HR DIAGRAM
HR Diagram and Star Clusters

BRIEF

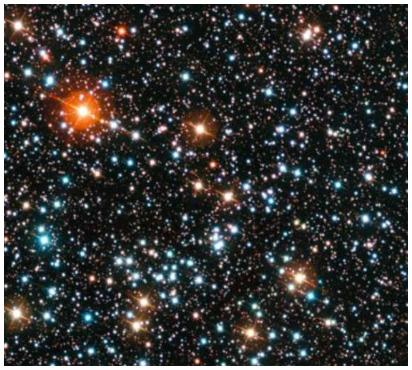
Overview

Result of a parent molecular gas cloud (Stellar Birthplace) collapsing into a group of stars found in the same region of space.

Due to this common origin, clusters are almost ideal laboratories for the study of stellar life sequences.

Being born in of the same material, the properties defining these stars are tightly contained as opposed to studying stars of different birth origins.

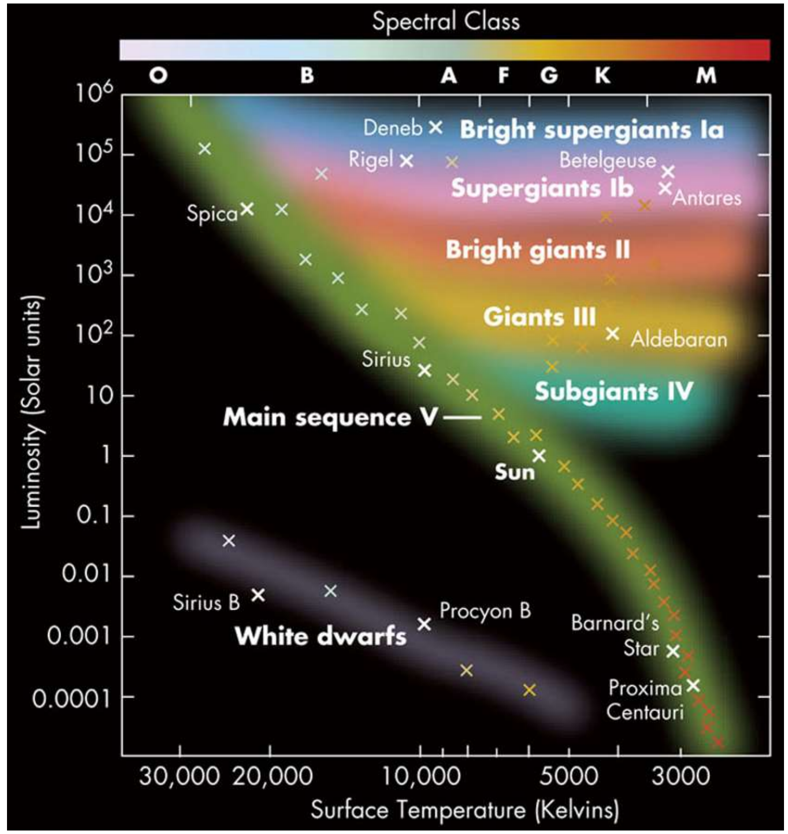
This allows theoretical models of star formation and evolution to be compared to actual processes.



HR Diagram Quick Review

H-R diagram broken into Stellar Types and Luminosity Classes:

- Stellar Types based on Temperature: O, B, A, F, G, K, M…..
- Luminosity classes based on Luminosity and Temperature:
    - Ia (bright supergiant),
    - Ib (supergiants),
    - II (bright giants),
    - III (giants),
    - IV (subgiants),
    - V (main sequence)
    - White Dwarf



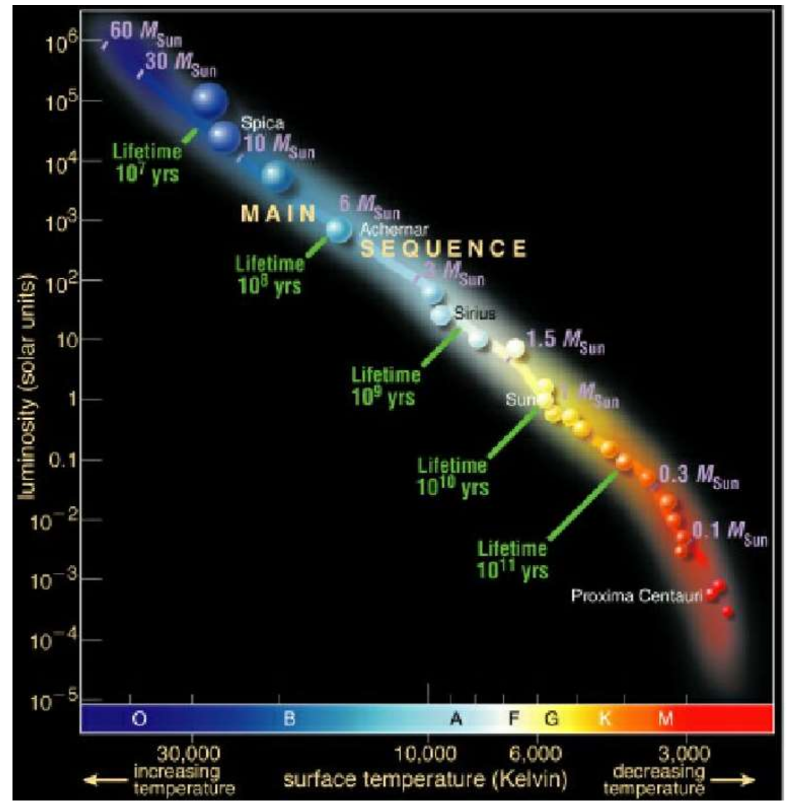
Star classification example: The Sun is G2V

HR Diagram Main Sequence Review

Most of the stars we see in the sky are main sequence stars!

Properties of Main Sequence Stars

1. Hydrogen to Helium Fusion
2. Hot, blue stars are more massive, and larger in size but have much shorter lifetimes
3. Small, cool, red stars have longer lifetimes.
4. Upper limit of stellar mass: ~ 100 M_{sun}
5. Lower limit of stellar mass: ~ 0.08 M_{sun}
    - The core temperature of objects with mass less than 0.08 M_{sun} is not hot enough to trigger hydrogen burning.
    - Jupiter is 0.001 M_{su}



HR Diagram Main Sequence Review

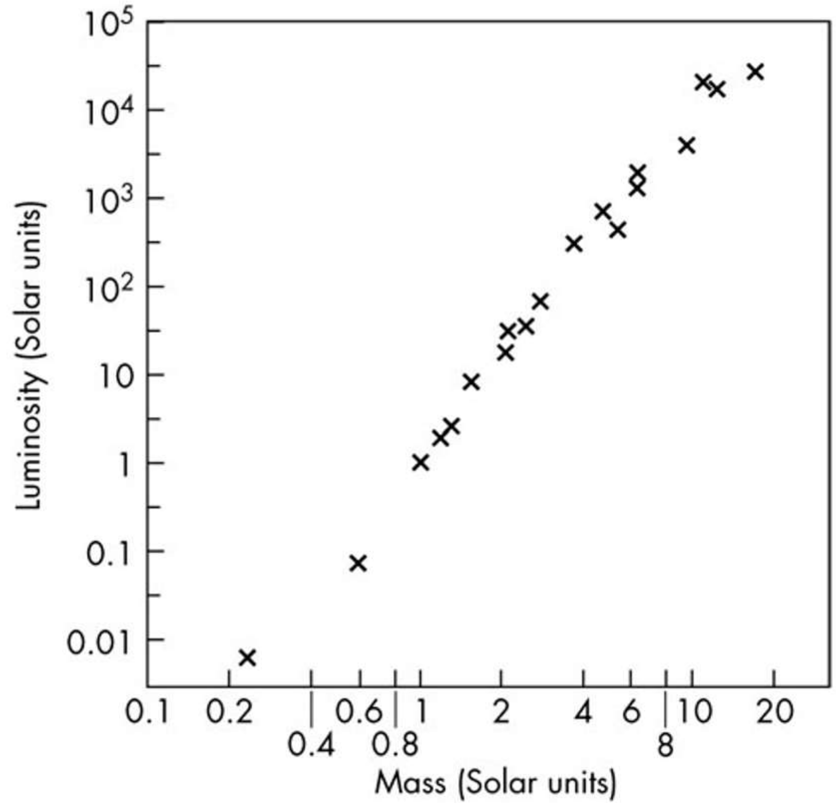
Once we have observationally determined the luminosity and mass of many main sequence stars, we find that the higher the mass M of a star is, the higher is its luminosity (L).

Main-sequence stars obey a *mass-luminosity relation,* approximately given by:

$$L = M^3$$

L and *M* are measured in solar units

IMPORTANT: This is true ONLY for Main Sequence stars. Once a star leaves the Main Sequence, this relation breaks down



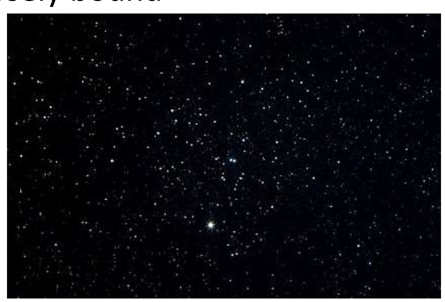
Types of Star Clusters

Open Clusters (Pleiades)

Small numbers to a few thousand
Loosely bound by gravity
Mainly found in the plane of the Milky Way
Will disperse over time due to gravitational interactions

Associations (Hyades Association)

Less massive and more extended, about 10s of parsecs
Typically no more than a few hundred bright stars
Typically rich in young stars (many T Tauri stars)
Loosely bound



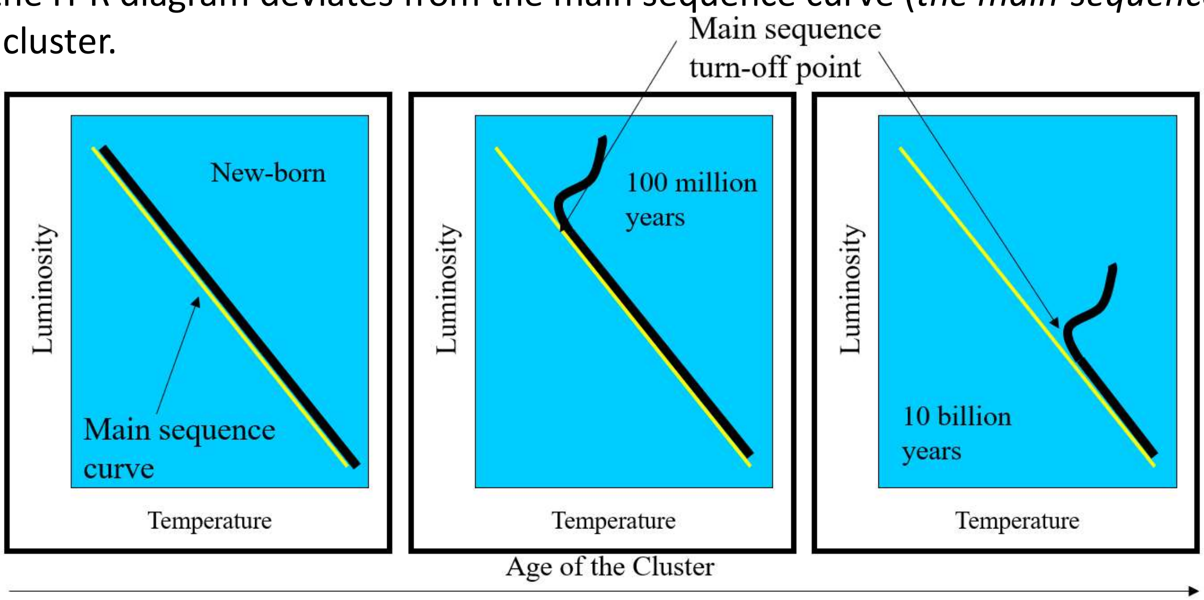
Globular Clusters

Spherical in shape
Found in Halo, not the plane
Very old
Don't contain O – F stars
Contain later stars

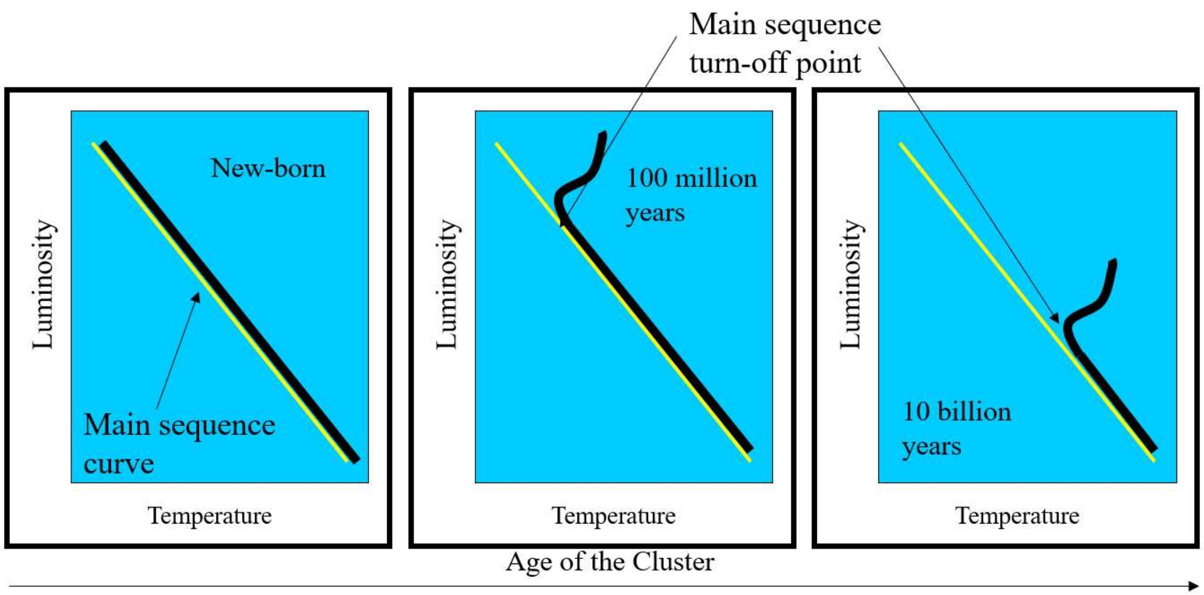
Star Clusters and Age with the HR Diagram

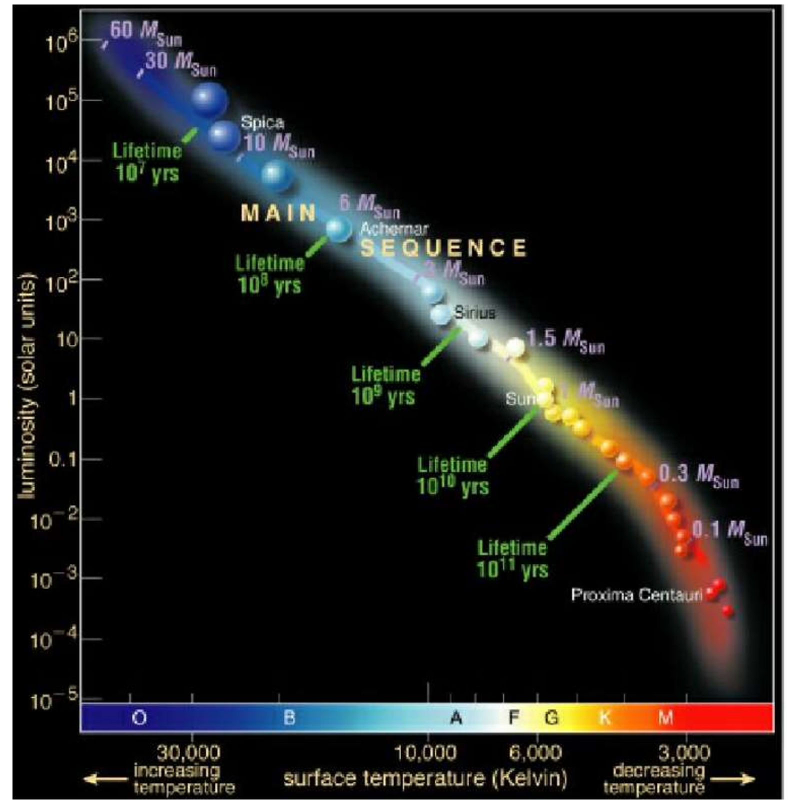
When a star cluster is born, it contains stars spanning the entire range of the H-R diagram.

As the cluster ages, the high-luminosity, hot, blue stars move away from the main sequence curve first.
The point where the curve of the H-R diagram deviates from the main sequence curve (*the main-sequence turn-off point*) indicates the age of the cluster.



Star Clusters and Age with the HR Diagram

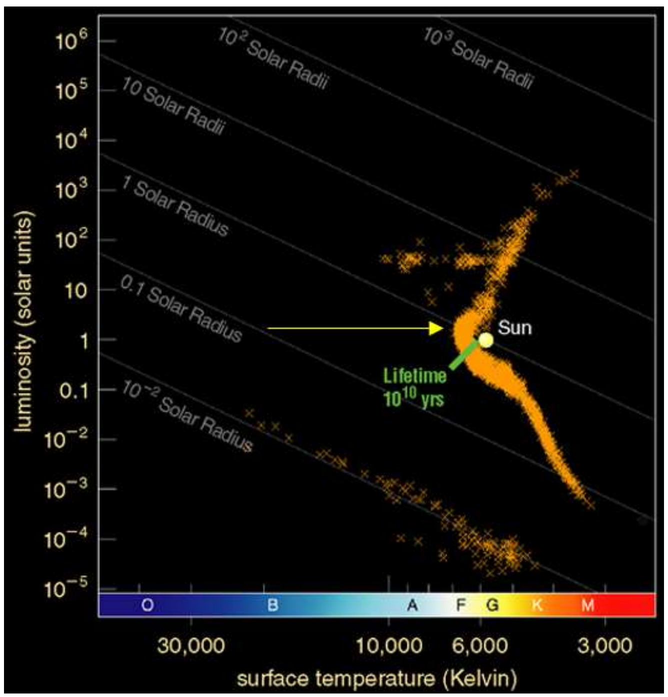


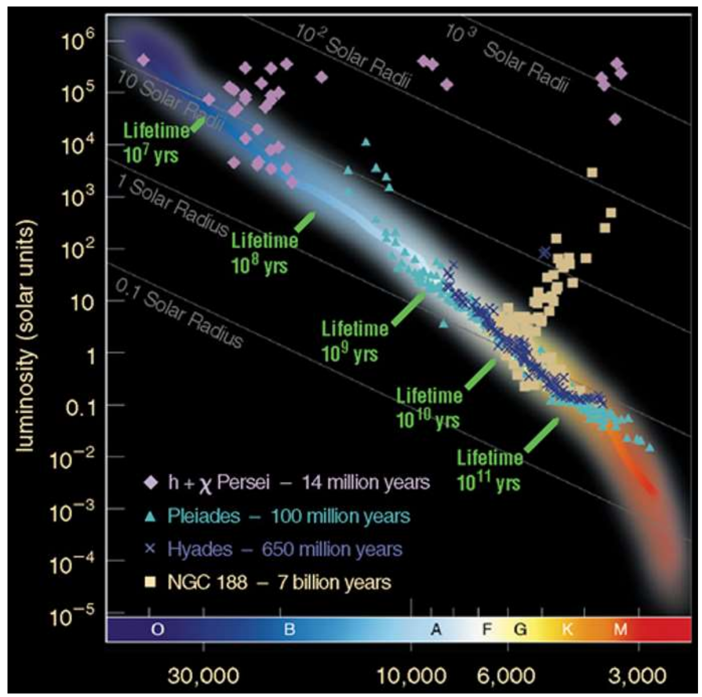


Overview

M4 main-sequence turn-off point example:

- Age: 12 ~ 14 billion years.
- Age of the universe must be at least 12 ~ 14 billion years.





Summary

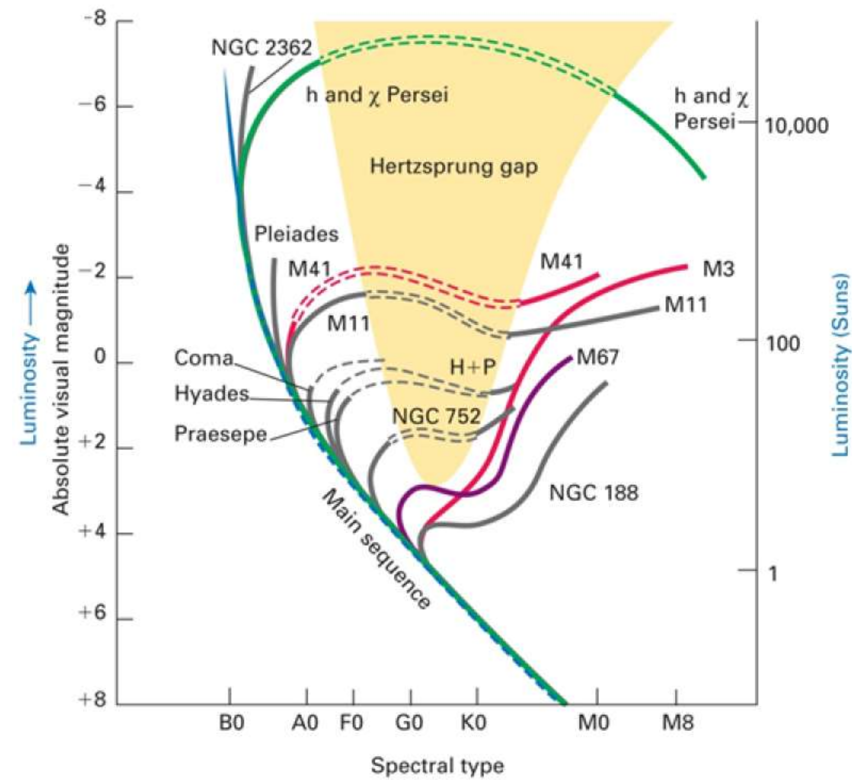
Clusters provide the best means for us to compare theories to actual stellar evolution.

Clusters form from the same gas cloud and come in 3 Types:

- Open
- Associations
- Globular

Using the HR Diagram we can measure the age of these systems by determining the Main Sequence turn off point.

Clusters can be studied with photometry and spectroscopy.



Questions?