Apparent and Absolute Magnitude

Introducing the **parsec** as a unit of distance also helps to define a convenient relationship, used by astronomers, between the **apparent brightness** of a source and its intrinsic brightness, or **luminosity**.

Recall from A1X that astronomers use the **magnitude system** to express ratios of **observed flux** to differences in **apparent magnitude**, via the equation:

$$m_1 - m_2 = -2.5\log_{10}\frac{F_1}{F_2} \qquad (5)$$

Remember: the minus sign in front of 2.5 means that *brighter* objects have *smaller* (i.e. more negative) apparent magnitudes – see Figure 4.

We can use Equation (1) to express the apparent magnitudes of the stars in terms of their distance and luminosity, instead of their flux:

$$m_1 - m_2 = -2.5\log_{10}\frac{4\pi D_2^2 L_1}{4\pi D_1^2 L_2}$$

Using the properties of logarithms, we can rewrite this as:

$$m_1 - m_2 = 5\log_{10} D_1 - 5\log_{10} D_2 + 2.5\log_{10} L_2 - 2.5\log_{10} L_1 \qquad (6)$$

Now suppose the two stars have the *same* luminosity (or, equivalently, suppose that the *same* star is being observed from two different places, which are a distance D_1 and D_2 respectively from the star). Equation (6) simplifies to:

$$m_1 = m_2 + 5\log_{10} D_1 - 5\log_{10} D_2 \qquad (7)$$

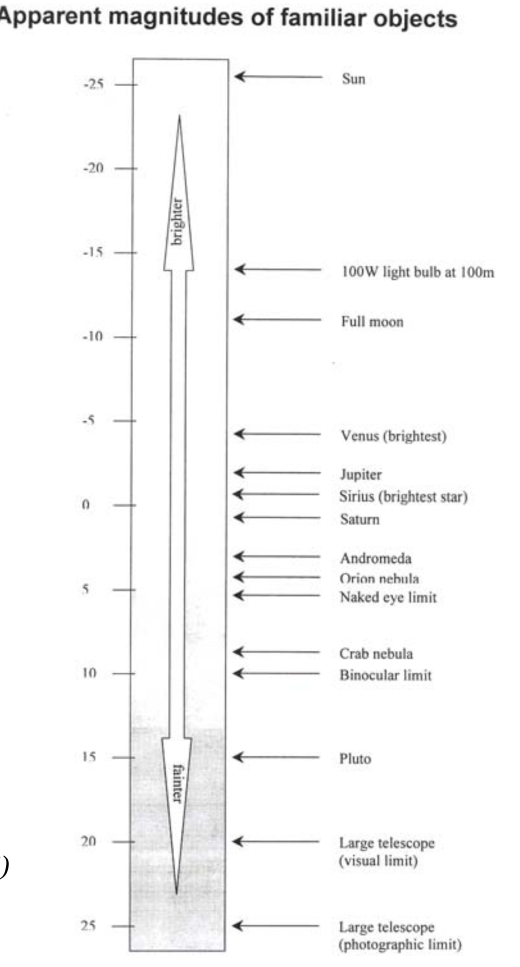

Figure 4: Illustration of the apparent magnitude scale (handout given out in A1X)

We can use Equation (7) to introduce the **absolute magnitude** of a star, defined as the **apparent magnitude which the star would have if it were at a distance of 10 parsecs**. Absolute magnitude is usually written as *M* (not to be confused with mass!). Thus, in Equation (7), if we measure distance in parsecs, and set $D_2 = 10$, then $m_2 = M$ and

$$m = M + 5\log_{10} D - 5 \qquad (8)$$

Equation (8) is analogous to Equation (1), in that it relates the apparent magnitude, absolute magnitude and distance of a star, just as Equation (1) relates the flux, luminosity and distance of a star. Where apparent magnitudes define a logarithmic scale measuring fluxes, absolute magnitudes define a logarithmic scale measuring *luminosities*. In particular:

$$M_1 - M_2 = -2.5\log_{10}\frac{L_1}{L_2} \qquad (9)$$

The quantity $m - M$ is known as the **distance modulus** and is often written as μ. Inverting Equation (8):

$$D = 10^{0.2(m-M+5)} = 10^{0.2(\mu+5)} \qquad (10)$$

where D is measured in pc. In A1Y Cosmology, we will also measure distances in **megaparsecs (Mpc)**, where 1 Mpc $= 10^6$ pc. Hence, in cosmology we replace Equation (8) by:

$$m = M + 5\log_{10}(D \times 10^6) - 5 = M + 5\log_{10} D + 25 \qquad (11)$$

where D is now measured in Mpc.