The Magnitude Scale

First introduced by Hipparchus (160 - 127 B.C.):

• Brightest stars: ~1st magnitude
• Faintest stars (unaided eye): 6th magnitude

More quantitative:

• 1 mag. difference gives a factor of 2.512 in apparent brightness (larger magnitude = fainter object!)
• 1st mag. stars appear 100 times brighter than 6th mag. stars

Magnitudes

• Magnitudes are a logarithmic measure of the flux from an object.
• Flux ($F$) is related to an object’s luminosity ($L$) and distance ($r$) as:

$$ F = \frac{L}{4\pi r^2} $$

Think-Pair-Share

• What flux is measured from the sun at the surface of Mars, at a distance of 1.5 AU from the sun?

$$ 1 \, L_\odot = 3.826 \times 10^{33} \text{ ergs s}^{-1} $$

$$ 1 \, AU = 1.5 \times 10^{13} \text{ cm} $$

Magnitudes

• Magnitude

$$ m = -2.5 \log_{10} \left( \frac{L}{4\pi r^2} \right) + \text{constant} $$

• Magnitude difference

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

Absolute Magnitude

• magnitude an object would have at a distance of 10 pc.

$$ m - M = 5 \log_{10} \left( \frac{d}{10 \, \text{pc}} \right) = 5 \log_{10}(d) - 5 $$

• This is known as distance modulus.
Definition of a parsec
• Distance from which radius of Earth’s orbit, 1 AU, subtends 1 second of arc.

Think-Pair-Share
• Use trigonometry to determine what a parsec is in terms of AU.
• What is a parsec in units of cm?

Parallax
• In general, we can relate the parallax of an object in arcseconds to its distance in parsecs using the following:

\[ d = \frac{1}{p''} \text{ pc} \]

Think-Pair-Share
• The apparent magnitude of the sun is -26.81. What is its absolute magnitude?

Magnitude Zeropoint
• The star Vega is by definition \( m = 0 \).
• All magnitudes are measured relative to Vega.

\[ m_2 - m_1 = 2.5 \log_{10} \left( \frac{F_1}{F_2} \right) \]

\[ m_0 = 2.5 \log_{10} \left( \frac{F_{\text{Vega}}}{F_0} \right) \]

Photometric Bands
• Magnitudes are usually measured at a particular wavelength
Photometric Bands

- The Sloan Digital Sky Survey (SDSS) uses different filters

SDSS filter set