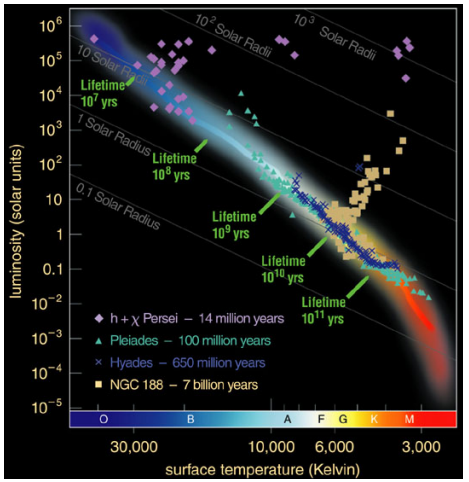
Card Activity, Sep. 27

Make a qualitative sketch of the HR Diagram you would expect to find for the following cases. Label the axes and indicate the direction of increasing values. Indicate with dots or shading where the stars should lie.

(a) Cluster A: A relatively young cluster, that formed more recently than, for example, the Hyades.
(b) Cluster B: A relatively old cluster, that formed about 10 billion years ago.
(c) Now assume that Clusters A and B were to physically merge, combining into a single cluster. What would the HR diagram look like then? Explain your reasoning.

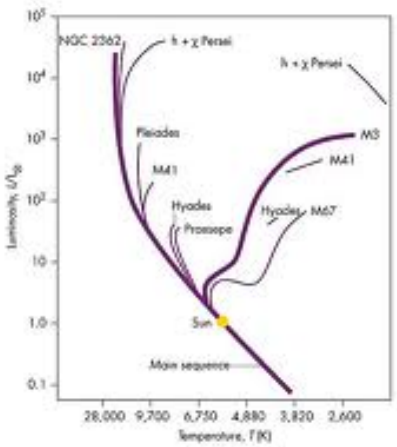
Determining the Ages of Star Clusters



Star clusters of different ages have different turn-off points; younger ones still have high-mass Main Sequence stars, for older clusters, more of the M.S. has "peeled off."

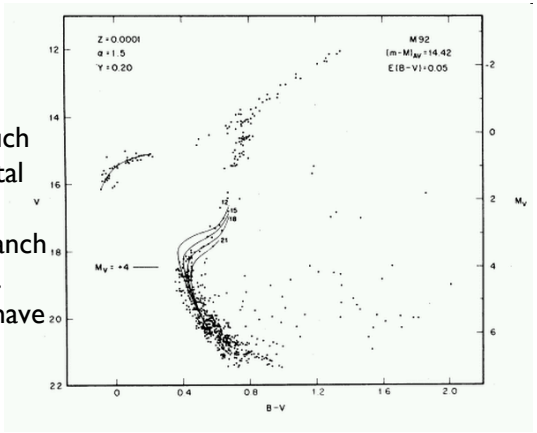
Star Cluster HR Diagrams

The young cluster, (a), will show stars extending up to a high luminosity point on the HR diagram, like for example, NGC 2362. An older cluster, (b), will look like M3, with a turn-off point lower on the Main Sequence. The combined cluster will be the sum of (a) + (b), looking like the bold lines in this sketch.



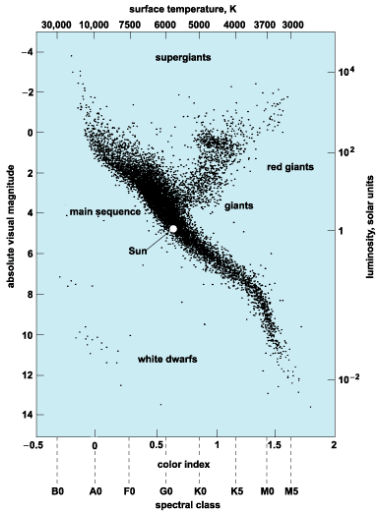
HR Diagrams of Old Star Clusters

The HR diagram of an older cluster may show concentrations of non-Main Sequence stars, such as red giants, a horizontal branch, the second red giant ("asymptotic") branch and some white dwarfs. The young cluster will have just a few luminous red giants, at most.



"Mixed-Age" HR Diagrams

The diagram at right shows a sample of stars that are not in a cluster (we call them "field stars"). They have a range of ages, so there are still some short-lived, upper Main Sequence stars, but at the same time we see a turn-off just a little above the Sun.



Errors and Misconceptions

- For (c), some groups showed a turnoff point in between those for clusters (a) and (b), reasoning that they would "average out." NO. There are two groups of stars, with two different but specific ages, so you should see ***two separate turn-off points***.
- Some groups failed to draw a full HR diagram for each cluster; they showed only a Main Sequence, with (a) and (b) marked as separate points on it.
- "The Main Sequence would shift to the left." Nope. Combining the two clusters doesn't change the properties of the stars in them.

Correct Points & Clarifications

- "Even if you merge [the clusters], you still have all the same types of stars on the diagram."
- "You would see an overlay of the two diagrams, with higher density of stars in the areas of overlap."
- "Younger stars have higher temperature because of mass, older stars the opposite." This assertion is not justified. High-mass stars on the Main Sequence must have formed recently because of their short lifetimes; low-mass MS stars can be old ***or young***.
- Another group omitted the lower-main sequence for Cluster (a). *Young stars do not have to be massive!*

Errors and Misconceptions

- Despite my warnings about misinterpretations of the Main Sequence, some of you think an individual star can move along it: "… the younger stars are still moving down and off, while the old ones are gone…"; "Older stars become cooler and lower luminosity…" Nope.
- One drawing for (c) showed stars "peeling off" the Main Sequence from both the top and the bottom! "This would be double-ended because there are stars at both ends of its life." After the MS, stars evolve to be red giants, towards the upper right.