Model of Stars—5 Oct

- Hot-plate model of a star
- Thermal radiation
- Hertzsprung-Russell diagram

- Homework 4
  - Due Mon, Oct 12
  - Missouri Club on Fri.

The Hot-plate Model of a Star

- The surface of a star is made of tiles of hot plates.
- How does the energy from the hot-plate get to my hand?
  - Key observation: I can hold my hand much closer to the hot plate when it faces to the side, rather than up.

http://www.acemart.com/graphics/00000001/products/WELLh70_01.jpg

The Hot-plate Model of a Star

- How does the energy from the hot-plate get to my hand?
  - Key observation: I can hold my hand much closer to the hot plate when it faces to the side, rather than up.
- Energy moves from the hot plate to my hand by
  - movement of hot air
  - by radiation (mostly infrared light)

1. How does energy move from the sun to the earth?
   A. By radiation only
   B. By movement of hot air only
   C. Both A & B

http://www.acemart.com/graphics/00000001/products/WELLh70_01.jpg

The Hot-plate Model of a Star

- The surface of a star is made of tiles of hot plates.

1. How does energy move from the sun to the earth?
   A. By radiation only
   B. By movement of hot air only
   C. Both A & B

- Energy leaves stars primarily by radiation.
  - For the sun, the radiation is mostly ultraviolet light, visible light and infrared light.

http://www.acemart.com/graphics/00000001/products/WELLh70_01.jpg

The Hot-plate Model of a Star

- The surface of a star is made of tiles of hot plates.
- We concentrate on the radiation produced by the hot plate.

1. What is a way to make hot plates produce more energy per second? (The same question applies to a star: What are two ways to make a star brighter or more luminous?)
   - A. Make the plates hotter.
   - B. Make the plates bigger.
   - C. <u>Make plates hotter & bigger.</u>
   - D. None of the above answers.

- The luminosity of a star (the energy produced every second) depends on temperature and size.

http://www.acemart.com/graphics/00000001/products/WELLh70_01.jpg

The Hot-plate Model of a Star

- The surface of a star is made of tiles of hot plates.
- The luminosity of a star (the energy produced every second) depends on temperature and size.

1. What can I do to make the same hot-plate at the same setting burn my hand and not burn my hand? (Without modifying the sun, what can I do to make the sun brighter or fainter?)
   - A. <u>Move my hand closer or farther.</u>
   - B. It is not possible.

- The flux of a star (the energy received at the earth every second) depends on temperature, size, and <u>distance</u> to the star.

http://www.acemart.com/graphics/00000001/products/WELLh70_01.jpg

Thermal radiation (Blackbody Radiation)

- Any object that absorbs light also emits light.
- Do people emit light?
  - People emit light in the "thermal infrared" part of the spectrum.
  - Your eyes cannot see infrared radiation. $8000 < \lambda < 12000$nm
  - You can see visible light
    - Blue 440nm
    - Green 550nm
    - Red 620nm
- A perfect absorber (perfectly black) emits a characteristic spectrum of light. (Called thermal or black-body radiation.)
  - Intensity depends only on
    - Temperature
    - Area
- A non-perfect absorber (grey body) with emissivity ε absorbs a fraction ε and reflects a fraction $(1-\varepsilon)$.
  - Intensity is ε that of thermal radiation.

Picture taken with an infrared camera
ornitorinko.org:8080/.../portrait-bits.jpg

Infrared camera—Seeing with infrared eyes

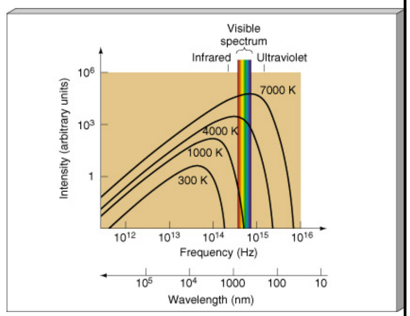
- A perfect absorber (perfectly black) emits a characteristic spectrum of light. (Called thermal or black-body radiation.)
  - Intensity depends only on
    - Temperature
    - Area
- A non-perfect absorber (grey body) with emissivity ε absorbs a fraction ε and reflects a fraction $(1-\varepsilon)$.
  - Intensity is ε that of thermal radiation.
- 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. <u>His forehead.</u>
  C. His eyeglasses.
  D. His moustache.

Model of a Star: Thermal Radiation

- Wien's Law

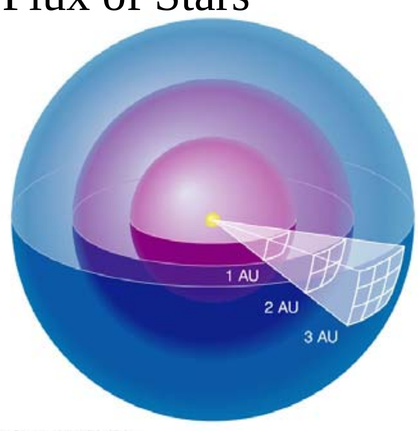
  λ_{peak} T = 2.9mm K
  - Brighter for hotter objects
  - Wavelength changes with temperature
    - For the sun, T=5700K.
      - λpeak =2.9mm/5700K=.0005mm=500nm
    - For a person, T=273+37=310K.
      - λpeak =2.9mm/310K=.01mm (infrared)



- Stefan-Boltzmann Law
  - Energy emitted per second depends on Area×T^4.

Luminosity & Flux of Stars

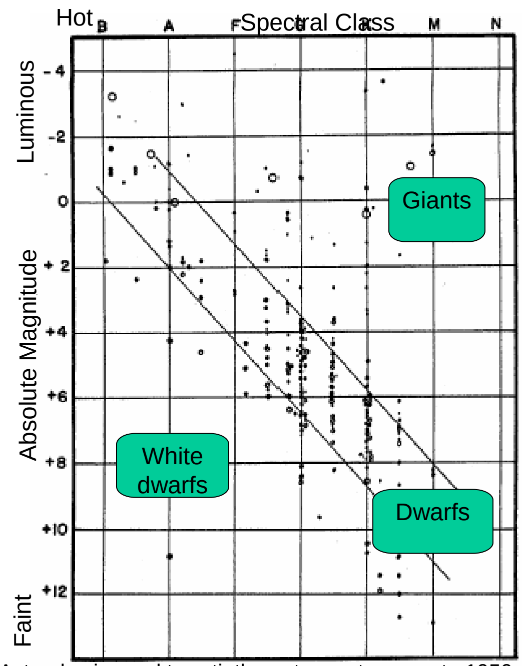
- Luminosity = amount of energy per second (Watt) produced by the star
  - $L=R^2T^4$
- Flux = energy per second received by a detector on earth (Watt/m^2)
  - $F=L/D^2$
- At greater distances from star, light is spread over larger area. Flux is lower.



Hertzsprung-Russell diagram

- HR Diagram is plot of temperature & luminosity
  - Spectral Class is related to temperature
    - OBeAFineGirlKissMe.
  - Hottest stars on left
  - Most luminous stars are on the top.
- S-B Law: $L=AT^4$.

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

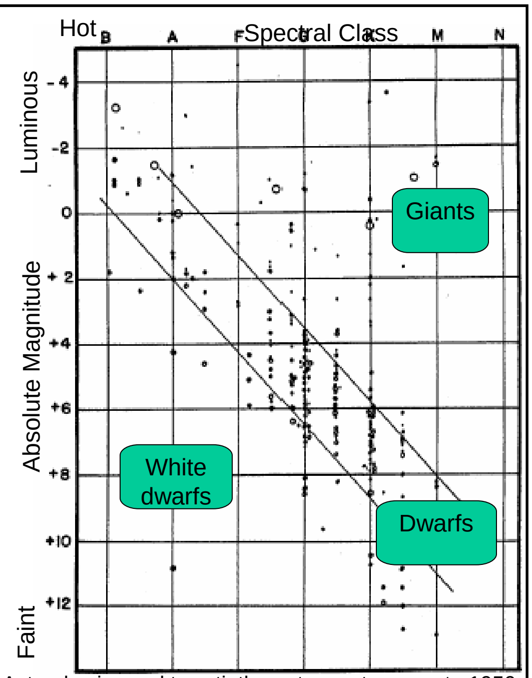


Astrophysics and twentieth-century astronomy to 1950, O Gingerich, ed., Cambridge, 1984

Hertzsprung-Russell diagram

- HR Diagram is plot of temperature & luminosity
  - Spectral Class is related to temperature
    - OBeAFineGirlKissMe.
  - Hottest stars on left
  - Most luminous stars are on the top.
- S-B Law: $L=AT^4$.

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

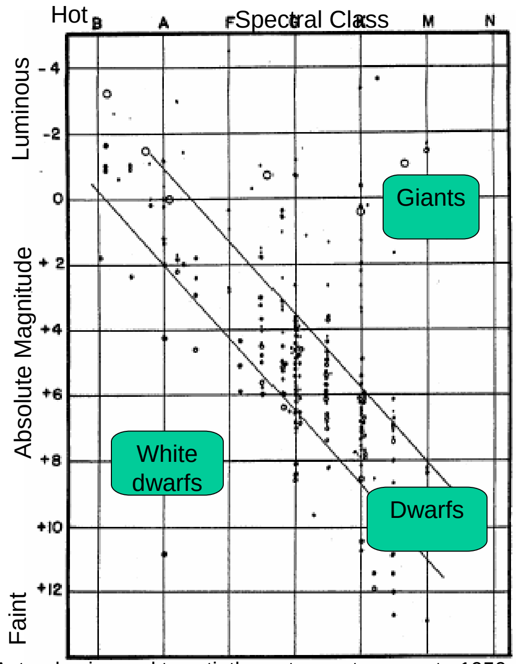


Astrophysics and twentieth-century astronomy to 1950, O Gingerich, ed., Cambridge, 1984

Hertzsprung-Russell diagram

- HR Diagram is plot of temperature & luminosity
  - Spectral Class is related to temperature
    - OBeAFineGirlKissMe.
  - Hottest stars on left
  - Most luminous stars are on the top.
- S-B Law: L=AT^4.

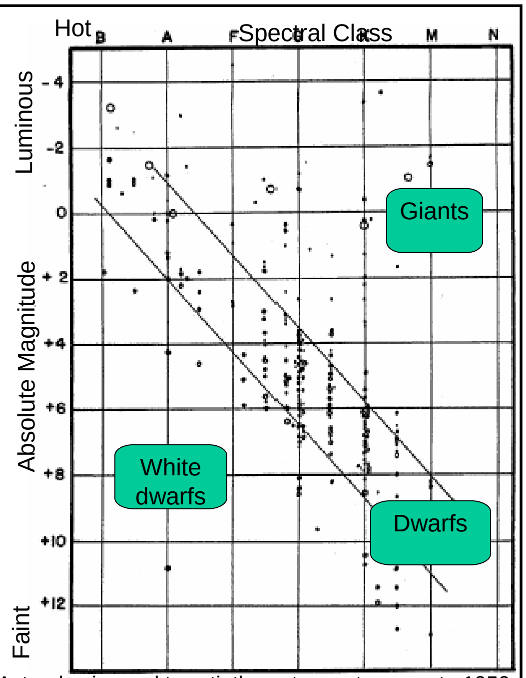
1. Can two stars of the same spectral class have different luminosities?
   A. No. No such cases exist on the H-R diagram.
   B. Yes, temperatures differ
   C. <u>Yes, sizes differ</u>
   D. Yes, both size & temperatures differ.



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

Hertzsprung-Russell diagram

- HR Diagram is plot of temperature & luminosity
  - Spectral Class is related to temperature
    - OBeAFineGirlKissMe.
  - Hottest stars on left
  - Most luminous stars are on the top.
- S-B Law: L=AT^4.
- H-R diagram reveals stars are hot-plates.
  - Dwarfs have differing temperatures and approximately the same size.
  - Giants are large.
  - White dwarfs are small.



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