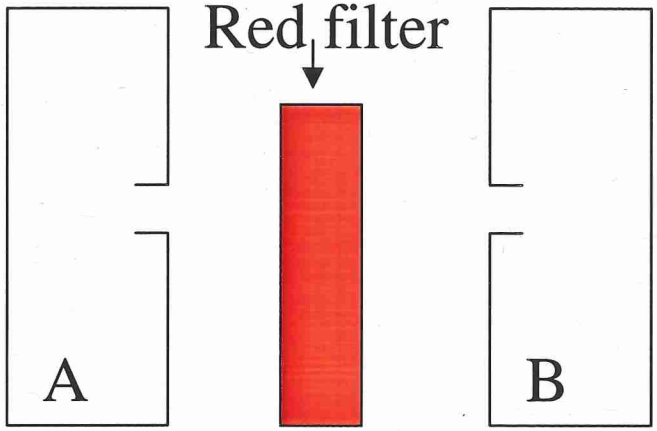
Black Body Radiation

- A BB absorbs all em radiation incident upon it (no reflections) and emits em spectrum dependent only on TEMPERATURE
- STEFAN-BOLTZMANN LAW
  Hotter BB emits more radiation at ALL wavelengths than a cooler BB of SAME AREA

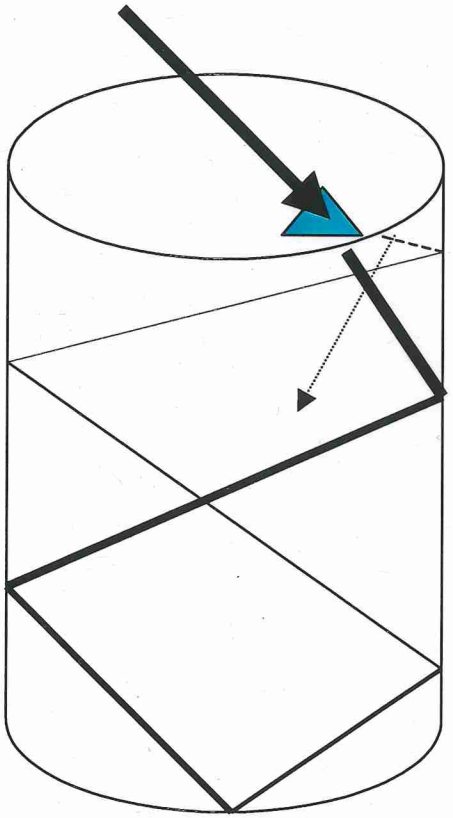
- WIEN'S LAW
  Hotter BB emits greater fraction of radiation at SHORTER WAVELENGTHS than cooler BB.
- PLANCK'S LAW
  Mathematical formula incorporating STEFAN-BOLTZMANN and WIEN's Laws.

A simple proof that BB spectrum depends only on temperature



- A and B are at the same temperature
- Suppose A emits more red light than B, then B will gain radiation (energy) and heat up. BUT ENERGY CANNOT FLOW IN ONE DIRECTION BETWEEN TWO OBJECTS AT SAME TEMPERATURE.
- Therefore, spectrum of A and B must be identical and dependent only on temperature.

Simple example of a black body



An empty can of your favorite beverage

- All incident light is eventually absorbed.
- Heating/cooling coils around can may be used to adjust temperature.
- Spectrum of light EMITTED through opening depends only on T.

BB LAWS AND STARS

- Stars are fair approximations to BBs.
- Luminosity is proportional to

SURFACE AREA X TEMPERATURE^4

$$L \propto R^2 T^4$$

$$\frac{L}{L_O} = \left(\frac{R}{R_O}\right)^2 \left(\frac{T}{T_O}\right)^4$$

- STELLAR COLORS may serve as a THERMOMETER thanks to WIEN'S LAW

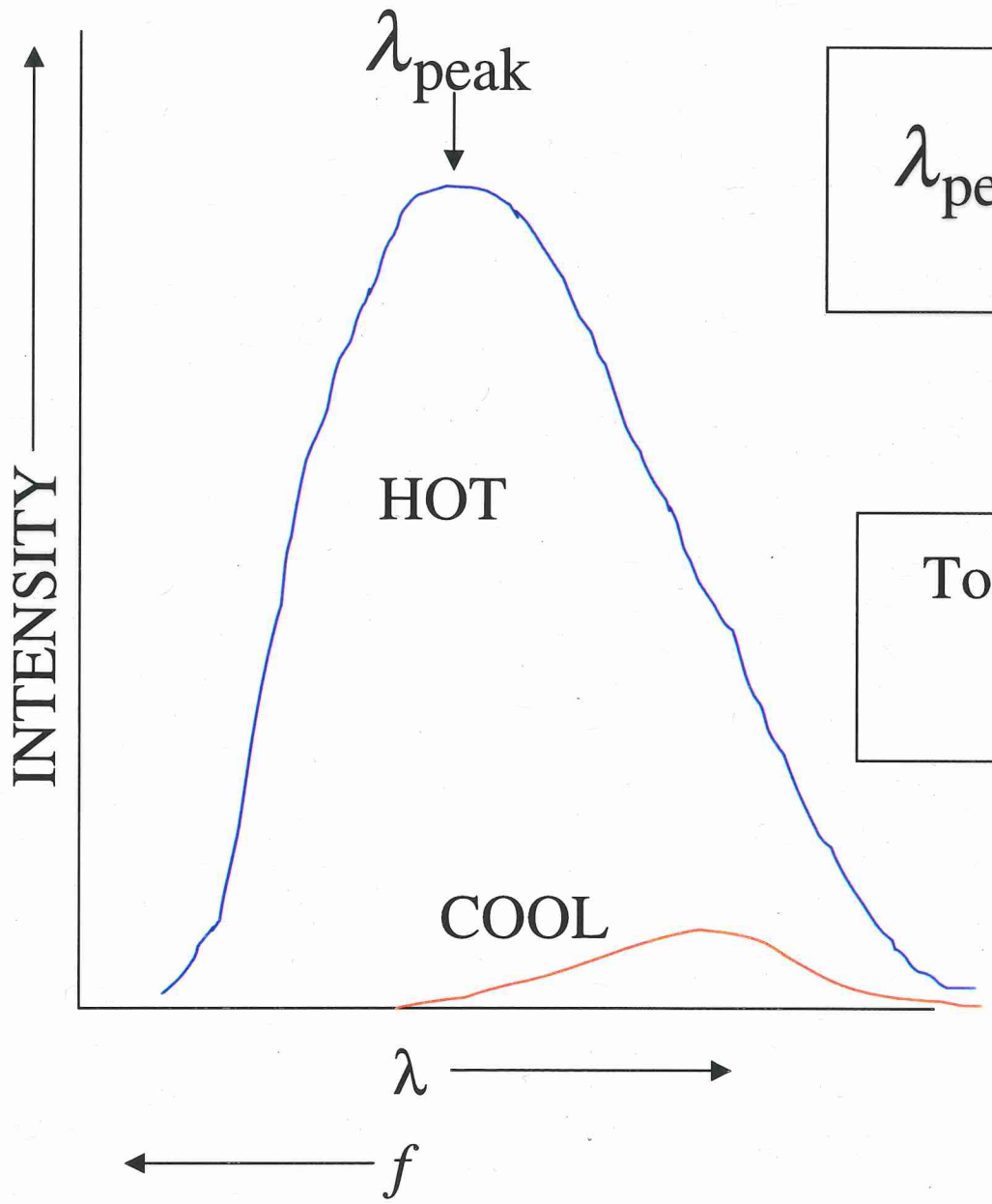
Hot stars → Blue [uv, x-ray]

Cool stars → Red

Very cool stars → Very red

BUT

Color may be altered ('reddened') by scattering of starlight by small dust grains



$$\lambda_{peak} \propto \frac{1}{T}$$

Total radiation emitted

$$L \propto T^4$$

A star has a surface temperature of 12,000 K and emits as much energy as the Sun (T = 6000 K).

Is the star smaller or larger than the Sun?

By how many times?

Two stars of equal size have T = 3,000 K and 12,000 K.

Which radiates more energy?

How many times more?

What color will each appear?

Which radiates more energy in the red part of the spectrum?

If a star is five times hotter than the Sun, how much more energy per second will it radiate from each square meter of its surface?

At what wavelength will it radiate the most energy?

The binary star UT-999 consists of a blue and a red star emitting the same total amount of energy.

Which star has the larger radius?