Hertzsprung-Russell Diagram—7 Oct

- Outline
  - Thermal radiation
    - Wien’s Law
    - Stefan-Boltzmann Law
  - Hertzsprung-Russell diagram
    - There are 3 types of stars: main-sequence or dwarfs, giants, white dwarfs
  - Missouri Club for Test 1

Infrared camera—Seeing with infrared eyes

- A perfect absorber (perfectly black) emits a characteristic spectrum of light. (Called thermal or black-body radiation.)
  - Intensity depends only on
    - Temperature
    - Area
- Thermal infrared
  - Wavelength is 8,000-12,000 nm
  - An object with a temperature of 300K emits most of its light in the thermal infrared.
  - Does infrared light show the same thing as visible light?

- Q Which is the hottest part of the man’s face?
  A. His hair.
  B. His forehead.
  C. His eyeglasses.
  D. His moustache.

Thermal Radiation

- Spectrum (intensity vs. wavelength) of thermal radiation.
  - Hotter objects are brighter at all wavelengths.
- Wien's Law

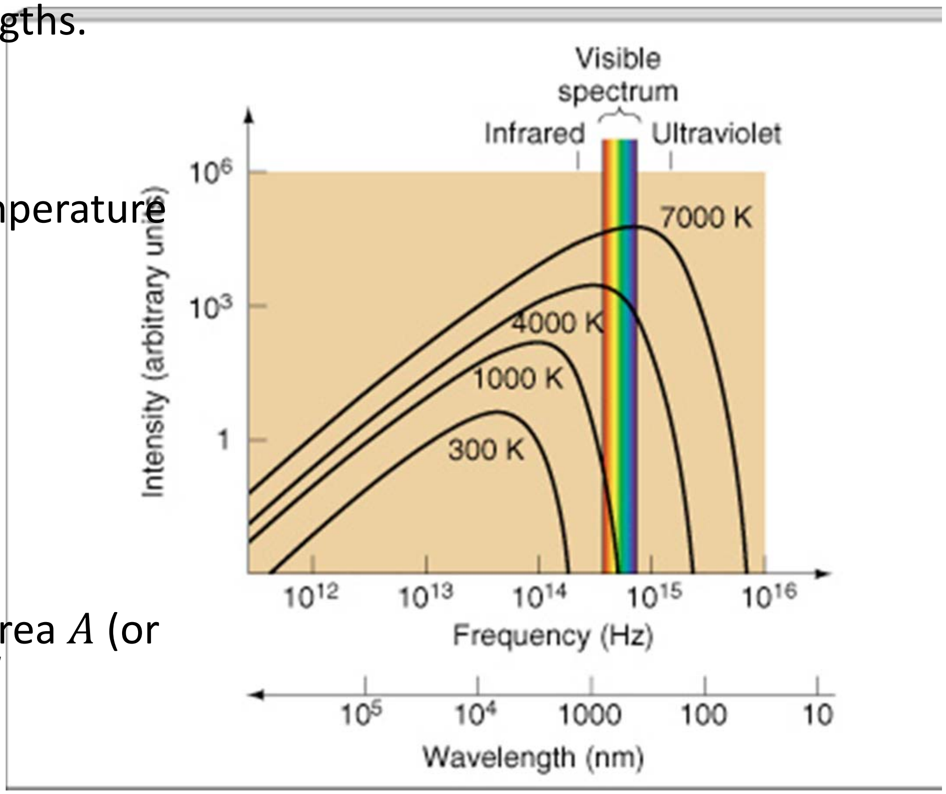
$$\lambda_{\text{peak}} T = 2.9\text{mm K}$$

  - Wavelength changes inversely with temperature
    - For the sun, T=5700K.

$$\lambda_{\text{peak}} = \frac{2.9\text{mm K}}{5700\text{K}} = 0.0005\text{mm} = 500\text{nm}$$

    - For a person, T=273+37=310K.

$$\lambda_{\text{peak}} = \frac{2.9\text{mm K}}{310\text{K}} = 0.01\text{mm} = 10\mu\text{m}$$

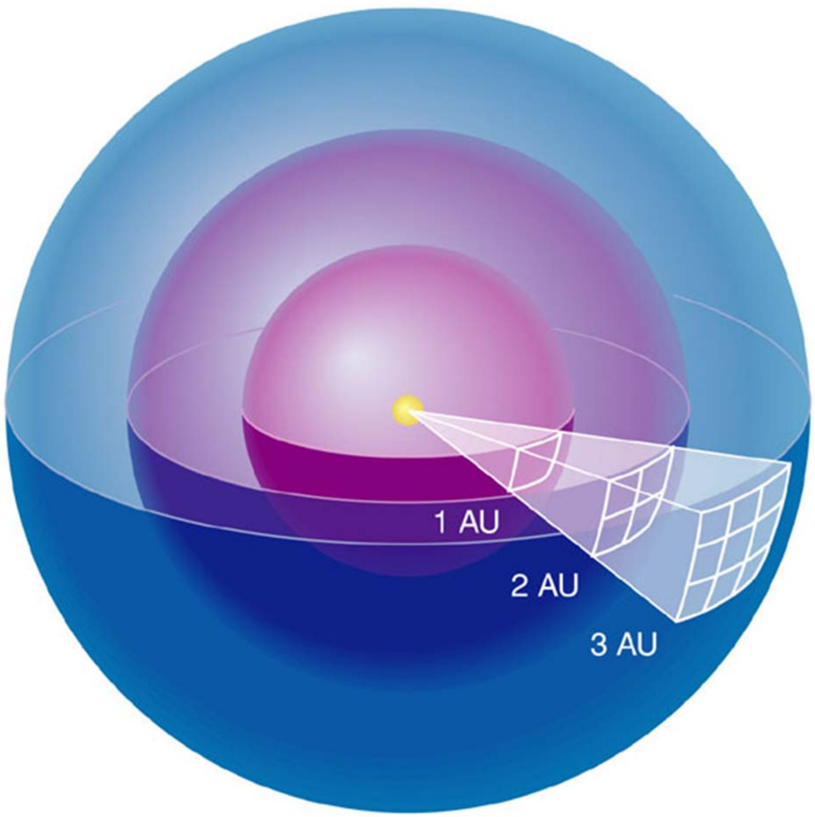


- Stefan-Boltzmann Law
  - Energy emitted per second depends on area A (or radius R for a sphere) and temperature T

$$L = AT^4$$
$$L = R^2T^4$$

Luminosity & Flux (apparent brightness) of Stars

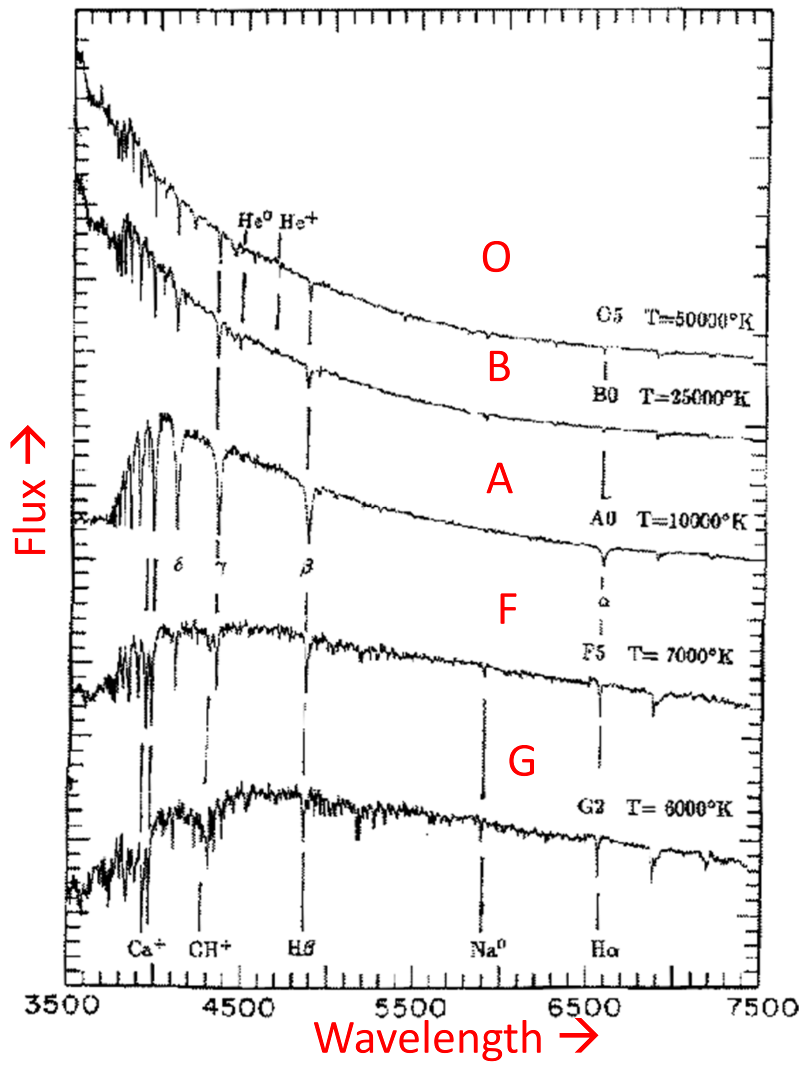
- Luminosity is amount of energy per second (Watt) produced by the star.
  - Intrinsic to the star.
  - With constants suppressed,
    $$L = R^2 T^4$$
- Flux is energy per second received by a detector on earth (Watt/m^2).
  - Depends on distance of star
    $$F = L/D^2$$
  - At greater distances from star, light is spread over larger area. Flux is lower.

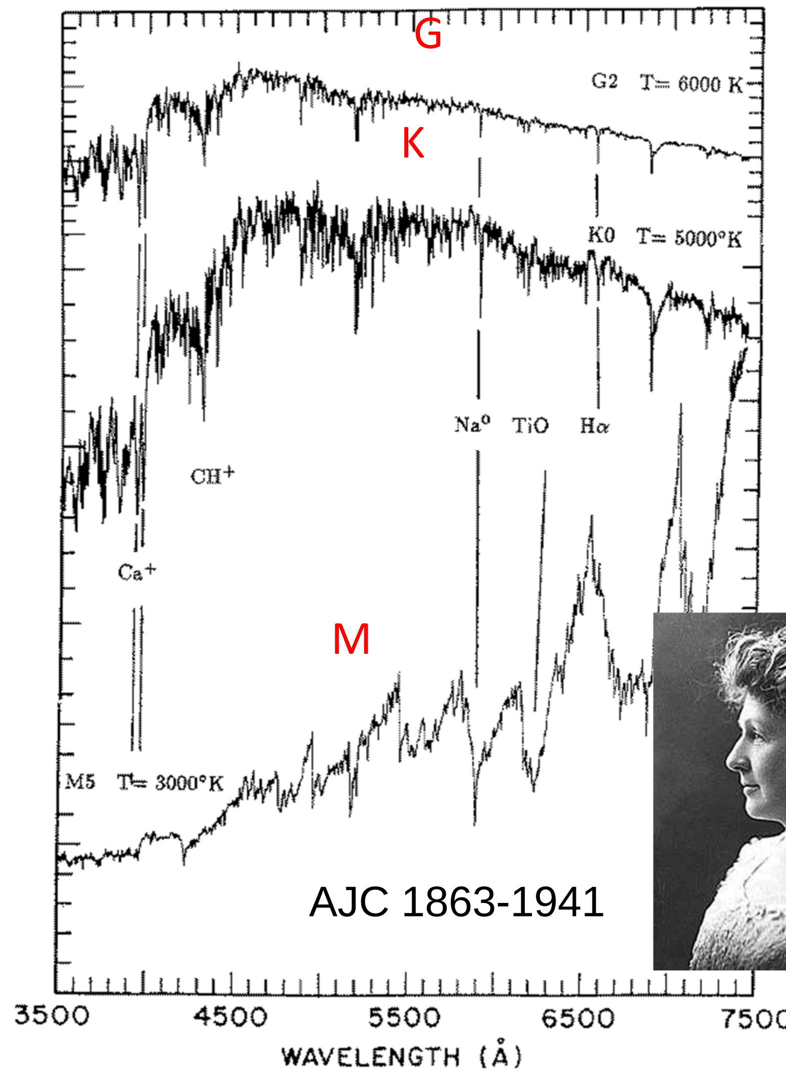


- The color of my cat is a property of my cat. It does not change with distance. I see the same color whether my cat is 1’ or 10’ from me.

1. S1: The flux of a star does not change with distance.
   S2: The luminosity does not change with distance.
   A. TT
   B. TF
   C. FT
   D. FF
2. __ is the quantity that I measure directly.
   A. Flux
   B. Luminosity

Annie Jump Cannon: Classify stars by spectra






AJC 1863-1941

- Classification is very efficient: Draper catalog has 250,000 stars.
- Spectral class was later found to be related to temperature.

  O be a fine girl kiss me.

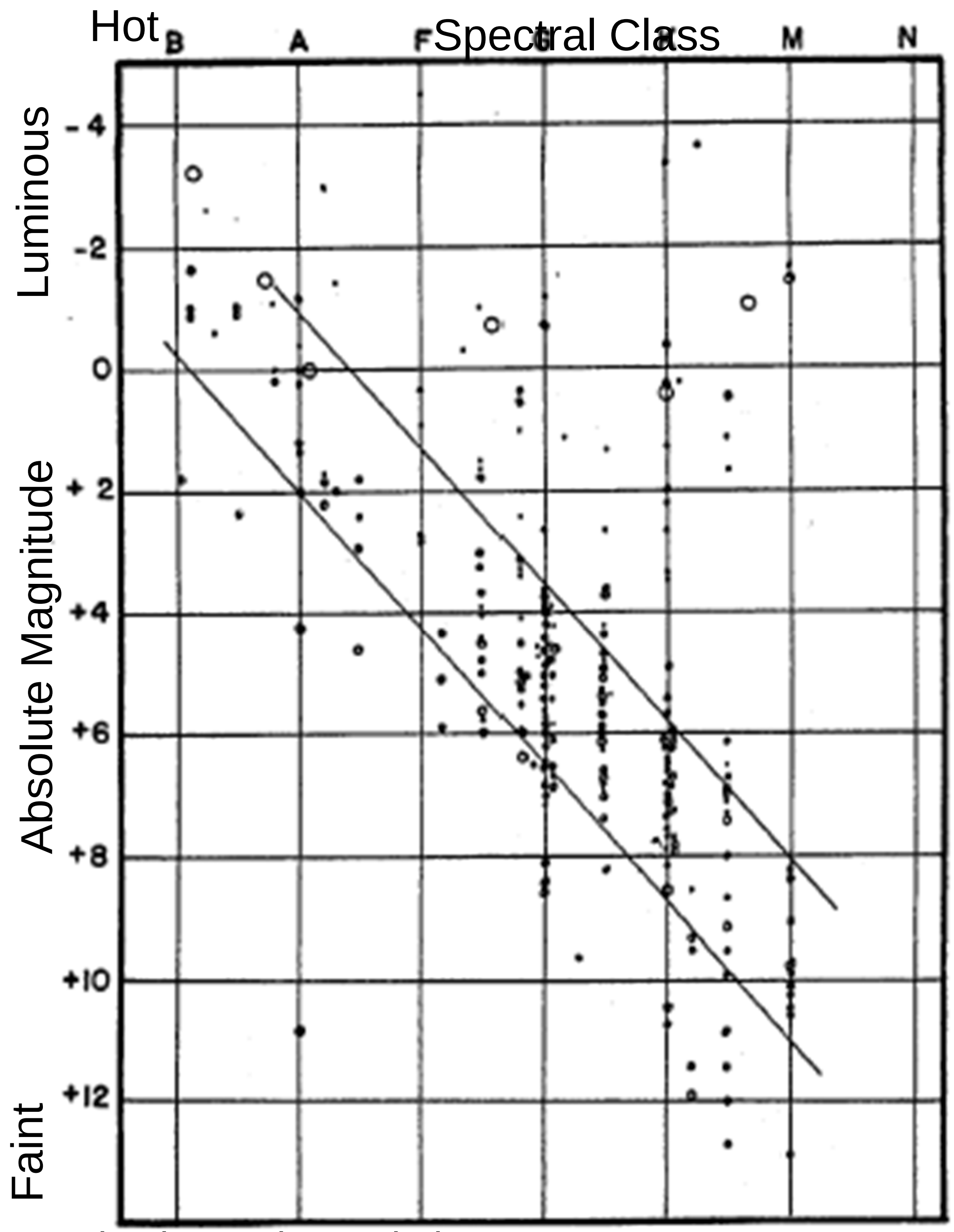
- Prof. Pickering's Team in 1913, from Barbara L. Welther, 1982, Isis 73, 94.
- AJC
  - BA, Wellesley, 1884
  - Pickering's assistant, 1896
  - Henry Draper catalog of stars, 1918-1924
  - Astronomer 1938

Hertzsprung-Russell diagram

- H-R Diagram is plot of temperature & luminosity
  - Hotter stars are on left.
  - More luminous stars are on the top.
  - Stars exist only with certain combinations of luminosity and temperature.

Ejnar Hertzsprung
1873-1967 (Danish)

Arthur Stanley Eddington
1882-1944 (English)

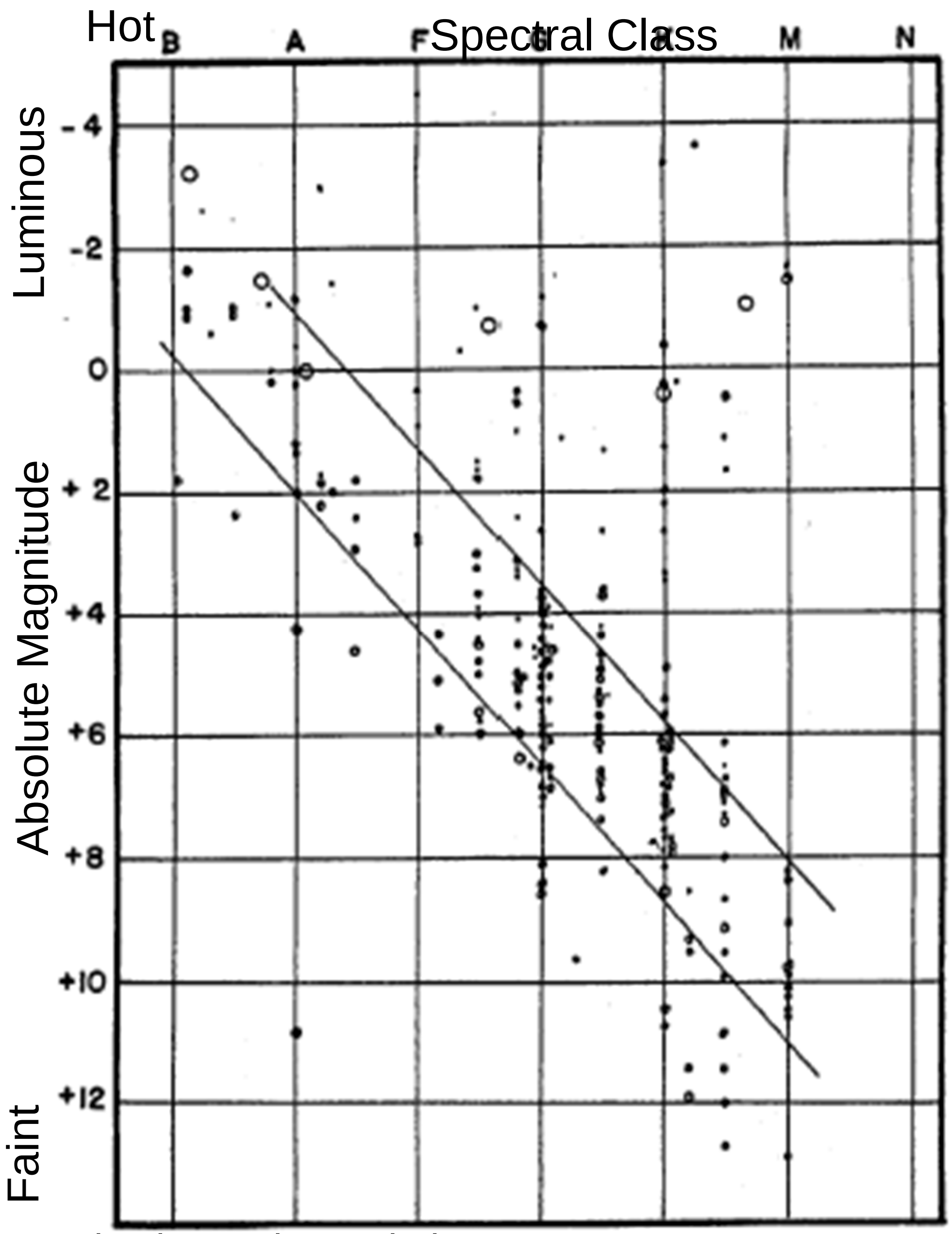


Astrophysics and twentieth-century astronomy to 1950, O Gingerich, ed., Cambridge, 1984

Hertzsprung-Russell diagram

- H-R Diagram is plot of temperature & luminosity.
- Stefan-Boltzmann Law: $L = AT^4$

1. A star is moved 10 times farther away. In the H-R diagram, it moves
   A. up
   B. down
   C. left
   D. right
   E. not at all



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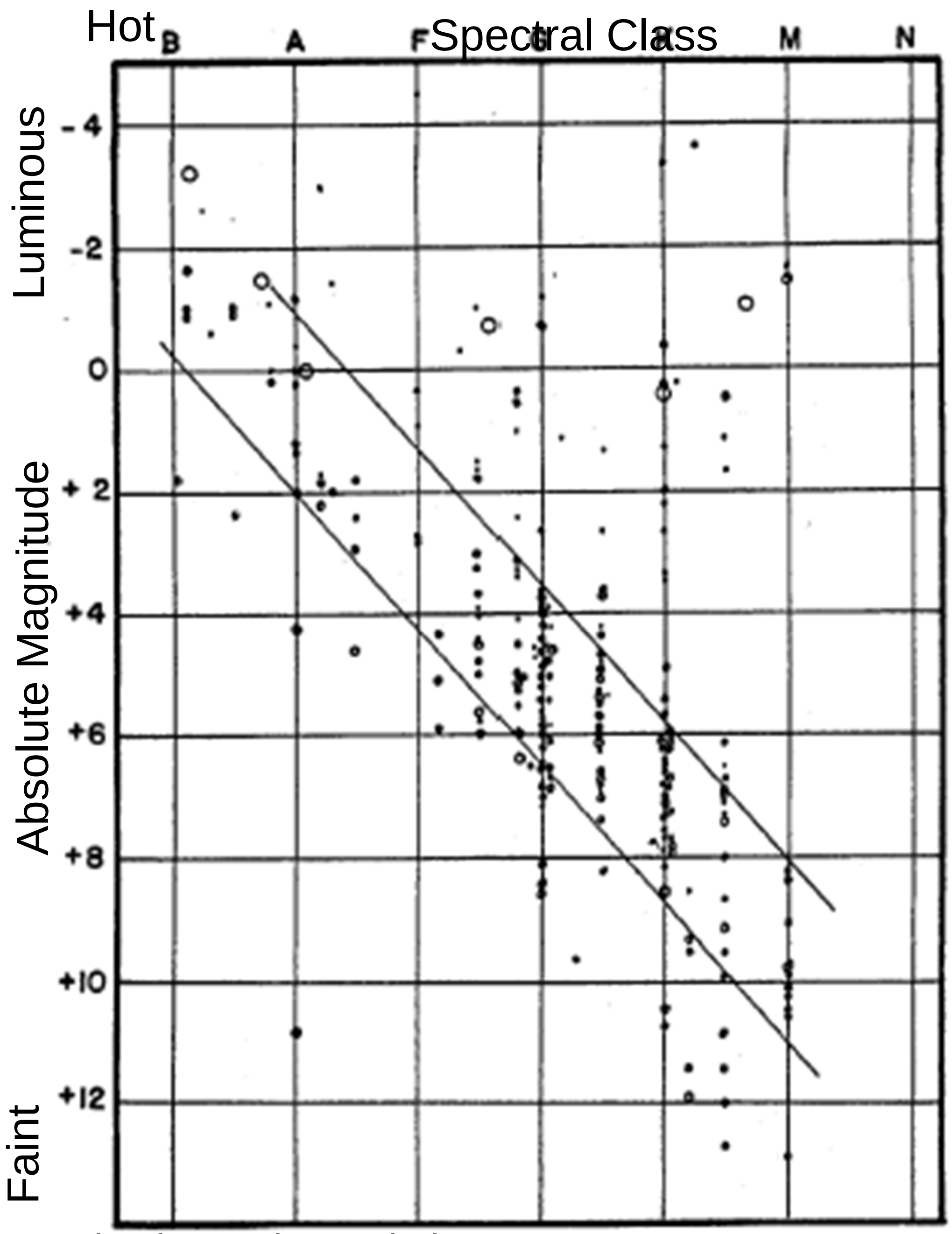
Hertzsprung-Russell diagram

- H-R Diagram is plot of temperature & luminosity
- Stefan-Boltzmann Law: $L = AT^4$

1. A star is gets hotter and its size does not change. In the H-R diagram, it moves
   A. up & left
   B. up & right
   C. up-down
   D. left-right
   E. not at all



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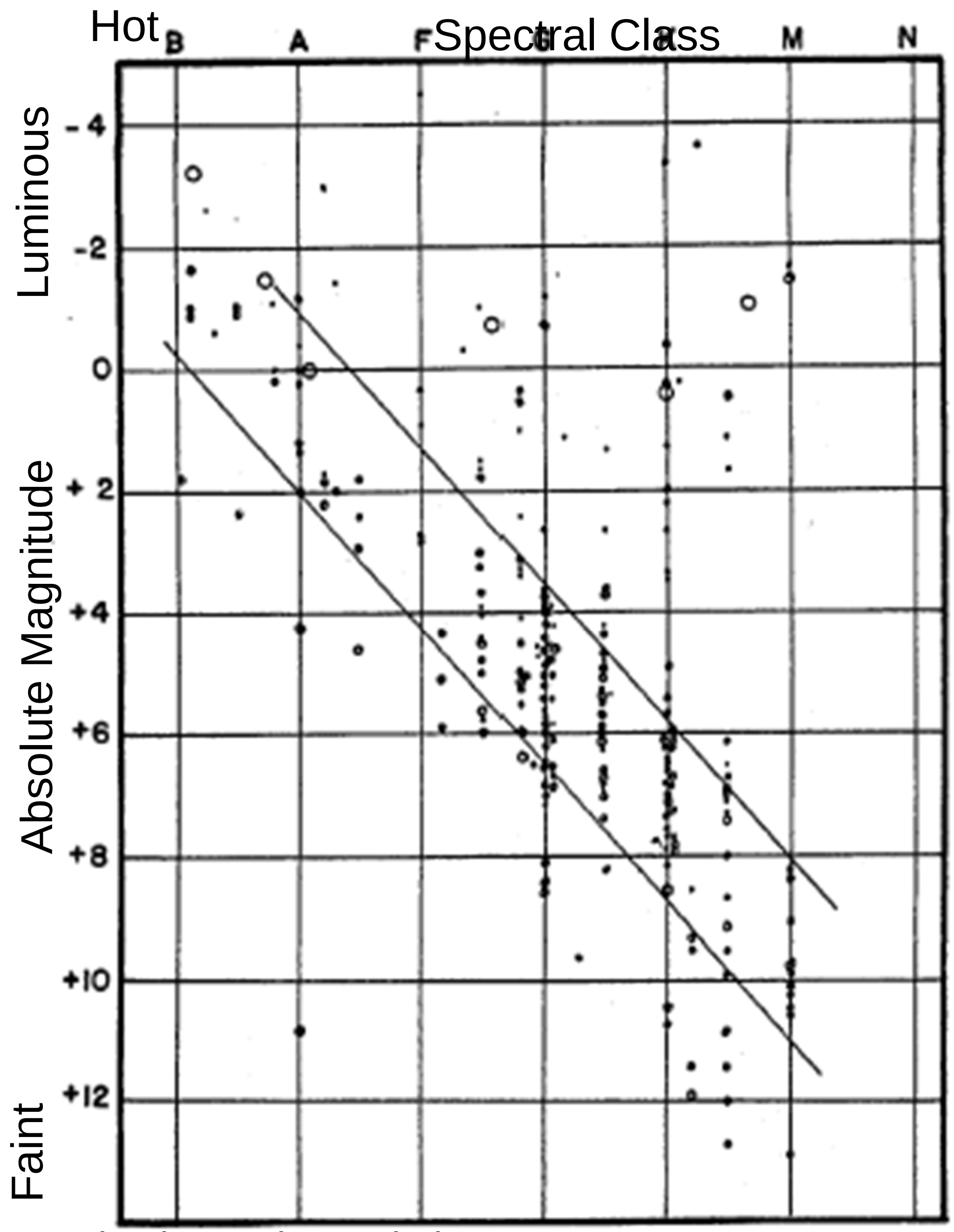
Hertzsprung-Russell diagram

- H-R Diagram is plot of temperature & luminosity
- Stefan-Boltzmann Law: $L = AT^4$

1. Can two stars of the same spectral class have different luminosities?
   A. No. No such cases exist on the H-R diagram.
   B. Yes, temperatures differ
   C. Yes, sizes differ
   D. Yes, both size & temperatures differ.



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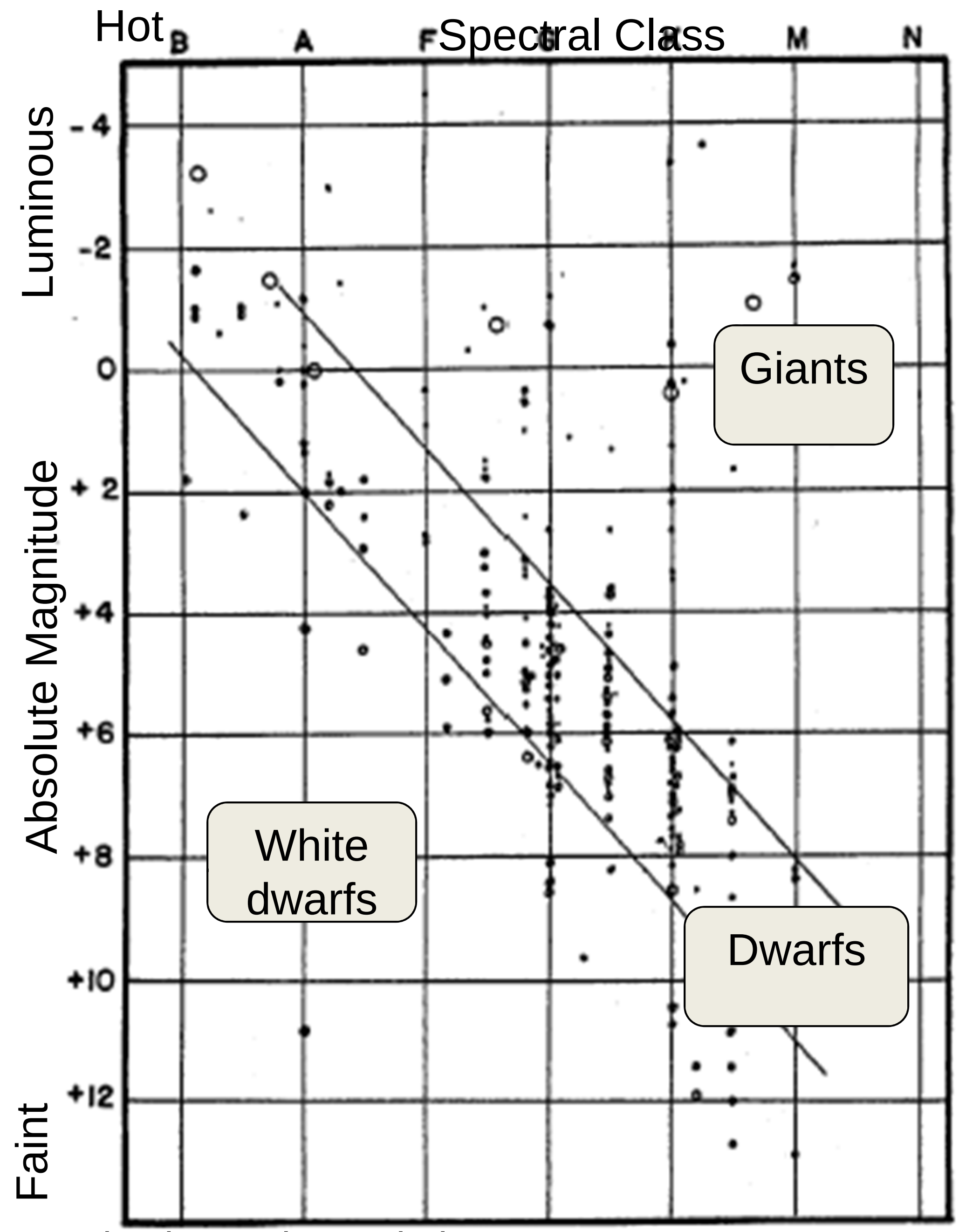
Hertzsprung-Russell diagram

- H-R Diagram is plot of temperature & luminosity
- Stefan-Boltzmann Law: $L = AT^4$
- H-R diagram reveals stars cannot have any combination of size and temperature. There are three types of stars.
  - Dwarfs have differing temperatures and approximately the same size. Dwarfs are most common.
  - Giants are large.
  - White dwarfs are small.



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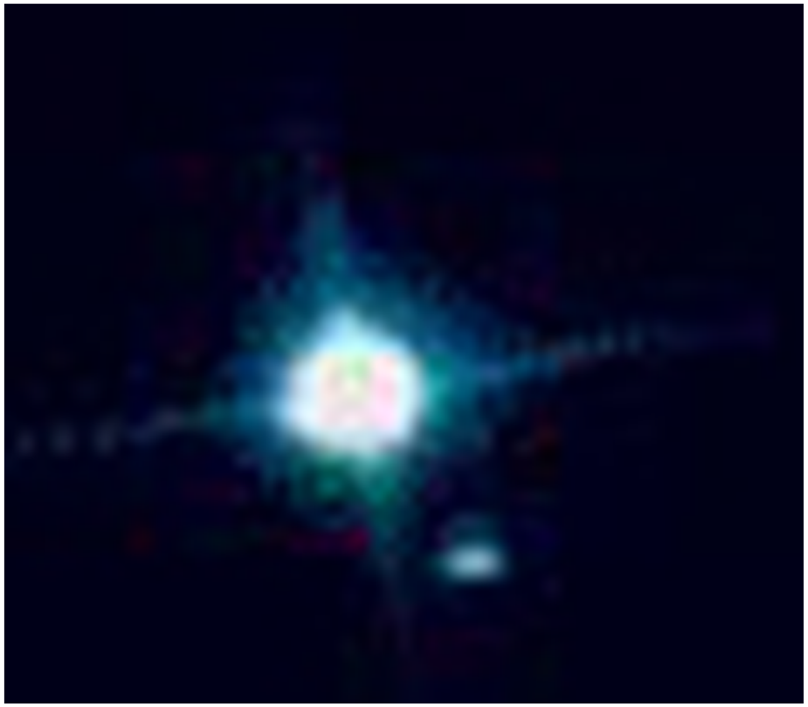
Discovery of White Dwarfs—8 Oct

- Homework 4 is due on Mon.
- Hertzsprung-Russell diagrams
- Magnitude, apparent & absolute
- Adams’ discovery



Sirius A & B

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