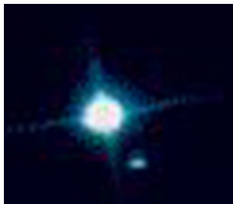
Discovery of White Dwarfs—12 Oct

- Outline
  - Example Hertzsprung-Russell diagrams
  - How are giants and main-sequence stars related?
  - Magnitude, apparent & absolute
  - Adams' discovery of first white dwarf



Sirius A & B
http://chandra.harvard.edu/photo/2000/0065/0065_optical.jpg

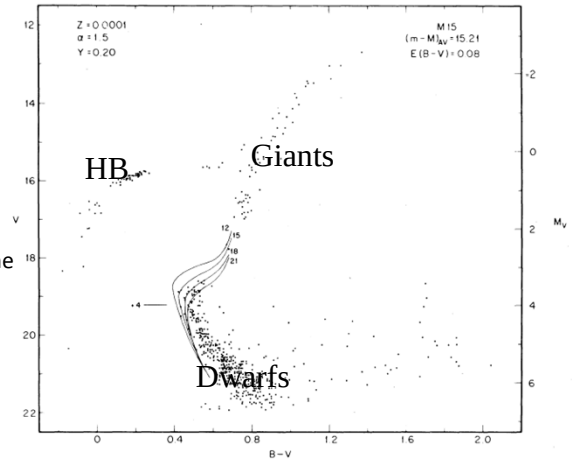
M15

- Globular cluster M15
  - All the stars were born at the same time.
  - Bright orange stars are giants.
  - Blue stars are dwarfs.

NASA: HST

H-R Diagram of a star cluster M15

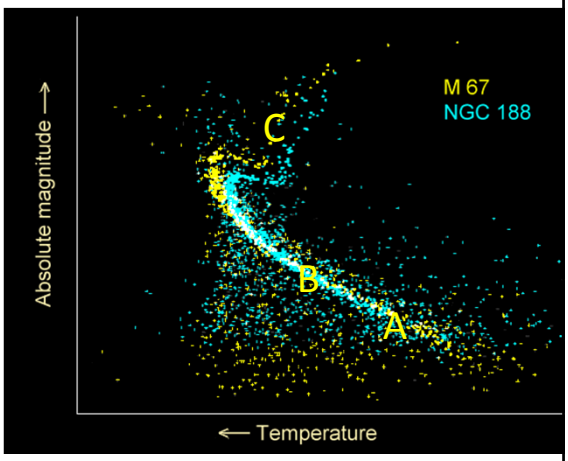
- Observations of a globular cluster M15 show
  - Main-sequence or dwarf stars
  - Giants
  - Horizontal-branch stars
  - White dwarfs are too faint for these observations.
- Giants are dying stars.
  - A star lives a long time as a dwarf. It is on the main sequence.
  - When it runs out of fuel, it becomes a giant and subsequently "traces out the giant branch."
  - At its brightest, a giant becomes 100 times as bright as it was as a dwarf.



H-R diagram of two star clusters

- What to ignore
- What is different about the two H-R diagrams?
- Where is the main sequence? Giants?
- Interpretation
  - Bluer stars live a shorter time.
  - As a star dies, it becomes a giant.
  - M67 is younger.

1. In M67, which star is in the process of dying?
2. In M67, which star has the longest lifetime?



http://en.wikipedia.org/wiki/Hertzsprung-Russell_diagram

Luminosity and flux

- Luminosity = amount of energy per second (Watt) produced by the star
  - $L=R^2T^4$
- Flux = energy per second received by a detector on earth (Watt/m^2)
  - $F=L/D^2$

1. As viewed from Earth, which is the faintest star?
   A. Sun
   B. Vega
   C. Sirius

Use flux

2. As viewed from a distance of 10 pc from each star, which is the faintest star?

Use luminosity

Star	Apparent mag	Flux		Absolute mag	Luminosity		Distance
		[W/m^2]	[f_{Vega}]		[W]	[L_{sun}]	[pc]
Sun	-26.7	1400	5.2×10^{10}	4.8	3.9×10^{26}	1	5×10^{-6}
Vega	0.0	2.7×10^{-8}	1	0.5	2.1×10^{28}	54	8
Sirius	-1.45	1.1×10^{-7}	3.9	1.4	9.0×10^{27}	23	2.7

Apparent & Absolute Magnitude

- Apparent mag is a logarithmetic expression of flux
- If the apparent mag changes by -2.5, the flux is brighter by a factor of 10.
  - If the apparent mag changes by +2.5, the flux is fainter by a factor of 10.

1. The apparent magnitude of a star is +2.5. Its flux is
   A. 2.7×10^{-6}W/m^2.
   B. 2.7×10^{-7}W/m^2.
   C. 2.7×10^{-8}W/m^2.
   D. 2.7×10^{-9}W/m^2.
   E. 2.7×10^{-10}W/m^2.
2. The apparent magnitude of a star is +5. Its flux is

Star	Apparent mag	Flux		Absolute mag	Luminosity		Distance
		[W/m^2]	[f_{Vega}]		[W]	[L_{sun}]	[pc]
Sun	-26.7	1400	5.2×10^{10}	4.8	3.9×10^{26}	1	5×10^{-6}
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Apparent & Absolute Magnitude

- Apparent mag is a logarithmetic expression of flux
- If the apparent mag changes by –2.5, the flux is brighter by a factor of 10.
- Fluxes and magnitudes of two stars A and B

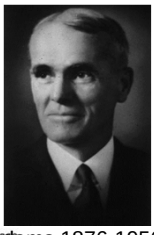
$$\frac{f_B}{f_A} = 10^{-(m_B - m_A)/2.5}$$

$$m_B - m_A = -2.5 \log_{10} \frac{f_B}{f_A}$$

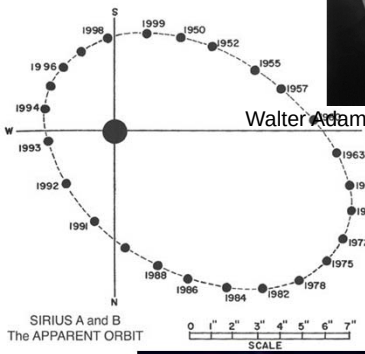
- Try it
  - If m_B is –2.5 more than m_A, $m_B - m_A = -2.5$, and $f_B/f_A = 10^{-(-2.5)/2.5} = 10^1 = 10$.
  - If B is brighter by a factor of 10, $f_B/f_A = 10$, and $m_B - m_A = -2.5 \log(10) = -2.5$.

Sirius A and Sirius B

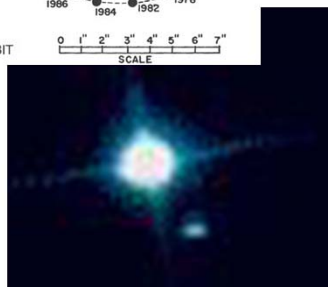
- We are Walter Adams of the Mt. Wilson Observatory in 1914. We are studying the double star Sirius A and B. (Sirius A & B orbit each other.)
- Sirius B is much fainter than Sirius A.



Walter Adams 1876-1956

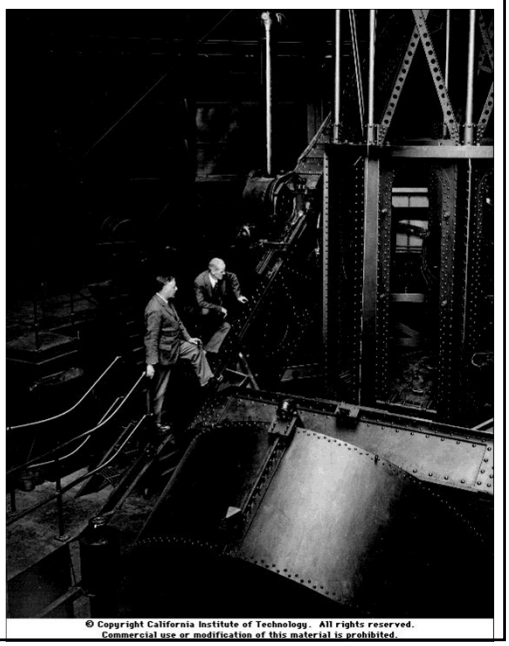


SIRIUS A and B
The APPARENT ORBIT



http://chandra.harvard.edu/photo/2000/0065/0065_optical.jpg

1. Sirius B may be faint for two reasons. It may be small or it may be
   A. farther away
   B. closer
   C. cooler
   D. hotter



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- Adams found that Sirius A and B have about the same color. Therefore Sirius B is smaller.