Astronomy 404
November 4, 2013

Chapter 13. Main Sequence and Post-Main Sequence Stellar Evolution

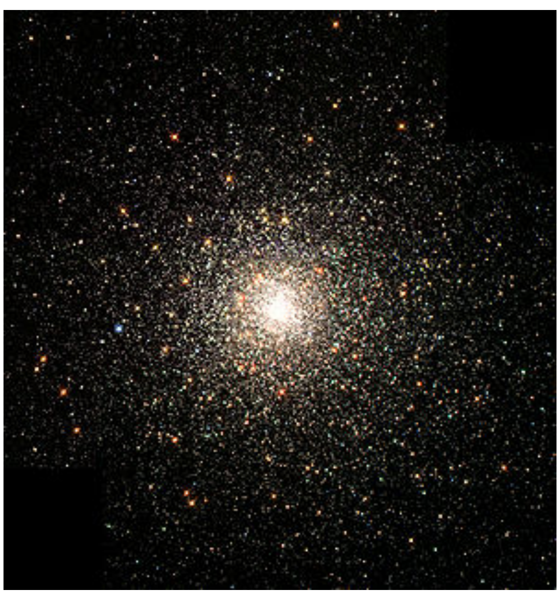
Population I, II, and III stars

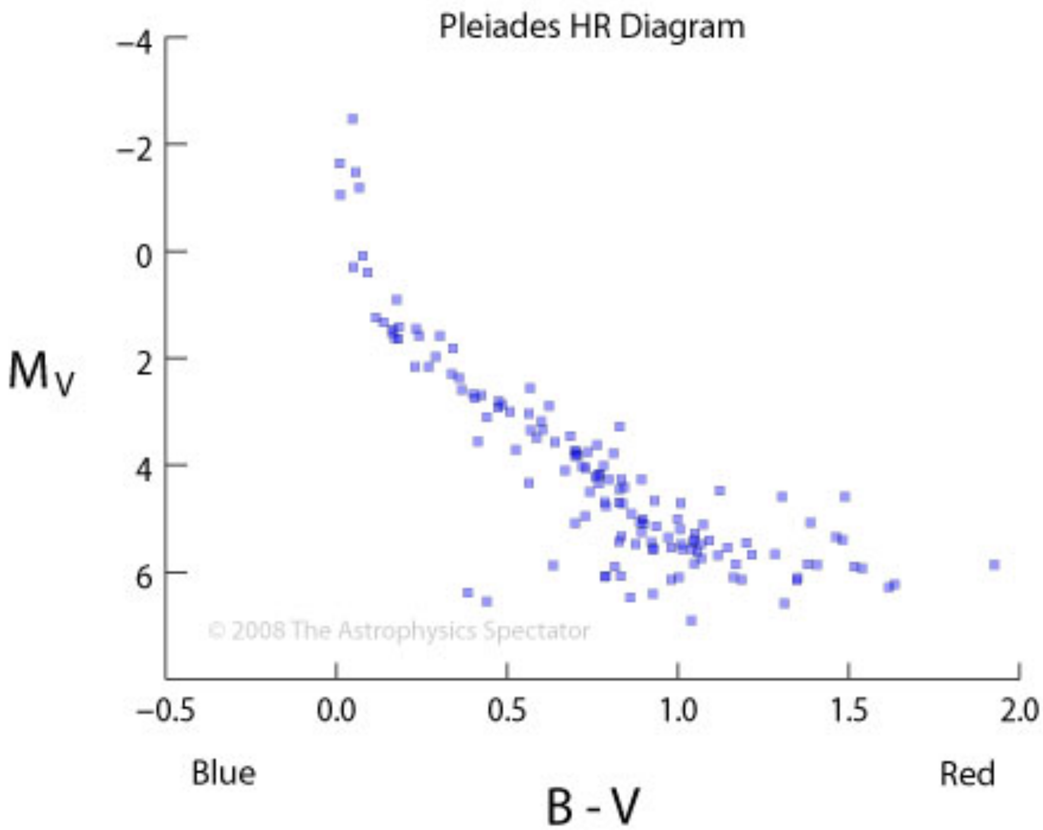
The Universe started with the Big Bang 13.7 Gyr ago. H and He were essentially the only elements produced by the associated nucleosynthesis. The first-generation stars must be metal-poor.

Population I stars are metal-rich, with Z as high as 0.03.
Population II stars are meta-poor, with $Z > 0$.
Population III stars are the first-generation stars with $Z \sim 0$.

Usually Pop I stars are found in the disk, Pop II stars can be found in the bulge and halo as well. Pop III stars are searched by rarely found.

Globular Clusters and Open Clusters



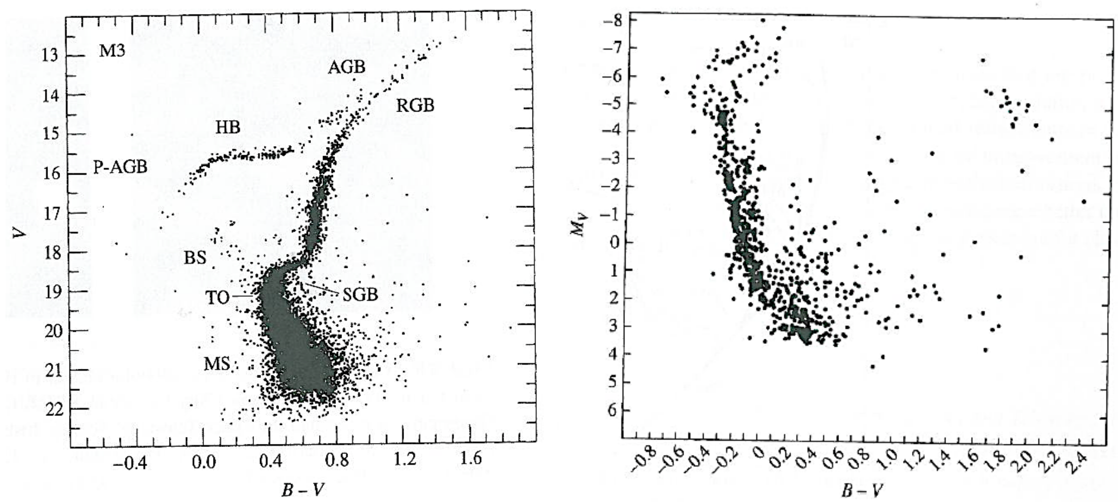


The above HR diagram can be used to estimate distances to other clusters by matching the main sequence and determine the distance modulus *m-M*. This method is called **spectroscopic parallax** or **main-sequence fitting**.

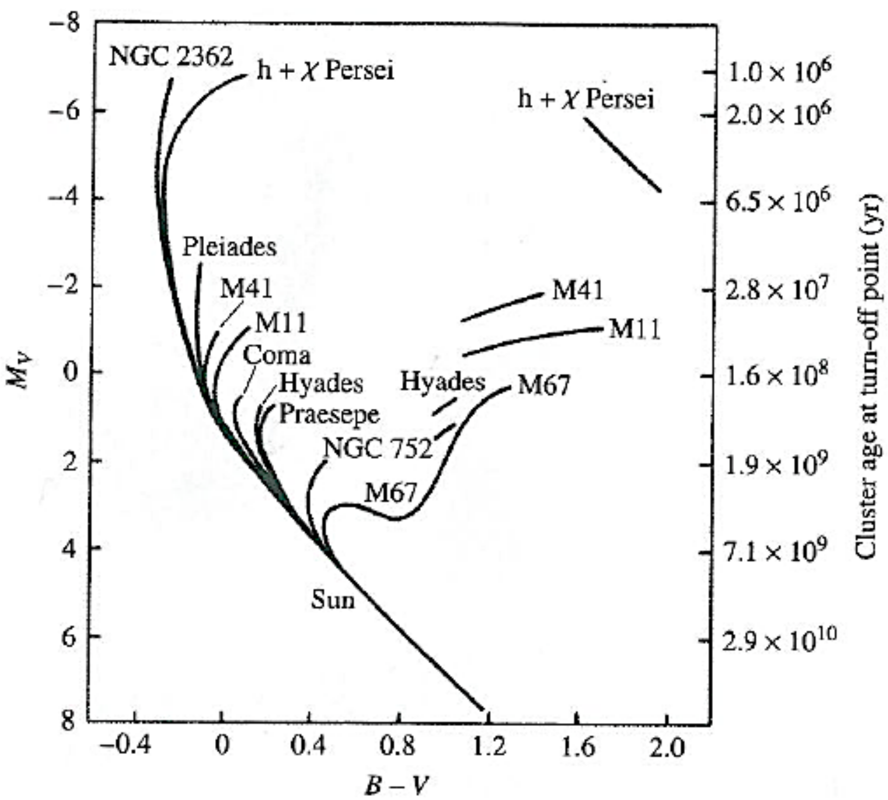
All stars in a cluster are formed at the same time, the so-called single-burst of star formation. Their color-magnitude diagrams can be very useful for studying stellar evolution.

Isochrones – the curve that connects the location of stars of different masses in the HR diagram at a specific time.

Isochrones are for a group of stars (such as clusters) and evolutionary track is for a single star.

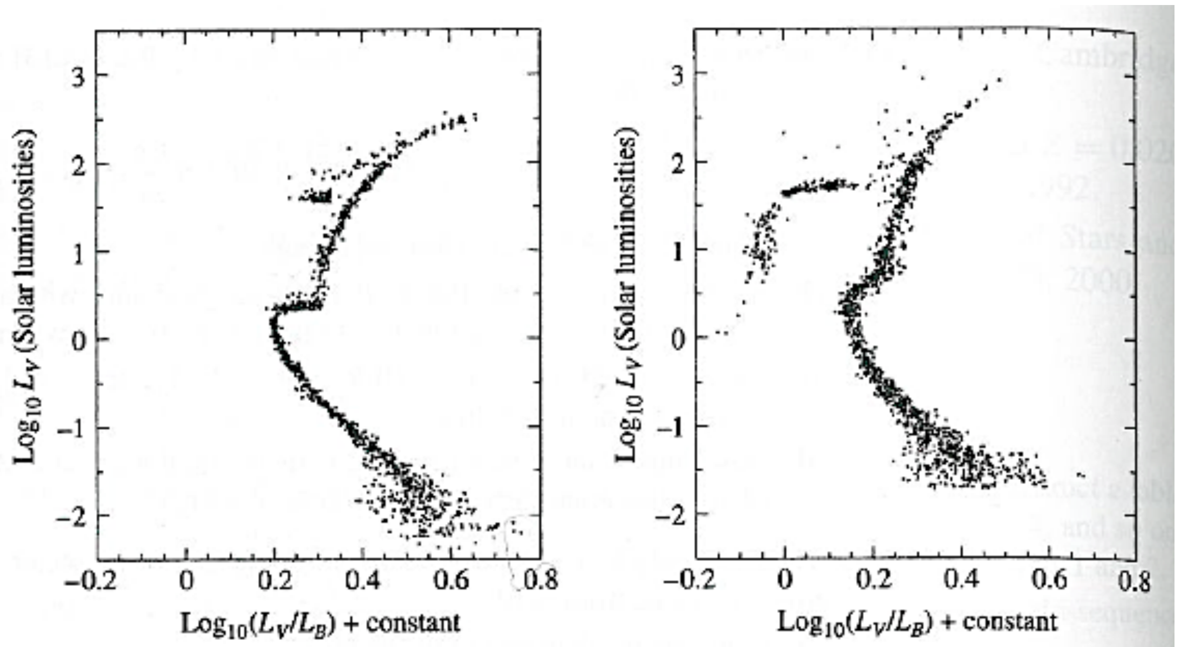


Above are CMDs for the globular cluster M3 (left) and the open cluster h and χ Persei.



The main sequence turn-off is roughly when H is exhausted in the core. The turn-off can be used to gauge the age of the cluster.

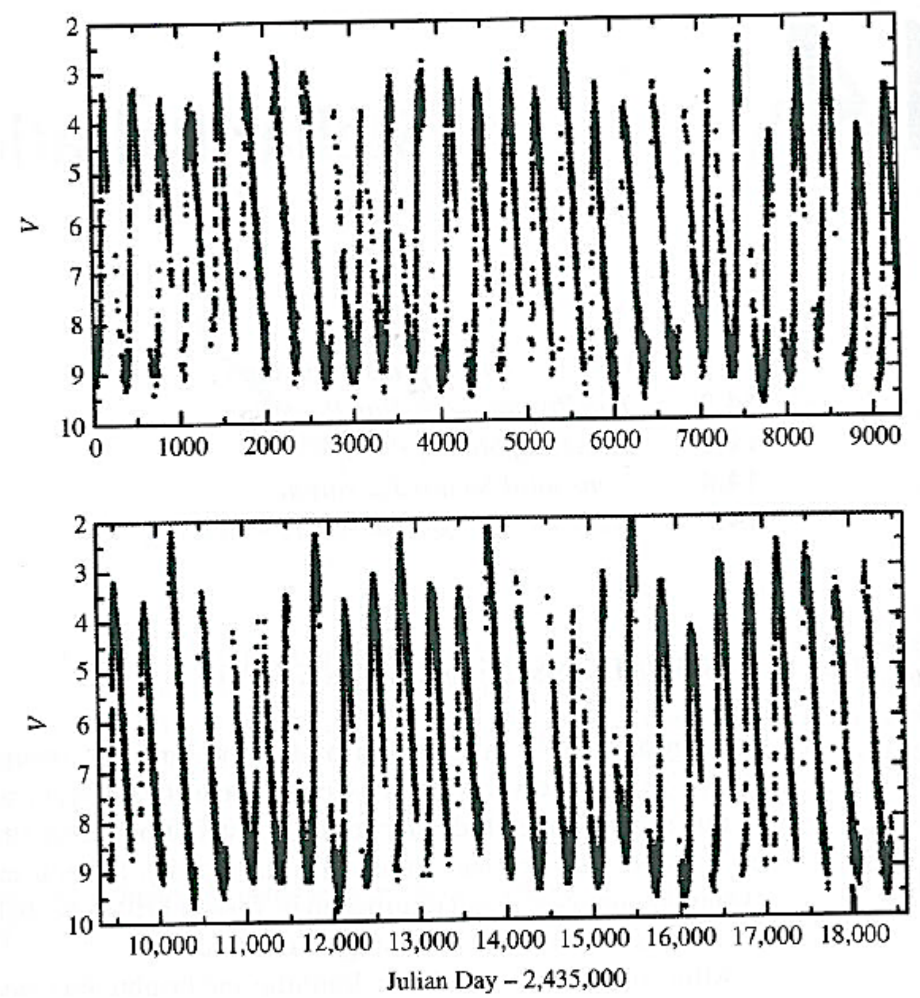
Hertzsprung gap – SGB evolution on a Kelvin-Helmholtz timescale.



The CMDs above are essentially V versus (B-V).
The cluster on the left has high metal abundance, so its horizontal branch is very red. The cluster on the right is metal-poor, so its horizontal branch extends to blue. The metal lines provides high opacity in the blue. Metal-poor stars have lower opacity in the blue, so can be seen deeper into the photosphere with higher temperature.

Chapter 14.   Stellar Pulsation

Some stars show periodic variations in their brightness, such as Mira whose light curve show 11-month periods. Below is Mira's light curve over 51 years.



Mira is a **pulsating star** and is the prototype of the **long period variables**, which have irregular light curves and pulsation periods of 100-700 days.

δ Cephei, on the other hand, varies regularly with a period of 5 days, 8 hours, and 48 min. δ Cephei is a **classical Cepheid**.

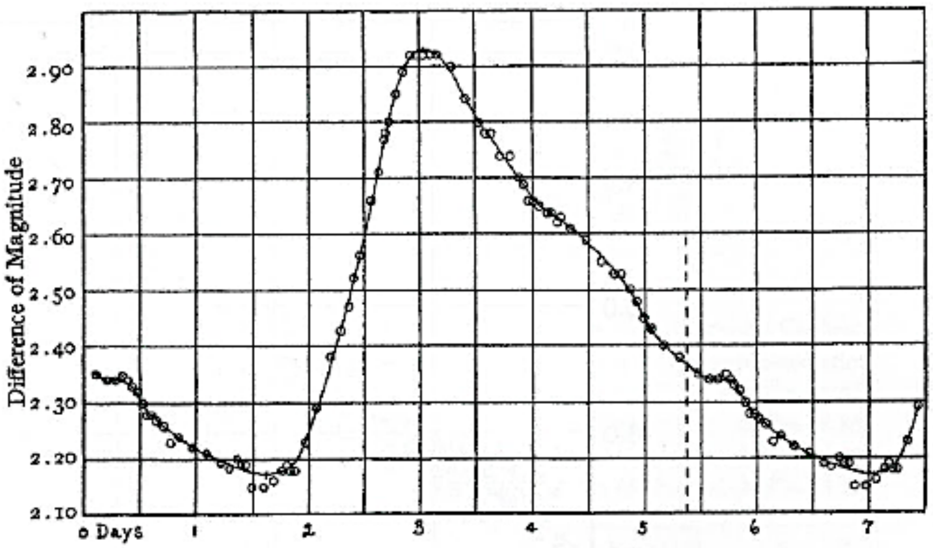
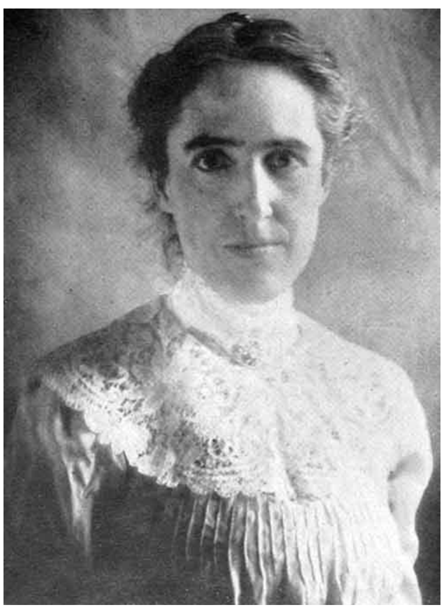
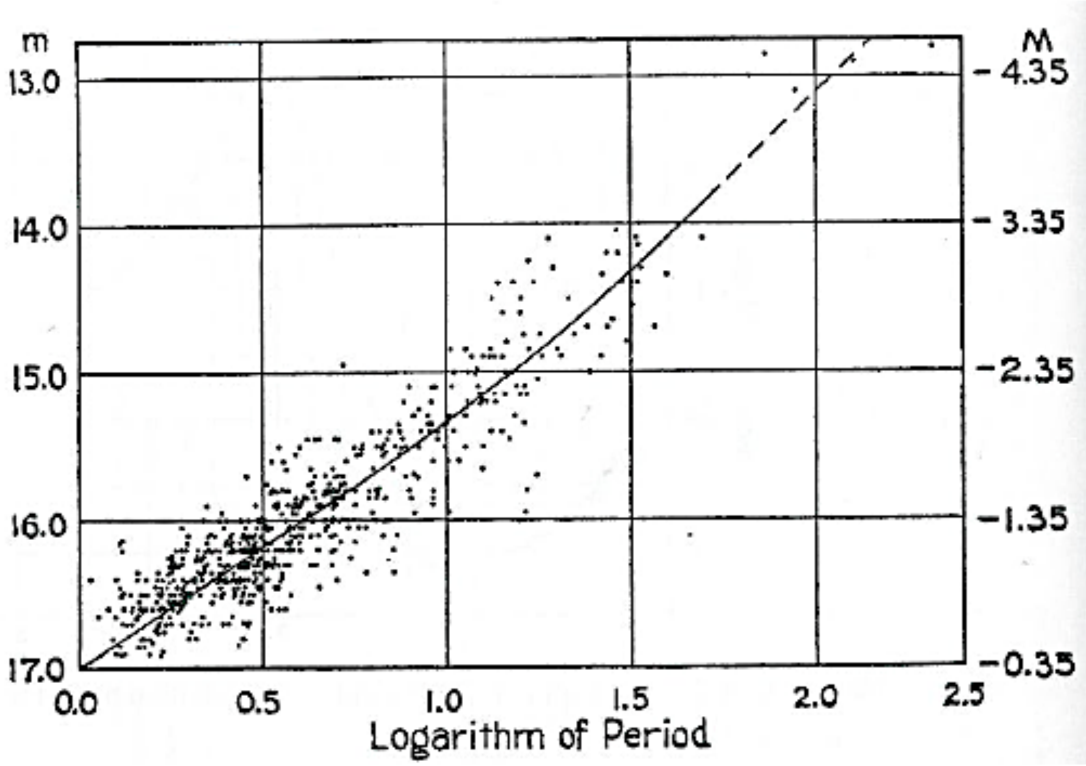


FIGURE 14.2 The light curve of δ Cephei. Its pulsation period is 5.37 days. (Figure from Stebbins, Joel, *Ap. J.*, *27*, 188, 1908.)



Henrietta Swan Leavitt (1968-1921) was one of the "computers" of Edward Pickering (1846-1919). Leavitt discovered ~2400 classical Cepheids in the Small Magellanic Cloud, and found that the apparent magnitudes of these cepheids are correlated with their pulsation periods!



$$M_{(V)} = -2.81 \log_{10} P_d - 1.43,$$

or

$$\log_{10} \frac{\langle L \rangle}{L_\odot} = 1.15 \log_{10} P_d + 2.47.$$

Since all stars in the SMC are at the same distance, 60 kpc, the differences in the apparent magnitude must reflect the intrinsic differences in their luminosities. **Period-luminosity relation**.