Chapter 8: The Family of Stars

Distances to Stars

Trigonometric Parallax:
Star appears slightly shifted from different positions of Earth on its orbit.
The farther away the star is (larger \( d \)), the smaller the parallax angle \( p \).

\[
\text{d in parsec (pc)} \quad \text{p in arc seconds}
\]

1 pc = 3.26 LY

Intrinsic Brightness / Absolute Visual Magnitude (II)

The flux received from the light is proportional to its intrinsic brightness or luminosity \( L \) and inversely proportional to the square of the distance \( d \):

\[
F \sim \frac{L}{d^2}
\]

Star A

Star B

Earth

Both stars may appear equally bright, although star A is intrinsically much brighter than star B.
The Distance Modulus
If we know a star’s absolute magnitude, we can infer its distance by comparing absolute and apparent magnitudes:

Distance Modulus
\[ m_V - M_V \]
\[ = -5 + 5 \log_{10}(d \text{ [pc]}) \]
Distance in units of parsec

Equivalent:
\[ d = 10^{(m_V - M_V + 5)/5} \text{ pc} \]

The Size (Radius) of a Star
We already know: flux increases with surface temperature \((\sim T^4)\); hotter stars are brighter.
But brightness also increases with size:

Star B will be brighter than star A.

Absolute brightness is proportional to radius squared, \(L \sim R^2\).

Quantitatively:
\[ L = \frac{4\pi R^2 \sigma T^4}{4\pi R^2 \sigma T^4} \]
Surface area of the star
Surface flux due to a blackbody spectrum

Organizing the Family of Stars: The Hertzsprung-Russell Diagram
We know:
Stars have different temperatures, different luminosities, and different sizes.
To bring some order into that zoo of different types of stars: organize them in a diagram of Luminosity versus Temperature (or spectral type).

The Hertzsprung Russell Diagram
Most stars are found along the main sequence.
The Hertzsprung-Russell Diagram (II)

Stars spend most of their active life time on the Main Sequence. Same temperature, but much brighter than MS stars → Must be much larger → Giant Stars

Radii of Stars in the Hertzsprung-Russell Diagram

- Calculate density of Sirius B and Betelgeuse.
- Rigel
- Betelgeuse
- Sun
- Polaris

Luminosity Classes

- Ia Bright Supergiants
- Ib Supergiants
- II Bright Giants
- III Giants
- IV Subgiants
- V Main-Sequence Stars

Luminosity effects on the width of spectral lines

- Lower gravity near the surfaces of giants ⇒ smaller pressure ⇒ smaller effect of pressure broadening ⇒ narrower lines
Surveys of Stars

Ideal situation:
Determine properties of all stars within a certain volume.

Problem:
Fainter stars are hard to observe; we might be biased towards the more luminous stars.

A Census of the Stars

Faint, red dwarfs (low mass) are the most common stars.

Bright, hot, blue main-sequence stars (high mass) are very rare.

Giants and supergiants are extremely rare.