BRIEF

STARS
Magnitudes: Absolute and Apparent

Overview

This class focuses on a basic understanding of Stellar Magnitudes.

Magnitudes are how we refer to the brightness of a star. The most fundamental measures of stellar magnitude are: Apparent and Absolute.

Brightness: Where it all begins

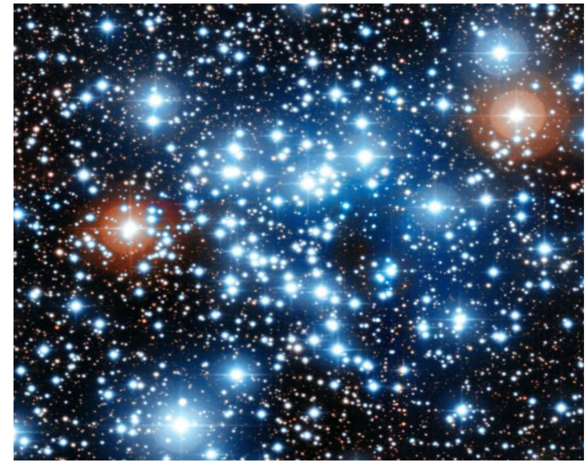
All stars have an inherent energy output from their internal fusion.

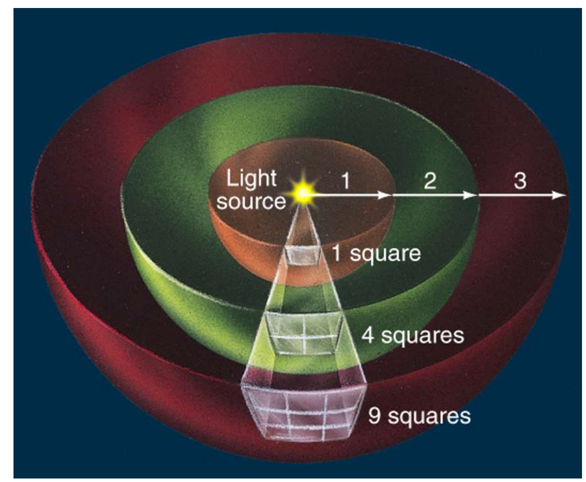
This energy output is referred to as Luminosity: The energy a star produces each second.

This Luminosity spreads out in a spherical shape from the point source: the star.

We can measure the portion of Luminosity that reaches us: Flux.

Flux is the total energy from a star that hits each square meter of a detector per second.





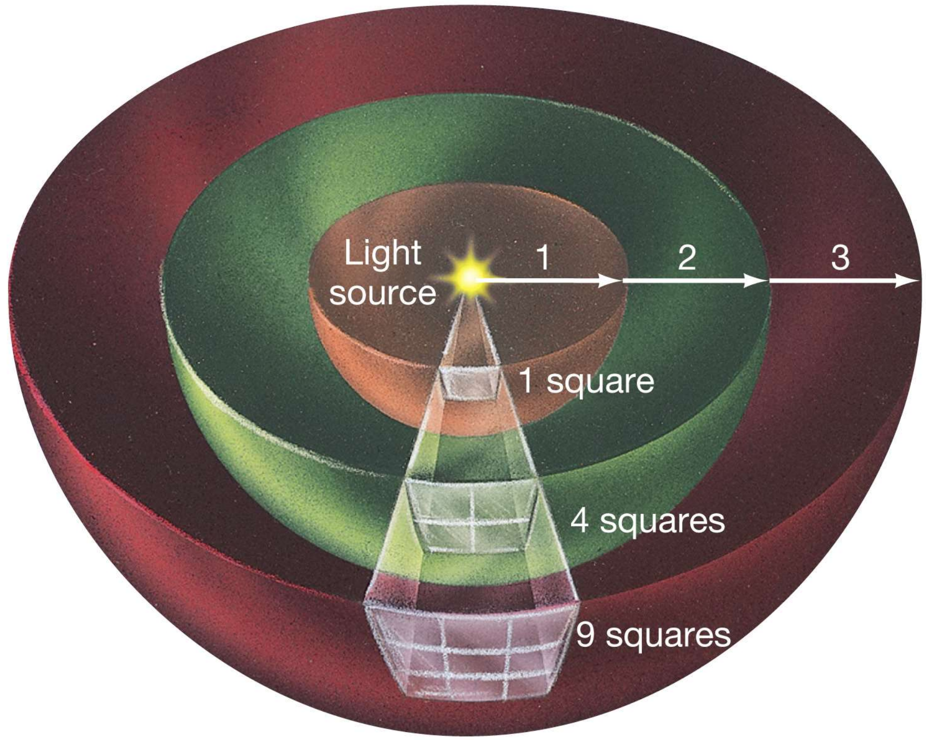
Inverse- Square Law of Brightness

As light moves away from a source such as a star, it is steadily diluted as it spreads over progressively larger surface areas (depicted here as sections of spherical shells).

Thus, the amount of radiation received by a detector (the source's apparent brightness) varies inversely as the square of its distance from the source.

$$\text{apparent brightness} \propto \frac{\text{luminosity}}{\text{distance}^2}.$$

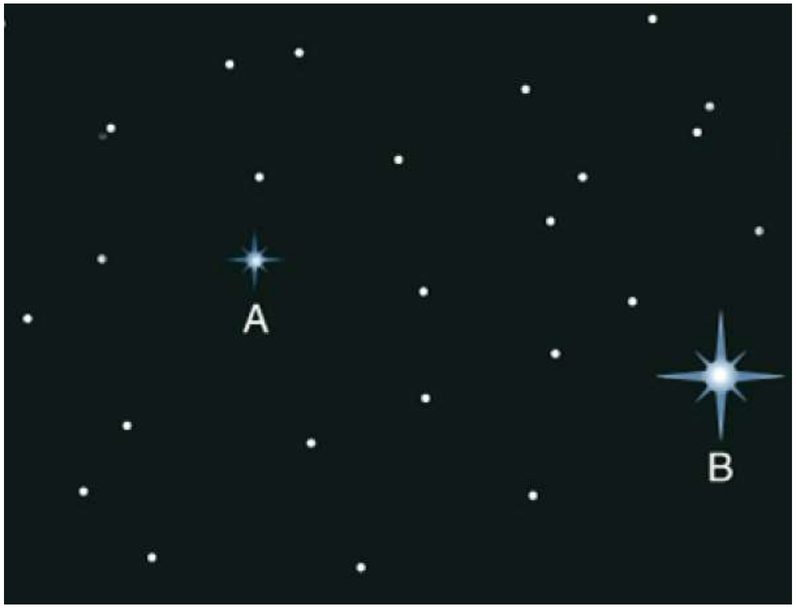
$$\text{Flux} = \frac{\text{Luminosity}}{4\pi d^2}$$



Apparent Magnitude

In the example to the right, two stars are more prominent amongst the starry background. From this perspective, they seem to have different magnitudes.

This is an example of apparent magnitude: brightness as they appear to us, the observer.



Magnitude Scale

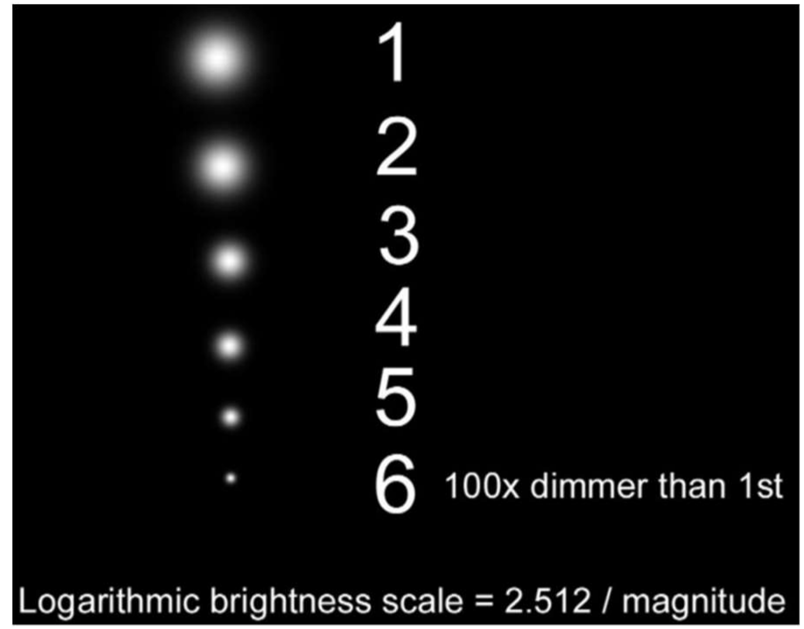
The ancient Greeks classified the brightness of stars based on their apparent brightness: Magnitude Scale.

On this scale, 1 is the brightest with fainter stars being of higher numbers. Thus, the HIGHER the number, the fainter the star's magnitude (Brightness).

So, a star of magnitude 1, is much brighter than a Star of magnitude 6.

The difference in brightness between a 1 and 6th magnitude star is about 100x.

This means the 5 subsequent intervals each equate to about 2.512 as bright as the next. This is a logarithmic scale.



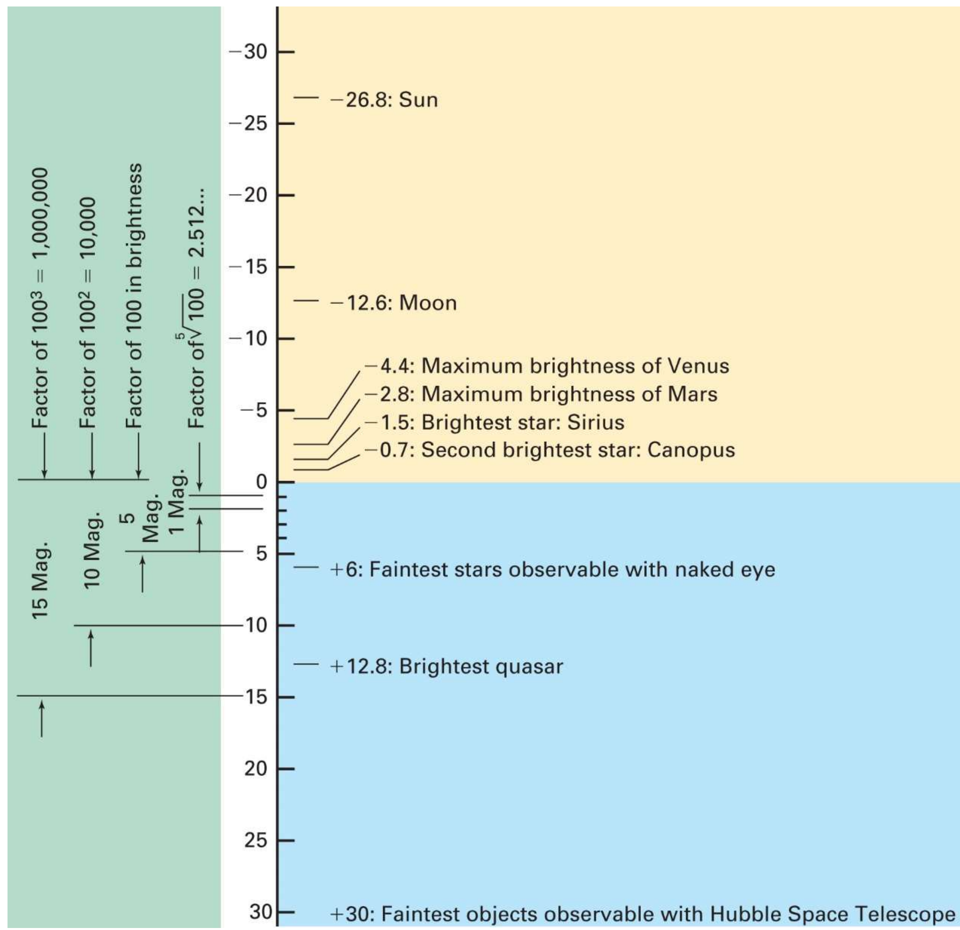
Magnitude Scale

To the right is a magnitude scale. Locate the Sun.

Notice it has a negative magnitude. That means it is very bright.

Look at the very bottom of the scale. The faintest object with Hubble is 30th magnitude.

It seems backwards, but this is how we measure magnitudes.

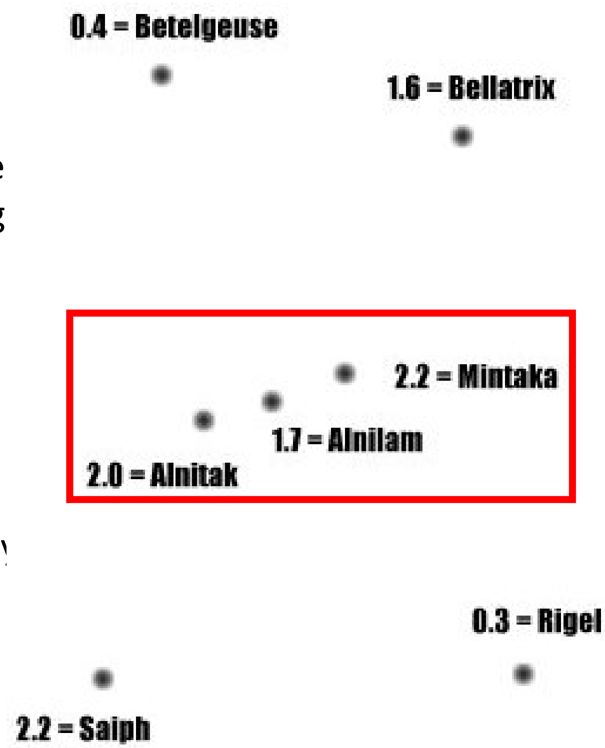


Sifting from Apparent to Absolute Magnitude

Looking at Orion's belt, notice the apparent magnitude of the three belt stars inside the red box. Their apparent magnitude is indicated to the right. Remember, apparent depends on two thing the star's luminosity and its distance from us.

What does this tell us about their intrinsic brightness?

Really, nothing. The star Alnilam, in the middle, is twice as far away as Alnitak and Mintaka. Yet, they are the same apparent brightness.



Absolute Magnitude

To gain a clearer, and more relative, understanding of the luminosity of stars, Astronomers derived a common yardstick: Absolute Magnitude.

Absolute Magnitude is the "true" brightness of a star if all stars were placed at the same distance of 10 parsecs. This allows for a common baseline from which to measure all stars.

Where apparent magnitude (m) is a measure of the intensity of light reaching the earth, Absolute magnitude (M) is a measure of how much light the object is putting out.

Thus, Absolute Magnitude is a measure of objects Luminosity

By definition, Absolute Magnitude = apparent magnitude if object was 10 Parsecs away (32.6 light years).

	Distance	**Apparent** Magnitude	**Absolute** Magnitude
Sirius	2.7 pc	-1.46	+1.4
Rigel	240 pc	+0.14	-6.8

Distance Modulus

Apparent (m) and Absolute (M) magnitudes, if both are known, can help determine the distance to a star. Conversely, if you know the distance (D) and one of the magnitudes, you can derive the other.

Using,
m = apparent magnitude
M = absolute Magnitude
D = distance to Star, so the weird equation is…….

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

This means that if you know the distance to a star (D), and the apparent magnitude (m), which you can measure by the size of an image on a photograph, then you can use this equation to find distance.

Where *D* is the distance to the star measured in parsecs.

For a star at *D* = 10 parsecs, 5log10 = 5, so *M* = *m*.

Summary

Let's review a few key terms:

- Luminosity: the energy output of a star
- Flux: Measurement of the amount of Luminosity that reaches our detector
- Inverse Square Law of Brightness: light fades by the inverse square of its distance away.
- Apparent Magnitude (m): how bright we see a star based on 1) its intrinsic Luminosity, and 2) its distance from us.
- Absolute Magnitude: the magnitude a star would have if placed at a distance of 10 pc.
    - This is distance independent.
    - Directly related to the luminosity of a star

Questions?