IXA. Stellar Classification Systems - MK, Harvard, Hertzsprung–Russell

Luminosity Defins. - Absolute & Apparent Magnitudes, Distance Modulus, Luminous Flux

Magnitude, in astronomy, is a measure of the **brightness** of a star or other celestial body.
The distance modulus, μ, is a **way of expressing distances** that is often used in astronomy. It describes distances on a **logarithmic scale** based on the astronomical magnitude system. The **apparent magnitude, *m***, of a star is the magnitude it has **as seen by an observer on Earth.** The distance modulus, μ, is defined as $\mu = m - M$ (ideally, corrected from the effects of interstellar absorption) where M, is the a**bsolute magnitude,** of an astronomical object.

Luminous flux is a measure of the **power of visible light** produced by a light source or light fitting. It is measured in lumens (lm). **Luminosity**, in astronomy, the amount of light emitted by an object in a **unit of time**, or its power (W). For example, the luminosity of the Sun is 3.846 × 10^{26} watts. **Luminosity is an absolute measure of radiant power**; that is, **its value is independent of an observer's distance from an object**

$$L_{\odot} := 3.846 \cdot 10^{26} W$$

Irradiance (or flux density) is a term of radiometry and is defined as the radiant flux received by some surface per unit area. In the SI system, it is specified in units of W/m^2.

Absolute magnitude M is defined as the **apparent magnitude** of an object when seen at a **distance of 10 parsecs**. If a light source has luminosity *L(d)* when observed from a **distance of d parsec**s, and luminosity *L(10)* when observed from a distance of 10 parsecs, the inverse-square law is then written like:

$$L(d) = \frac{L(10)}{\left(\frac{d}{10}\right)^2}$$

The apparent m and absolute magnitude M

$$m = -2.5\log_{10} F(d)$$

$$M = -2.5\log_{10} F(d = 10)$$

Estimating Distance to Star from Apparent Brightness and Hertzprung-Russell Diagram

One can use **detailed observations of nearby stars** to provide a means to measure distances to **more distant stars**. Using spectroscopy, one can measure precisely the colour of a nearby star; using photography, one can also measure its apparent brightness.

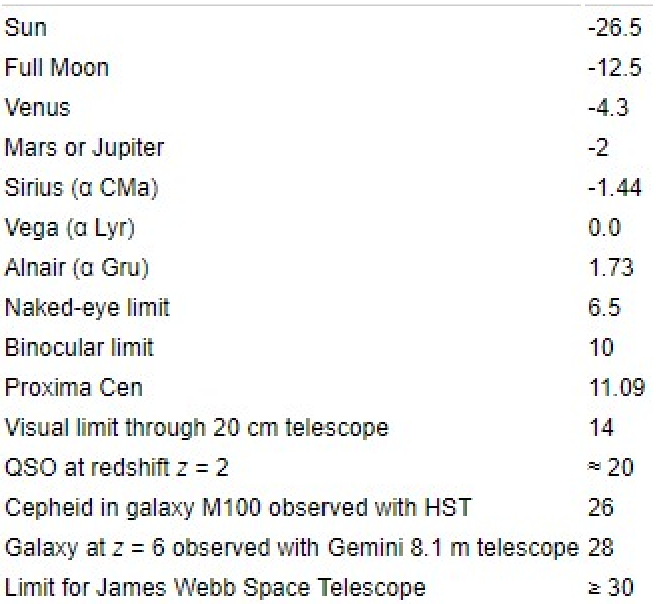
Using the apparent brightness, m, the distance, and inverse square law, one can **compute the absolute brightness** of these stars. Ejnar Hertzsprung (1873-1967) and Henry Russell (1877-1957) plotted this **absolute brightness against colo**r for thousands of nearby stars in 1905-1915. This yields the famous Hertzprung-Russell diagram. See Section IX. **Once one has this diagram, one can use it in reverse to measure distances to more stars than parallax methods can reach.** For any star, one can measure its colour and its apparent brightness and **from the Hertzprung-Russell diagram, one can then infer the Absolute Brightness**. From the apparent brightness and absolute brightness, **one can solve for distance**.

The distance modulus $m - M$ can be used to **determine the distance** to a star using the equation:

$$M = m - 5\log(d/10)$$

$$M = -2.5\log(F(d))$$

Magnitudes of Some Cosmological Light Sources



Sun	-26.5
Full Moon	-12.5
Venus	-4.3
Mars or Jupiter	-2
Sirius (α CMa)	-1.44
Vega (α Lyr)	0.0
Alnair (α Gru)	1.73
Naked-eye limit	6.5
Binocular limit	10
Proxima Cen	11.09
Visual limit through 20 cm telescope	14
QSO at redshift $z = 2$	≈ 20
Cepheid in galaxy M100 observed with HST	26
Galaxy at $z = 6$ observed with Gemini 8.1 m telescope	28
Limit for James Webb Space Telescope	≥ 30