an object is, the smaller its parallax. Stellar parallax measures are given in units of arcseconds ($''$), or in milliarcseconds (thousandths of arcseconds) (mas).



Parallax distances are measured in parsecs (parallax-second, abbreviated pc). One parsec is equivalent to 3.26 light years

$$\text{Distance in pc } (d_{\text{pc}}) \approx \frac{1}{p''} = \frac{1}{p\,(mas)/1000}$$

Apparent magnitude (m) is a measure of the relative brightness of a star. The magnitude scale is an inverse logarithmic relation. The brighter an object appears, the **lower** its magnitude.

Absolute magnitude (M) is defined to be equal to the apparent magnitude of a star if it were viewed from a distance of 10 pc.

$$M = m - 5\log_{10}(d_{\text{pc}}) + 5$$

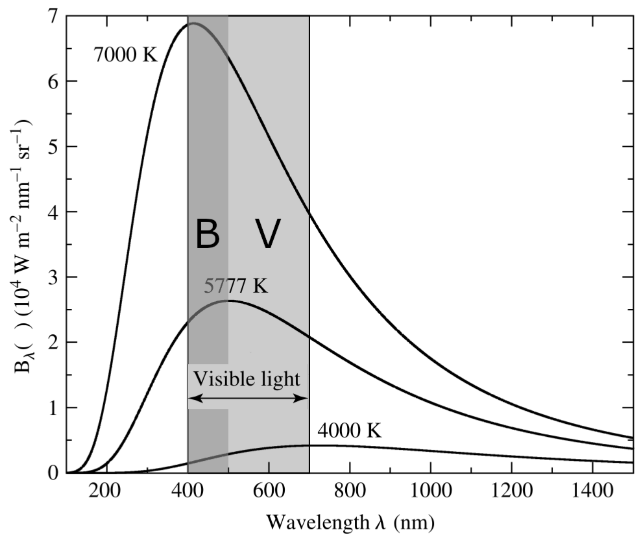
Spectrum - A plot of light intensity or power as a function of frequency or wavelength. In this class we will always use wavelength. The most common wavelength unit we will use is nanometers (nm, 10^{-9} m). Another common unit of wavelength is Angstroms (Å). 1 nm = 10 Å.

The visible part of the spectrum covers wavelengths from 400 nm - 700 nm (4,000 Å to 7,000 Å)

In this class we will assume that stars and planets radiate energy as perfect blackbodies. A blackbody radiator of temperature T emits a continuous spectrum with some energy at all wavelengths which peaks at a wavelength, $\lambda_{\max}$ which becomes shorter with increasing temperature.

For λ (in meters) and T (in Kelvin). $\lambda_{\max}$ is

$$\lambda_{\max} = \frac{0.002897755}{T}$$



Photometry is the science of measuring the flux or intensity of light radiated by astronomical objects.

The most commonly used system breaks the visible part of the spectrum in to two bandpasses. The **B** (blue) bandpass filters light of wavelengths between 400 nm and 500 nm, and the **V** (visual) bandpass filters light of wavelengths between 500 nm and 700 nm.

Color Index A simple numerical expression that determines the color of an object. To measure the index, one observes the magnitude of an object successively through two different filters, such as B and V. The difference in magnitudes found with these filters is called the B-V color index.

The smaller the color index, the more blue (or hotter) the object is.

Color Magnitude Diagram (CMD) A plot of Color Index vs. Magnitude. This is just a HR-diagram with a change of units.