STANDARD CANDLES

For stars that are a long way away, the most common approach for determining the luminosity of a star is by using a standard candle approach. A standard candle is a celestial object that whose brightness varies in a way that is related to its average luminosity. With these objects, measuring the time it takes for them to proceed through their cycle tells us their luminosity.

The three most used standard candles are Type Ia Supernovas, RR Lyraes and Cepheids. We will focus on Cepheids.

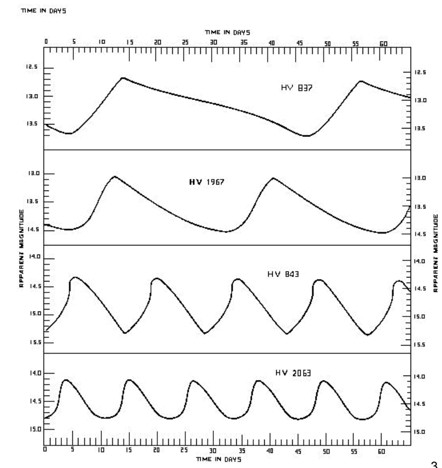
--Cepheid stars are relatively massive stars whose brightness varies with time. How so?

Cepheids have trouble balancing the energy generated at their core with the energy radiated at their surface. When energy builds up inside a Cepheid, it responds by expanding. As the outer surface gets larger, it vents more energy. With the venting, the energy content goes down and the star contracts back to its original size. Once there, its internal energy content begins to rise again and the cycle repeats itself. These objects have periods of from 1 to 100 days.

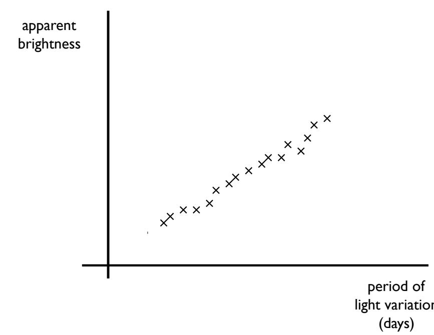
The consequence of this expansion, then contraction, then expansion, etc., is that the Cepheid gets brighter, then dimmer, then brighter in a periodic way. The period has been observed to be related to the Cepheid's luminosity.

Historically, in 1912, Henrietta Swan Leavitt from Harvard observed a group of Cepheids in the Small Magellanic Cloud, a companion galaxy of the Milky Way. All of the Cepheids were approximately the same distance from us, so the brighter ones were known to be the more luminous. What was notable was that the brighter the Cepheid, the longer its period of light variation.

Data from a *Sky and Telescope* article, as presented from the Web site http://www.motivated.math.org/, was found at http://www.astro.lsa.umich.edu/Course/MMSS/Interactive/Ex1.4/. (Remember, the smaller the apparent magnitude number, the brighter the object.)



Once the "apparent brightness" and *Cepheid period of light variation* information was observed and recorded, a graph similar to the one shown to the right was constructed.



With the *apparent brightness* versus *period* graph, all that was required to shift the axis to an absolute magnitude (hence luminosity) graph was to find one Cepheid that was within 3000 LY (1000 parsecs), measure its period of light variation, use parallax to determine its distance, the use the "luminosity/energy-flux/surface area" relationship to determine its luminosity. Having that one luminosity value allowed us to shift from an "apparent brightness" graph to an "actual brightness" (i.e., luminosity) graph. That is exactly what was done.

At this point, if we look at a star cluster or a galaxy and find a single Cepheid in the mix, we can use the rate its brightness fluctuations to determine its luminosity, then use out luminosity/energy-flux/distance relationship to determine its distance from us.

Pretty nifty, eh?