ASTR 1020: Stars & Galaxies

October 4, 2013

- Reading: Chapter 16.
- *Mastering Astronomy* Homework on The Properties of Stars is due tonight at midnight.

Astronomy in the News: Voyager 1 probe has left the solar system

Natalie Stinson

Today's Class:
The HR Diagram & Star Clusters

- Masses & Lifetimes of Stars.
- Measuring stellar ages with Star Clusters.

Reading Clicker Question: Which type of star is no longer undergoing nuclear fusion?

A. supergiants
B. M stars
C. main-sequence stars
D. white dwarfs
E. none of the above (all have nuclear fusion)

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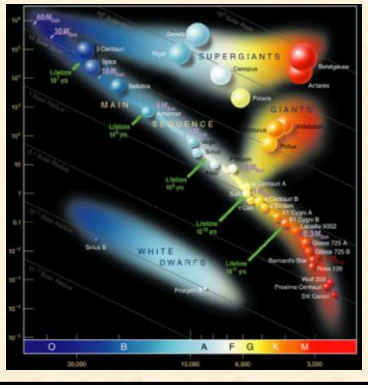
Hertzsprung-Russell (H-R) diagram



Stellar Properties Review

Luminosity: from brightness and distance

$(0.08\ M_{Sun})$ $10^{-4}\ L_{Sun}$ - $10^{6}\ L_{Sun}$ $(100\ M_{Sun})$

Temperature: from color and spectral type

$(0.08\ M_{Sun})$ 3,000 K - 50,000 K $(100\ M_{Sun})$

Mass: from period (p) and average separation (a) of binary-star orbit

$0.08\ M_{Sun}$ - $100\ M_{Sun}$

Mass & Lifetime

Until core hydrogen (10% of total) is used up

Sun's life expectancy: 10 billion years

Life expectancy of 10 M_{Sun} star:

10 times as much fuel, uses it 10^4 times as fast

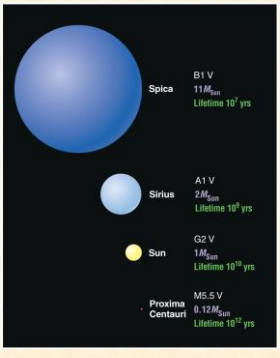
10 million years ~ 10 billion years x $10 / 10^4$

Life expectancy of 0.1 M_{Sun} star:

0.1 times as much fuel, uses it 0.01 times as fast

100 billion years ~ 10 billion years x $0.1 / 0.01$

Main-Sequence Star Summary



High Mass:

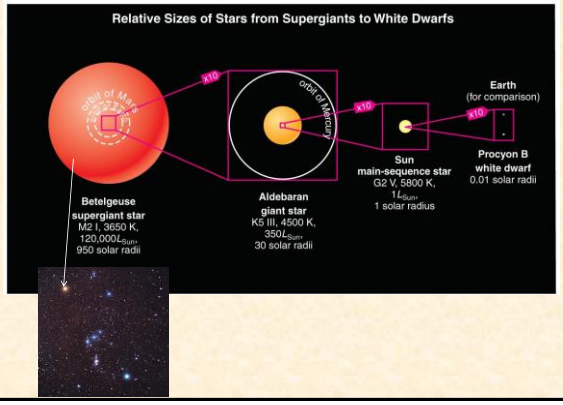
- High Luminosity
- Short-Lived
- Large Radius
- Blue

Low Mass:

- Low Luminosity
- Long-Lived
- Small Radius
- Red

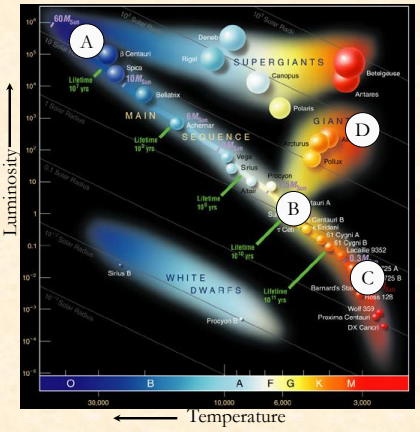
What are giants, supergiants, and white dwarfs?

Sizes of Giants and Supergiants



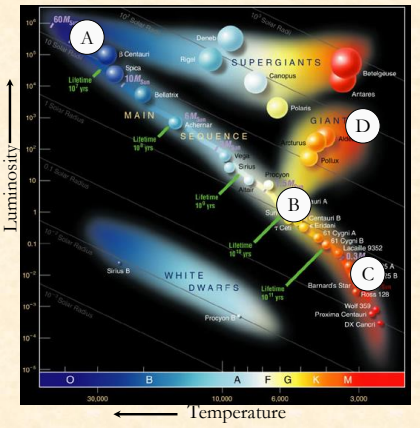
Off the Main Sequence

- Stellar properties depend on both mass and age: those that have finished fusing H to He in their cores are no longer on the main sequence.
- All stars become larger and redder after exhausting their core hydrogen: **giants** and **supergiants.**
- Most stars end up small and white after fusion has ceased: white dwarfs.



Clicker Question:

Which of these stars will have changed the least 10 billion years from now?



Which of these stars will have changed the least 10 billion years from now?

C

What have we learned?

- What is a Hertzsprung-Russell diagram?
  - An H-R diagram plots stellar luminosity of stars versus surface temperature (or color or spectral type)
- What is the significance of the main sequence?
  - Normal stars that fuse H to He in their cores fall on the main sequence of an H-R diagram
  - A star's mass determines its position along the main sequence (high-mass: luminous and blue; low-mass: faint and red)

What have we learned?

- What are giants, supergiants, and white dwarfs?
  - All stars become larger and redder after core hydrogen burning is exhausted: **giants** and **supergiants**
  - Most stars end up as tiny **white dwarfs** after fusion has ceased

Star Clusters

- What are the two types of star clusters?
- How do we measure the age of a star cluster?

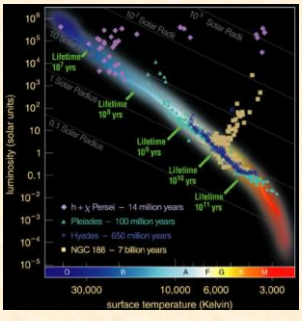
What are the two types of star clusters?

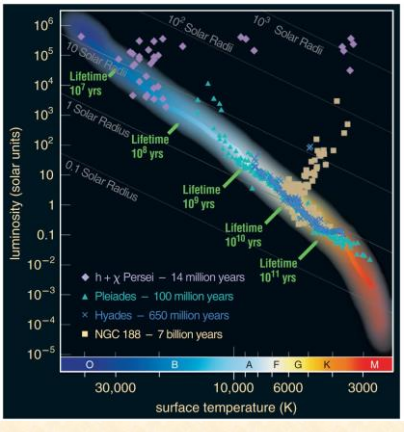
Pleiades star cluster

Open cluster: A few thousand loosely packed stars

Globular cluster: Up to a million or more stars in a dense ball bound together by gravity

How do we measure the age of a star cluster?





Main-sequence turnoff point of a cluster tells us its age

What have we learned?

- What are the two types of star clusters?
  - Open clusters are loosely packed and contain up to a few thousand stars
  - Globular clusters are densely packed and contain hundreds of thousands of stars
- How do we measure the age of a star cluster?
  - A star cluster's age roughly equals the life expectancy of its most massive stars still on the main sequence