Explanation of terms

Apparent magnitude

In astronomy, the term apparent magnitude is used to describe the measurement of an object's brightness as seen from Earth.

Today's telescopes have inbuilt charged-coupled devices (CCDs) which record the incoming light from a star. The apparent magnitude of the star can be calculated by measuring the starlight recorded on the CCD and using it in the formula for apparent magnitude (Equation 1).

We calculate an object's apparent magnitude using the equation:

$$\textit{apparent magnitude } (m) = -2.5 \log(\textit{intensity})$$

Here, 'intensity', also known as 'counts', refers to the amount of light that is emitted from the object and received by the CCD (see 'Photometry in Astronomy' worksheet).

However, it's a bit of an archaic system in that the brighter an object, the lower its apparent magnitude value. Objects that appear exceptionally bright have negative numbers, the Sun for example has an apparent magnitude of -27. Objects with apparent magnitude values higher than around 6, are unobservable to us with our naked eye alone.

The very first catalogues of stars were developed by a Greek astronomer, Hipparchus. He used a logarithmic scale when ordering apparent magnitudes of stars he observed. This scale was later formulised by Norman Pogson and it follows that if two stars have a magnitude difference of 1, the difference in apparent brightness corresponds to a factor of 2.512. So a star of first magnitude will appear twice as bright as a star of second magnitude.

This scale is summarised in Table 1.

Magnitude difference between 2 stars	Calculation of factor difference in apparent brightness	Factor difference in apparent brightness
1	$(2.512)^1$	2.512
2	$(2.512)^2$	6.310
3	$(2.512)^3$	15.85
4	$(2.512)^4$	39.82
5	$(2.512)^5$	100.0

An object's apparent brightness is measured in intensity or counts (depending on the software instruments that are used). Objects closer to the observer appear brighter and objects further away appear fainter.

This is due to the 'inverse square law':

$$b \propto \frac{1}{d^2}$$

Where:
b = apparent brightness (W m^{-2}) d = distance from observer (m)

This relationship means that if you moved a light source to a position 2 times further away than its original distance, its measured brightness would drop by a factor of 4. If you placed it at 3 times the distance, the brightness would drop by a factor of 9. This is illustrated in Figure 1.

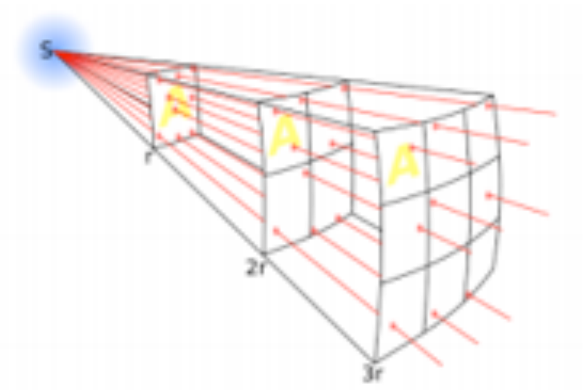

Figure 1 – An illustration of the inverse square law and how apparent brightness decreases with distance. Image Credit: By Borb, CC BY-SA 3.0

A star radiates its light over a spherical area. The red lines we see in Figure 1 represent the intensity of light emitting from a star at point S. As you increase the distance from the star, you increase the radius (r).

As can be seen from the equation for the area of a sphere, its surface area becomes larger with a larger radius.

$$A = 4\pi r^2$$

Where:
A = area (m2) r = radius of sphere (m)

Thus since the light intensity is per unit area, it appears dimmer.

So the inverse square law explains how an object's apparent brightness is influenced by the distance of the observer. This leads us to question, how do we determine the true brightness of an object? This is where absolute magnitude is used.

Apparent magnitude

We have seen how apparent magnitude describes how bright an object is to an observer and why the apparent brightness of a star varies in relation to its distance from Earth. However, in order to determine how bright an object is relative to other objects in the Universe, we must account for the object's distance from Earth.

To do this, astronomers hypothetically place all objects at an equal distance from Earth and measure what their brightness would be from this point. This is a distance of 10 parsecs (pc), where 1 parsec is equal to 3.09 x 1016 m. You may also be interested to know that 1 parsec is equivalent to 3.26 light years, or the distance that light travels in 3.26 years!

By placing all objects at a defined distance, astronomers are able to compare the "true" brightness of various objects. We call this the absolute magnitude

This is illustrated in Figure 2 and calculated through the equation below.

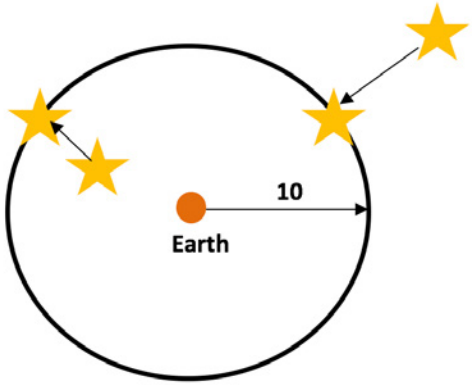

Figure 2 – A diagram illustrating how astronomers would hypothetically place objects at a distance of 10 pc from Earth to determine their absolute magnitude.

$$M = m + 5 - 5\log d$$

Where:
M = absolute magnitude m = apparent magnitude d = distance (pc)

If two of the three parameters above are known (m, M or d), we can rearrange this equation to calculate the remaining unknown value.

e.g. If we know an object's apparent and absolute magnitude we can rearrange the equation to determine the distance to the object:

$$d = 10^{\left(\frac{m-M+5}{5}\right)}$$

Where:
M = absolute magnitude m = apparent magnitude d = distance (pc)

Modified Julian Date

Julian Days refer to a continuous count of days since the beginning of the Julian period. Julian Day 0 therefore corresponds to noon on the 1st January, 4713 BC. Unlike the standard dating system, Julian Date is denoted by numbers and decimal fractions.

For any given moment since this beginning date, the Julian Date (JD) is denoted by the Julian Day number (beginning at Greenwich Mean Time noon), plus the fraction of the day at that particular moment.

The Modified Julian Date simplifies this notation. From the beginning of the Julian period up until now, Julian days have corresponded to between 2400000 and 2500000, MJD therefore eliminates this value from the number. MJD also begins at midnight rather than noon, therefore subtracting half a day from JD.

MJD is therefore derived from JD according to:

$$MJD = JD - 2400000.5$$

This modification means that MJD provides a 5-digit number for each day, followed by a decimal value corresponding to what time of day it is.

Astronomers commonly use this dating system as it provides a more straightforward method of performing chronological calculations.