A Very Incomplete Stars Tutorial

Coordinates

Right Ascension (abbrev. RA or α) is the celestial equivalent of terrestrial longitude. For RA, the zero point is known as the First Point of Aries, which is the place in the sky where the Sun crosses the celestial equator at the March equinox. RA is measured eastward from the March equinox. RA is customarily measured in hours, minutes, and seconds, with 24 hours being equivalent to a full circle.

For Example: α = 20h 23m 12.12s

Declination (abbrev. dec or δ) is comparable to latitude, projected onto the celestial sphere, and is measured in degrees north and south of the celestial equator. Therefore, points north of the celestial equator have positive declinations, while those to the south have negative declinations. The sign is customarily included even if it is positive. Declination is expressed in degrees [°], arcminutes [′], and arcseconds[″].

For Example: $\delta = +23^\circ\ 52'\ 12.12''$

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

A celestial object that passes over zenith (point directly overhead), has a declination equal to the observer's latitude. A pole star therefore has the declination +90° or -90°. Conversely, at northern latitudes, celestial objects with a declination greater than 90° - δ, are always visible. Such stars are called circumpolar stars, while the phenomenon of a sun not setting is called midnight sun.

$$24 \text{ hours} = 360^\circ$$
$$1 \text{ hour} = 15^\circ$$
$$1 \text{ minute} = 15'$$
$$1 \text{ second} = 15''$$

Magnitude and Brightness

The **Apparent Magnitude** (m) of a celestial body is a measure of its brightness as seen by an observer on Earth, normalized to the value it would have in the absence of the atmosphere. The brighter the object appears, the lower the value of its magnitude.

The magnitude listed in our dataset is the V magnitude. This corresponds to the magnitude of the star in the visible (540 nm) portion of the spectrum.

The color index (B-V) is the difference in magnitude between the star as seen in the blue part of the spectrum (442 nm) and the visual magnitude. Stars with a lower value of B-V are bluer than stars with a higher value of B-V.

The magnitude scale is logarithmic. The difference in brightness in stars can be found from their difference in magnitude Δm via:

$$\text{Difference in Brightness} = 2.512^{\Delta m}$$

Distance and Absolute Magnitude

All of the objects in our datasets have parallaxes measured by the Hipparcos satellite. With the measured parallax, you can get the distance to the star (in parsecs, where 1 parsec = 3.26 light-years).

$$\text{Distance [parsec]} = 1.0 \; / \; \text{Parallax [arcsec]}$$

The **Absolute Magnitude** is the magnitude a star would have located at a distance of 10 parsecs. The absolute magnitude [M], of a star can be calculated from its apparent magnitude [m] and parallax [P].

$$M = m + 5(\log_{10} P + 1)$$

where P is the star's parallax in arcseconds.

Proper Motion

The proper motion is measured by two quantities: the position angle and the proper motion itself. The first quantity indicates the direction of the proper motion on the celestial sphere (with 0 degrees meaning the motion due north, 90 degrees due east, and so on), and the second quantity gives the motion's magnitude, in seconds of arc per year.

Proper motion may also be given by the angular components in the right ascension (μ_α) and declination (μ_δ). These coordinates correspond to longitude and latitude (respectively) on the celestial sphere. The net proper motion (μ) is given by:

$$\mu^2 = {\mu_\delta}^2 + {\mu_\alpha}^2 \cdot \cos^2 \delta$$

where δ is the declination. Remember in our data sets the two proper motions (last two columns) are:

$$\text{uRA} = \mu_\alpha \cdot \cos\delta \qquad\qquad \text{uDec} = \mu_\delta$$

so:

$$\mu^2 = \text{uDec}^2 + \text{uRA}^2$$

The proper motion angle (θ) is related to these components by:

$$\mu_\delta = \mu\cos\theta \qquad\qquad \mu_\alpha\cos\delta = \mu\sin\theta$$

$$\theta = cos^{-1}(\mu_\delta/\mu)$$

so solving for θ and remembering `arccosine` has a range of $0 < \theta < \pi$ and the RA goes "backward":

$$\begin{array}{ll} \theta = \theta & \text{if uRA} < 0 \\ \theta = 360^\circ - \theta & \text{if uRA} >= 0 \end{array}$$