Magnitudes

ASTR 250

Hipparchus ~ 2nd Century B.C. defined 6 brightness classes seperated by ~ factor of two.

1st class = brightest   6th class = dimmest

The modern definition of magnitudes :

observed flux
$erg \cdot s^{-1} \cdot cm^{-2}$

$$\text{Apparent magnitude} = m_V \equiv -2.5 \log_{10}\left(\frac{F}{F(m=0)}\right)$$

have to specify wavelength
V= Visual Band ~ 545 nm

flux of object with magnitude = 0
Vega is the basis most commonly used

Consider a star that is 5th magnitude $m_V = +5$

$$5 = -2.5 \log_{10}\left(\frac{F(m=5)}{F(m=0)}\right)$$

$$5 = \log_{10}\left(\frac{F(m=5)}{F(m=0)}\right)^{-2.5} = \log_{10}\left(\frac{F(m=0)}{F(m=5)}\right)^{+5/2}$$

$$10^5 = \left(\frac{F(m=0)}{F(m=5)}\right)^{5/2}$$

$$\Rightarrow \frac{F(m=0)}{F(m=5)} = \left(10^5\right)^{2/5} = 10^2 = 100$$

So 5 magnitude difference ⇒ Factor of 100 in observed flux

Difference in magnitude between two stars :

$$m_1 - m_2 = -2.5 \log_{10}\left(\frac{F_1}{F(m=0)}\right) - 2.5 \log_{10}\left(\frac{F_2}{F(m=0)}\right) = -2.5 \log_{10} \frac{F_1}{F_2}$$

We defined the absolute magnitude as the apparent magnitude of a star at $D = 10pc$

observed flux at actual distance D

$$m_v - M_v = -2.5 \log_{10}\left(\frac{F(D)}{F(10pc)}\right)$$

observed flux if star were placed at 10pc

apparent magnitude at actual distance D

absolute magnitude (always capital M)

SINCE $F(D) \sim \frac{1}{D^2}$ we can simplify: $\frac{F(D)}{F(10pc)} = \left(\frac{10}{D_{pc}}\right)^2$

Distance measured in PC

$$\begin{aligned} m_v - M_v &= -2.5 \log_{10}\left(\frac{10}{D_{pc}}\right)^2 \\ &= -5 \log_{10}\left(\frac{10}{D_{pc}}\right) \\ &= +5 \log_{10}\left(\frac{D_{pc}}{10}\right) \end{aligned}$$

= this is also called the Distance Modulus

Colors

Modern magnitudes are defined in a filter system:

Johnson & Morgan Filters

U	B	V	R	I
367 nm	436nm	545nm	638nm	797nm

We define the "color" of an object as the difference in magnitudes between two filters

For instance $B - V$ or $U - B$ etc.

↑ B-band magnitude

↑ V-band magnitude

IN the Johnson & Morgan System: $B-V = U-B = 0.0$ for Vega

The SuN:

$m_V = -26.8$ mag apparent magnitude

$M_V = +4.83$ mag absolute magnitude

$B-V = +0.62$ mag

$U-B = +0.10$ mag

Since this is positive it means $B > V$

⇒ B is a larger number

⇒ B is fainter than V

SuN is brighter at V than B.