ASTR 1020

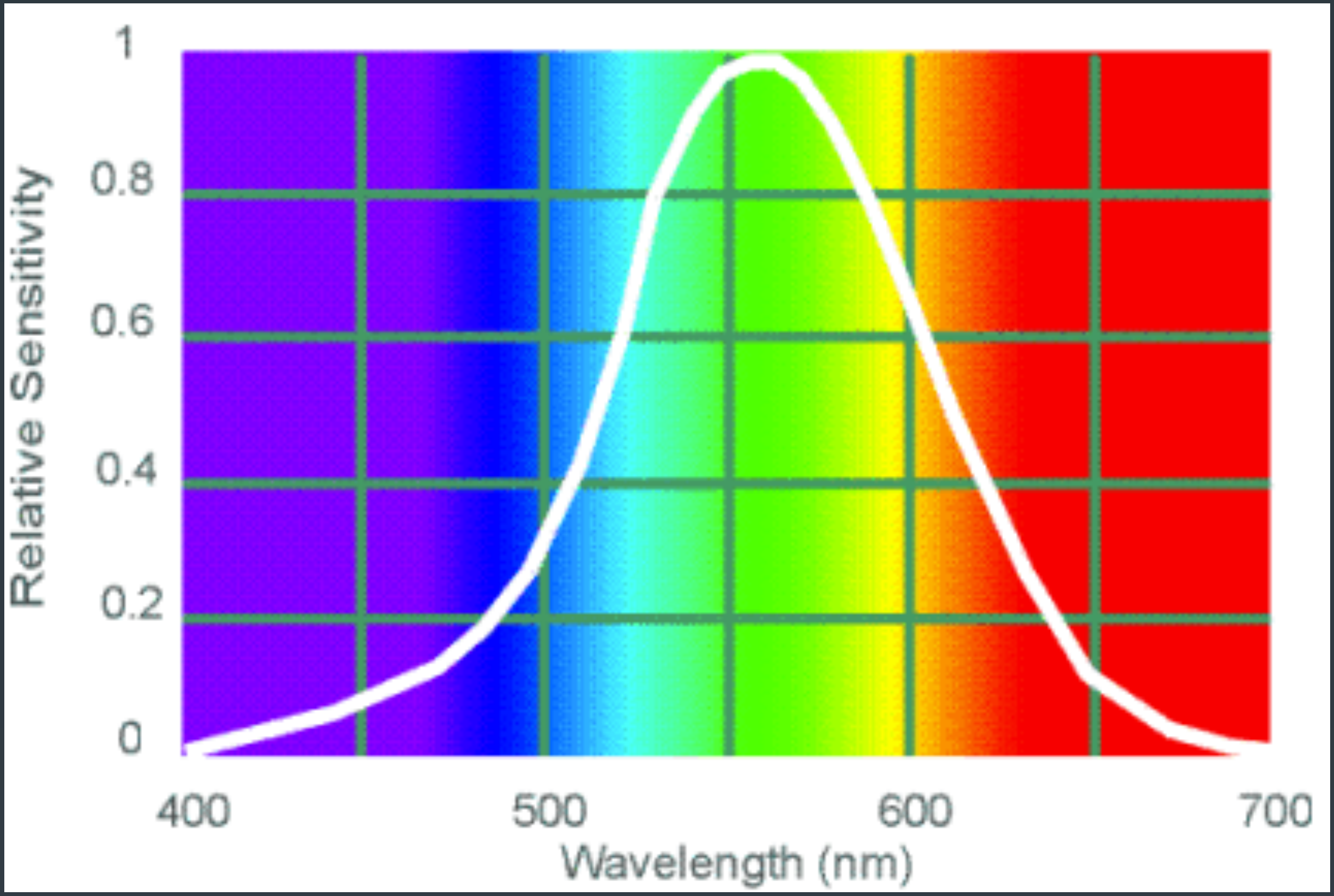
Lab CLEA: Photometry of the Pleiades

The Pleiades

The Pleiades, or the Seven Sisters, is an open star cluster of middle-aged, hot blue B-type stars in the constellation of Taurus the Bull, between Orion and Perseus.

Photometry

Photometry is a measure of how much light there is. It basically studies the unnormalized continuum you've seen in spectroscopy. It looks at ranges of wavelengths, such as blue (B-band), or green (V-band), and asks, how much light does this object give off in this color?

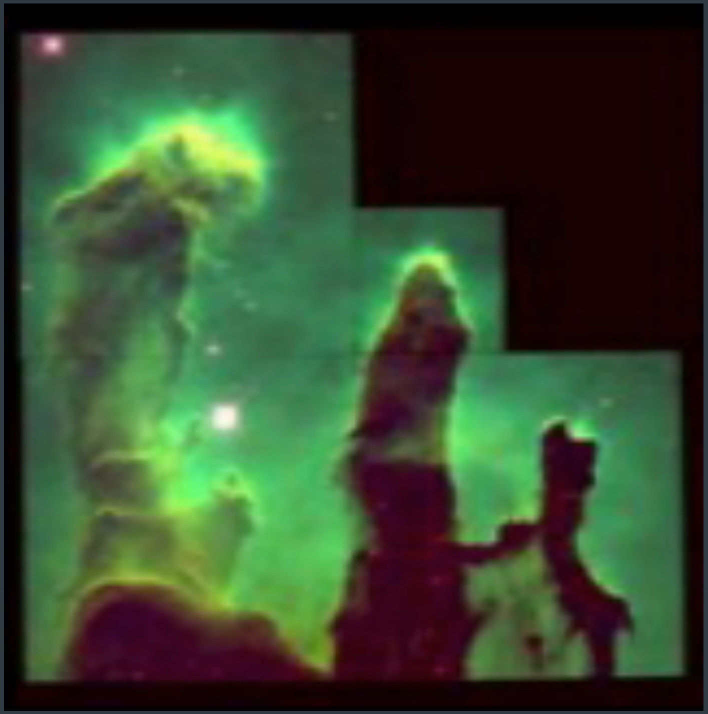


B-Band, V-Band, and B-V

We measure the light of each color by putting a filter on the camera that only admits light within a certain range of wavelengths. Two common filters are B-band, for hot blue light, and V-band, for green light right in the middle of the visual spectrum. B - V gives what is called the B - V color, essentially, how blue or not-blue is this object?

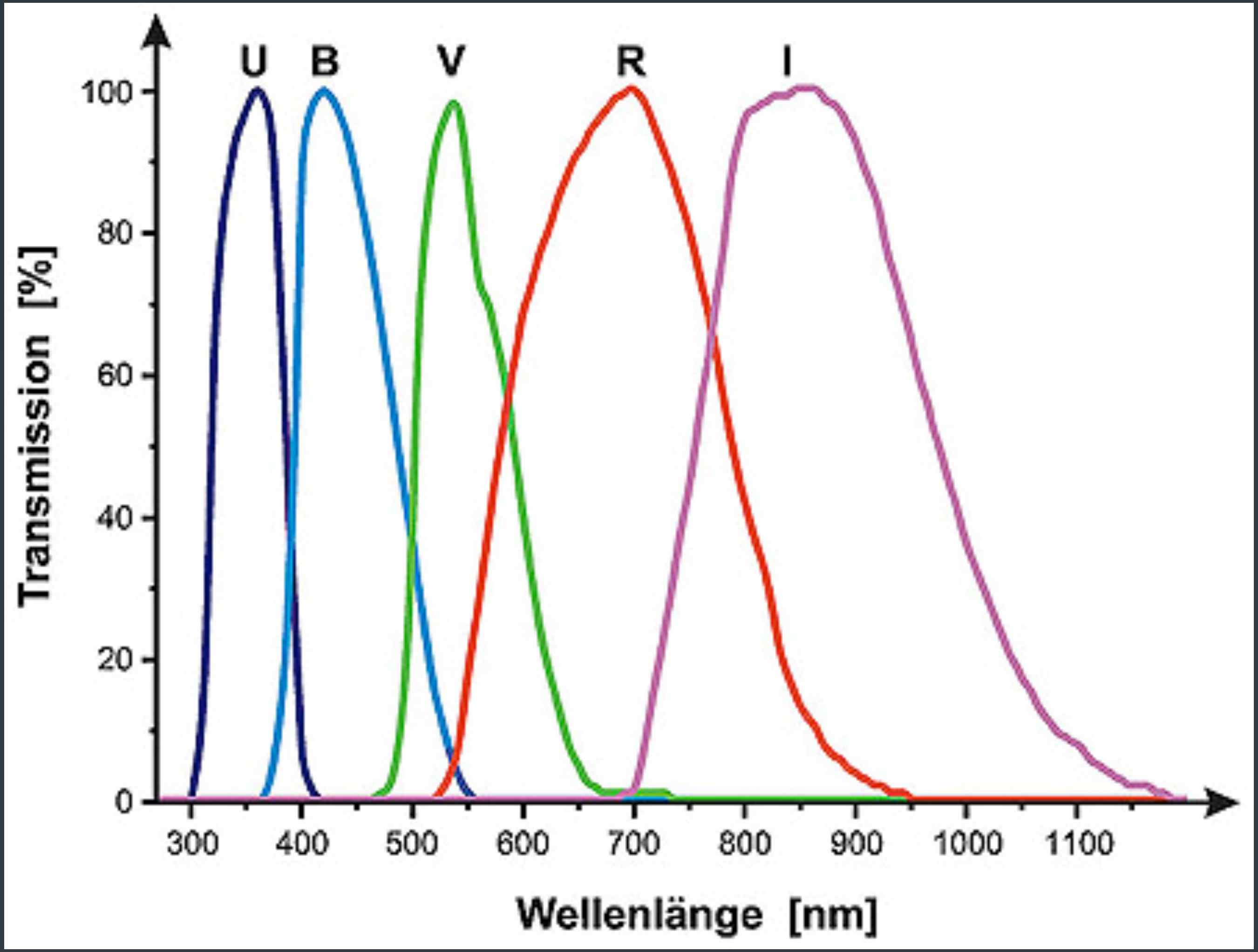
B-band

V-band



Band Graphs

We can graph the light curve of each band to get something like this. There are many other filters besides B and V.



Blanks

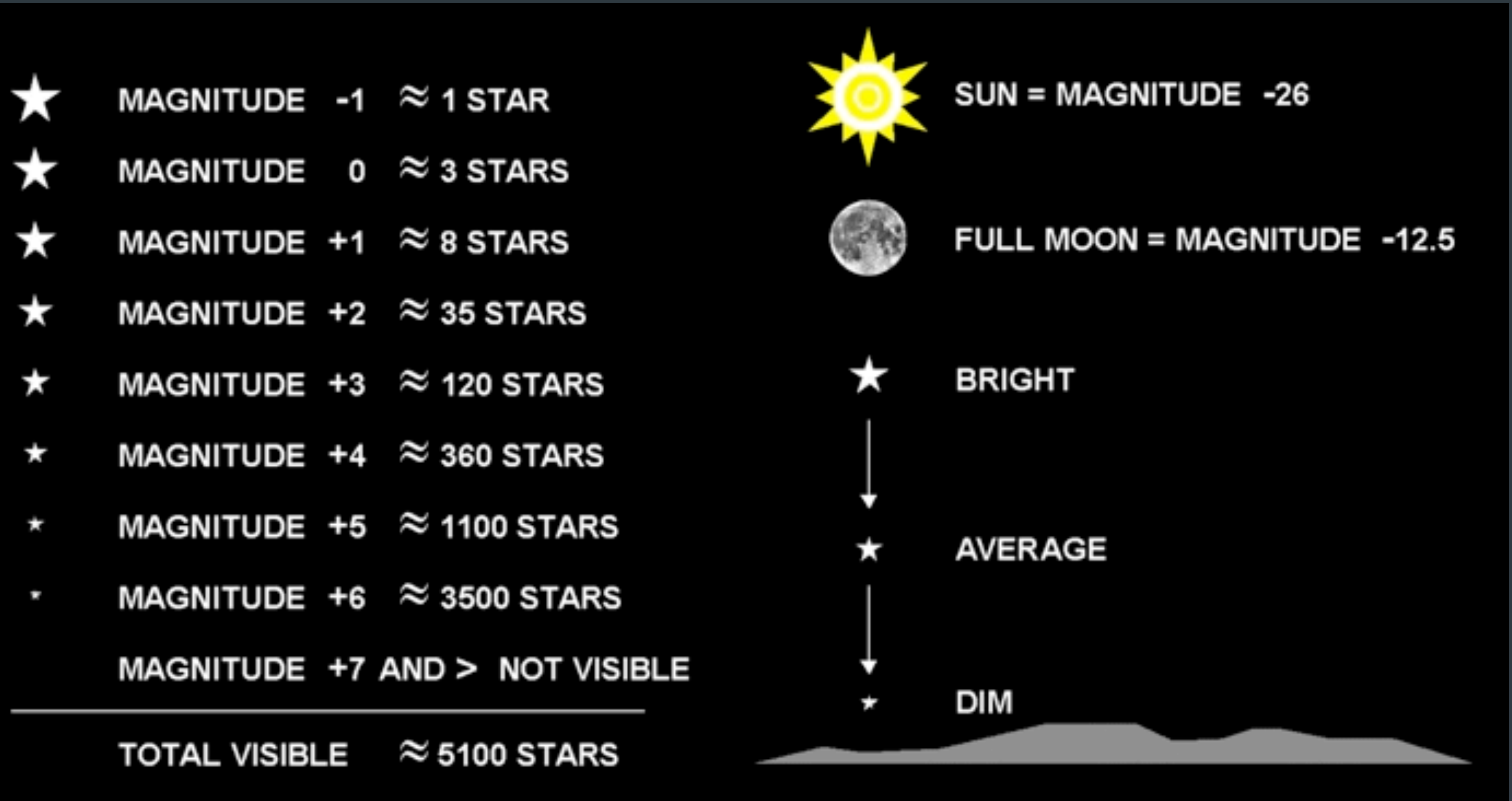
The sky between stars may look dark, but it's not pitch black. To make sure we study the light coming only from our star of interest, we must take some measurements of empty sky to subtract out all background light. We'll measure raw counts for our blanks.

Photometric Camera

Pick an object, aim your camera at it, and take some light measurements! **Integration seconds** is exposure time, how long we'll leave the camera open collecting light. **Number of integrations** is how many pictures we'll take. The goal of photometry is not to make a pretty picture, but to count how many photons enter the camera during the picture-taking. We're using the camera to measure how much light is coming from a star.

Magnitude

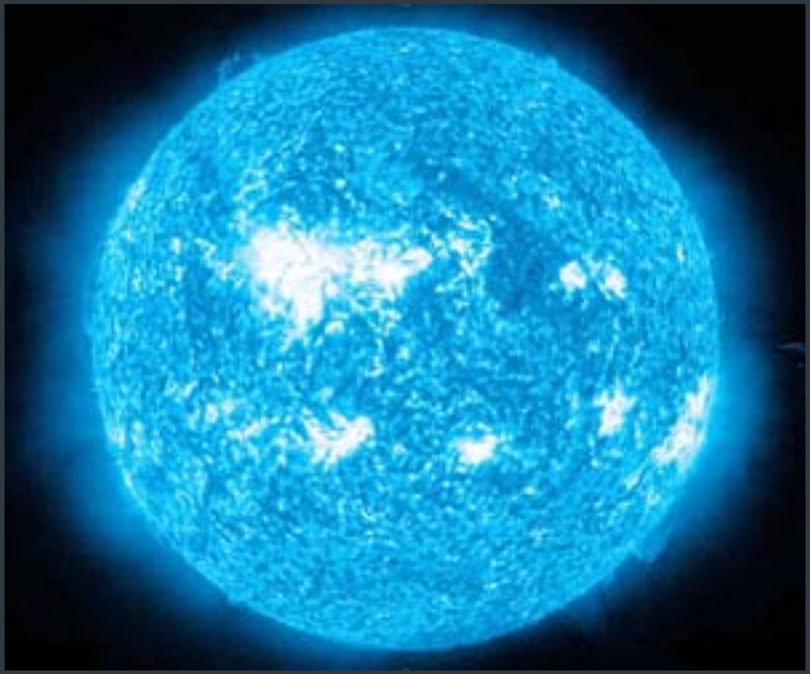
Magnitude is a measure of how bright a star is. The scale feels backwards: Small numbers are for bright stars, and big numbers are for faint stars. In fact, the brightest objects, like the moon, have negative magnitudes. The brighter the object, the smaller or more negative the magnitude.



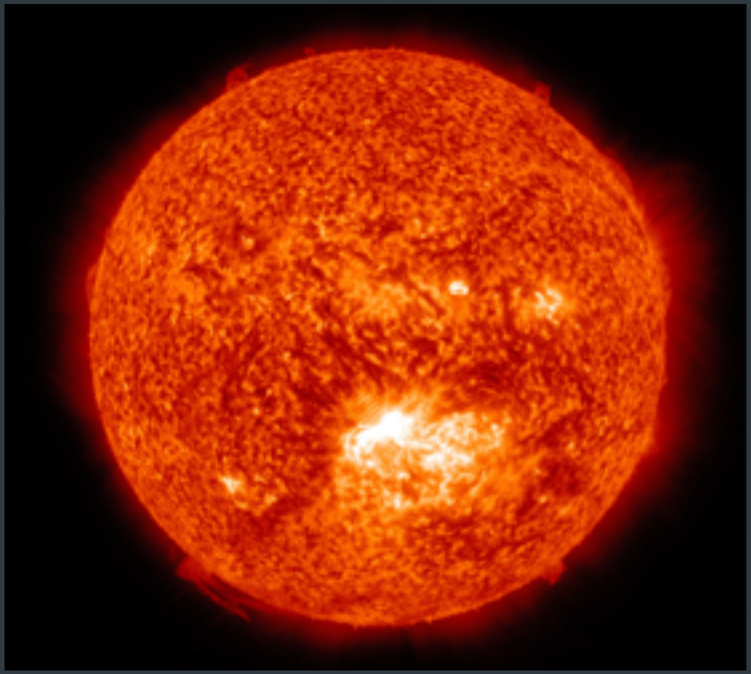
Color from B and V Magnitudes

B - V (blue minus green) is a measure of a star's color. Brighter = smaller magnitude number. This means a star with small B - V is bluer, and a star with large B - V is redder.

small B - V

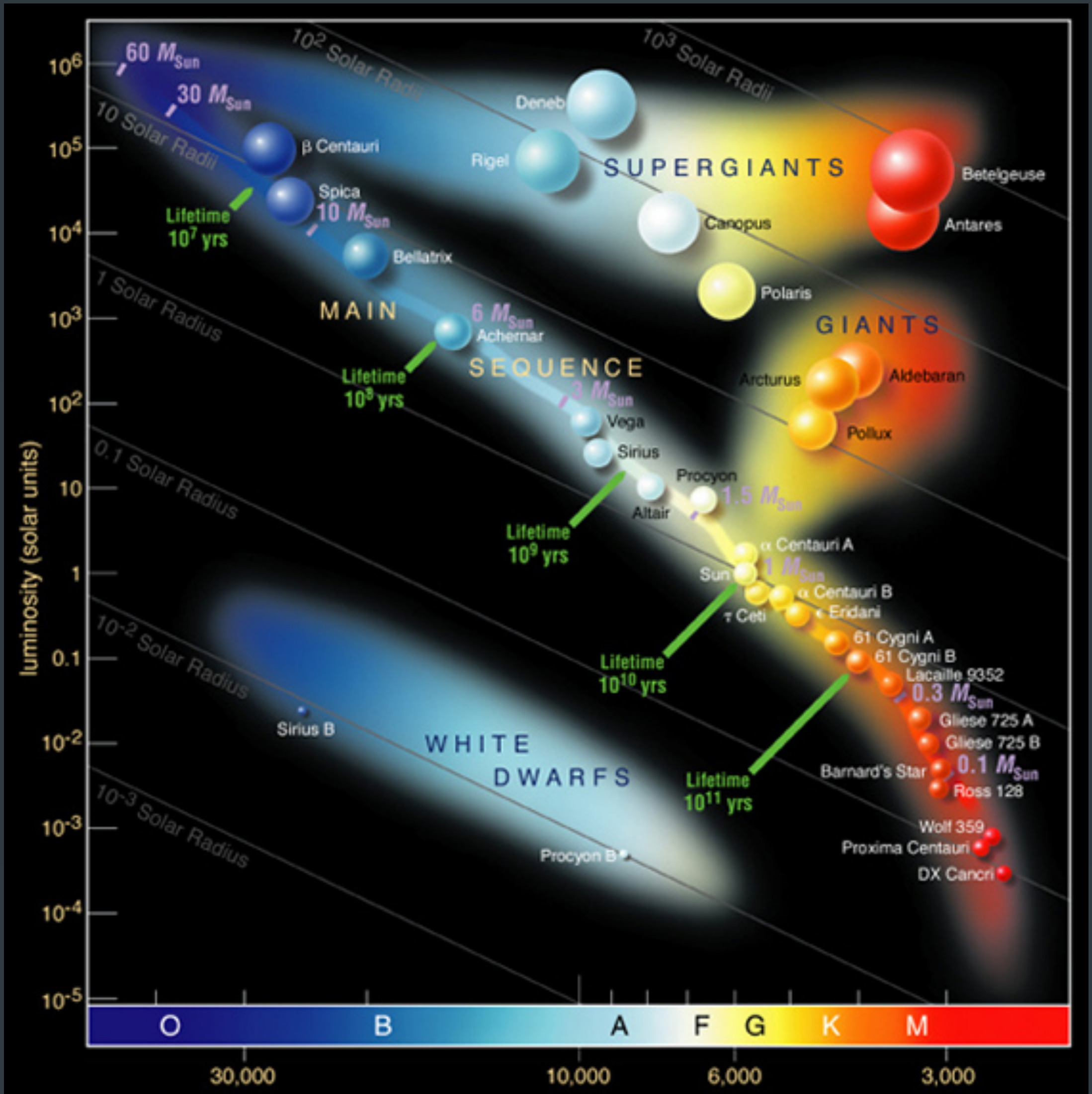


large B - V



HR Diagram

A Hertzsprung-Russell diagram plots star brightness (luminosity or magnitude) vs. star color (temperature or B - V). We'll be plotting magnitude vs. B - V.

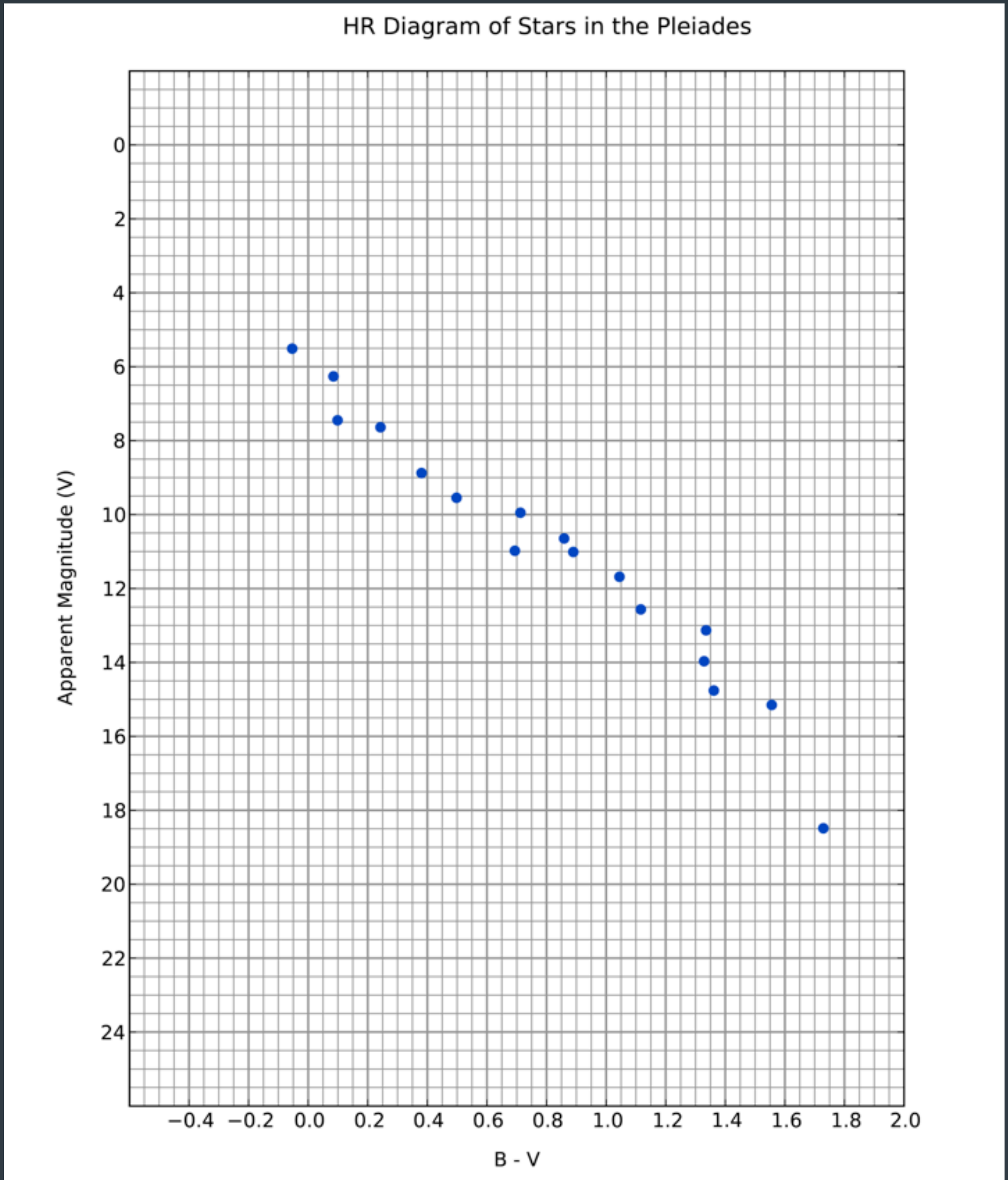


Closer Brighter, Farther Dimmer

Lights look brighter closer up than farther away. We can measure the magnitude of an object at some known distance and then compare this its magnitude at some farther distance to determine what that farther distance is.

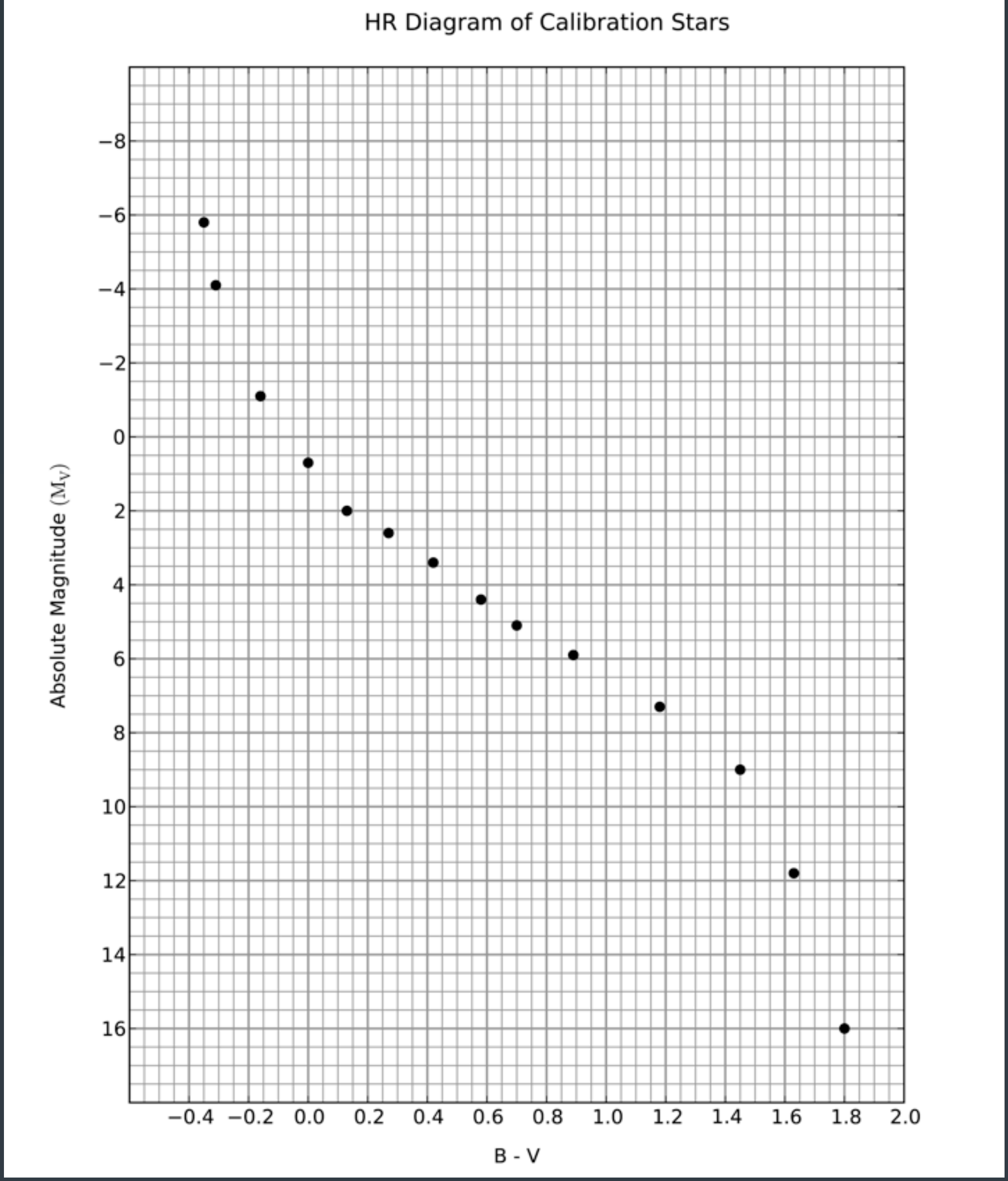
Apparent Magnitude

Here's how bright the Pleiades look from Earth.



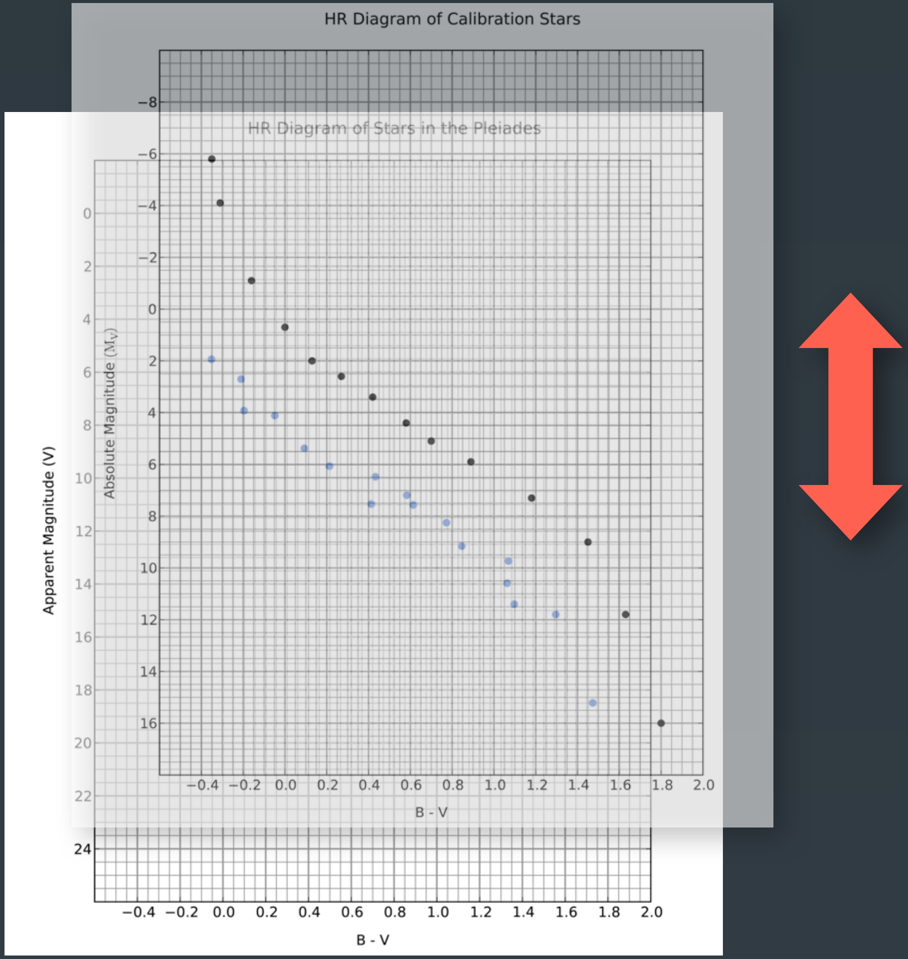
Absolute Magnitude

Here's how bright the Pleiades look from just 10 pc away. Note the smaller magnitudes (which means the Pleiades look brighter when they're closer up).



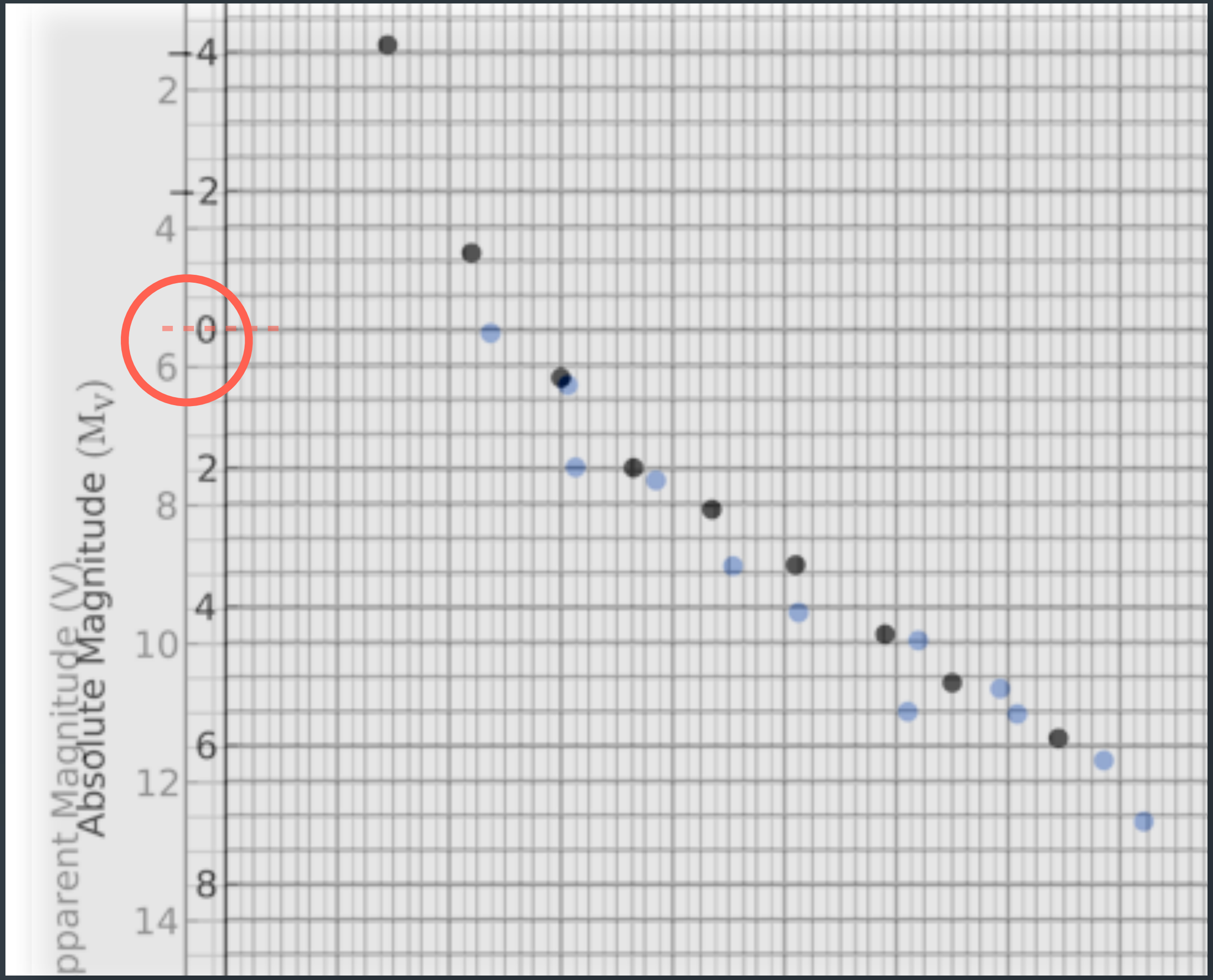
Distance Modulus

We can calculate the distance between the Pleiades and Earth by comparing how bright the Pleiades look from Earth (apparent magnitude V, paper scale) and how bright the Pleiades look from 10 pc away (absolute magnitude M_V, transparent scale). Align the scales horizontally and then slide the transparent scale up and down until the dots line up.



Distance Modulus

Once the dots are lined up, compare the paper and transparent vertical scales. What's the subtractive difference between the paper V scale and the transparent M_V scale? Equivalently, where does the transparent 0 hit on the paper scale? This is equal to the distance modulus $V - M_V$. You can carefully scoot the transparency sideways to help you read the two vertical scales.

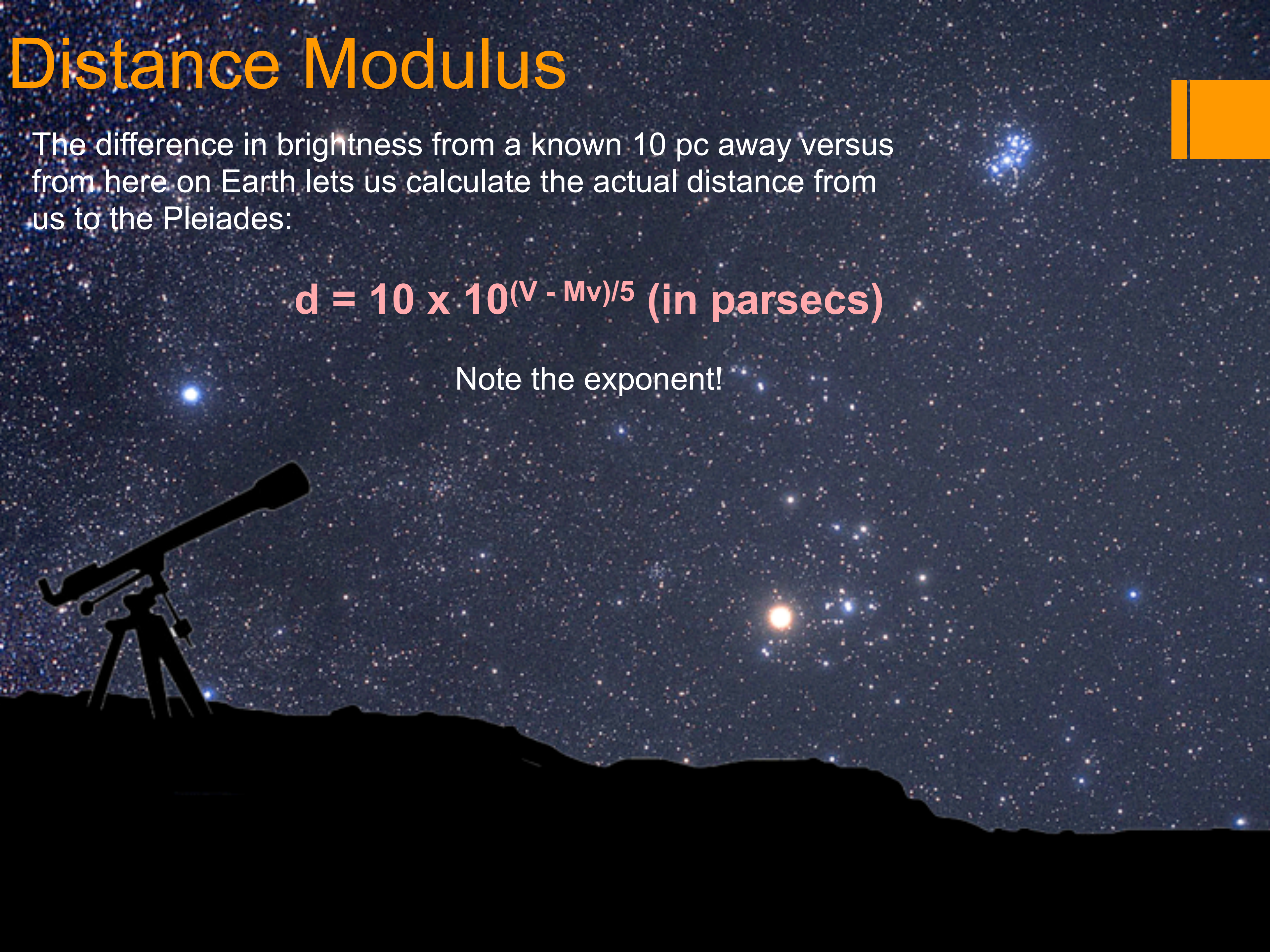


Distance Modulus

The difference in brightness from a known 10 pc away versus from here on Earth lets us calculate the actual distance from us to the Pleiades:

$$d = 10 \times 10^{(V - Mv)/5} \text{ (in parsecs)}$$

Note the exponent!



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