The equation: $$B = \frac{L}{4\pi\, d^2}$$

describes the observed brightness of an object, given its luminosity and the distance d to that object.

Explain why the brightness of an object is proportional to one over the square of the distance to the object.

Because luminosity is a property of the star it will not change because of distance; therefore, it is just like a constant- as is 4pi- and are relatively unrelated to distance. The brightness is proportional to 1/(distance squared). As the distance increases brightness decreases. Distance is the only variable that is changing in the equation.

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Explain why the brightness of an object is proportional to one over the square of the distance to the object.

Brightness is measured by the amount of energy a star collects each second and the rate at which a telescope with an area of 1m^2 collects energy. The brightness of the object is proportional to 1/d^2 because the amount of light seen by a telescope goes down as the distance from the source goes up.

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Explain why the brightness of an object is proportional to one over the square of the distance to the object.

The brightness of an object is proportional to 1/d^2 because 4πd^2 is area that light is spread over a distance d away from the source and brightness is the amount of light seen in a telescope.

...we consider the photons as emanating from the center of the object in an ever-widening sphere. So, what we are calculating is the number of photons in the tiny portion of the sphere's surface area which we intercept. This imaginary sphere has radius d, which is why brightness is proportional to 1/d^2.

Consider two stars, Star A and Star B. Both stars have the same observed brightness.

Star A has a temperature (observed from its color) that is *twice* that of Star B.

The distance to Star A is *four times* the distance to Star B.

What, if anything, can you say about the *radius* of the two stars? If you can't say anything, what additional information would you need to be able to say anything about the radii of the two stars?

Eyes on the Prize

How old is the Universe?
How do we know?

- Age of the Solar system: 4.6 billion years
  - Radiometric dating of the oldest meteorites
    - (Potassium-40 ½-life: 1.26 Gyr)
- Can we learn anything about the ages of stars?
  - The Sun must be 4.6 billion years old
    - If powered by fusion, that gives the right age!
    - Other observations (e.g. Neutrinos) support fusion
- What can we learn about ages of other stars?
  - Everything is from *light* seen from those stars....

- Observing the light from other stars
  - Electromagnetic spectrum
    - Redder = longer wavelength, lower frequency
    - Bluer = shorter wavelength, higher frequency
    - Radio – Infrared – Optical – Ultraviolet – X-rays – γ Rays
  - Doppler Shift : how fast is the source moving?
    - Approaching = Blueshift
    - Receding = Redshift
    - Wavelength change of 1% :
      - $v = 0.01c = 3\times10^6$ m/s = 6,700,000 mph
  - Blackbody radiation : high-density "thermal" sources
    - Hotter = bluer, cooler = redder
    - Hotter = more luminous at all wavelengths
      - ...for objects of the same size!
  - Luminosity (intrinsic) vs. Brightness (Observed)

Quantities we might measure / calculate:

- Brightness B : directly observed (sometimes called "Flux")
- Color : ratio of brightness at different wavelengths
- Distance d : hard to measure, can be done
- Luminosity L : calculate from B and d
- Temperature T : determine from color
- Radius R : calculate from L and T

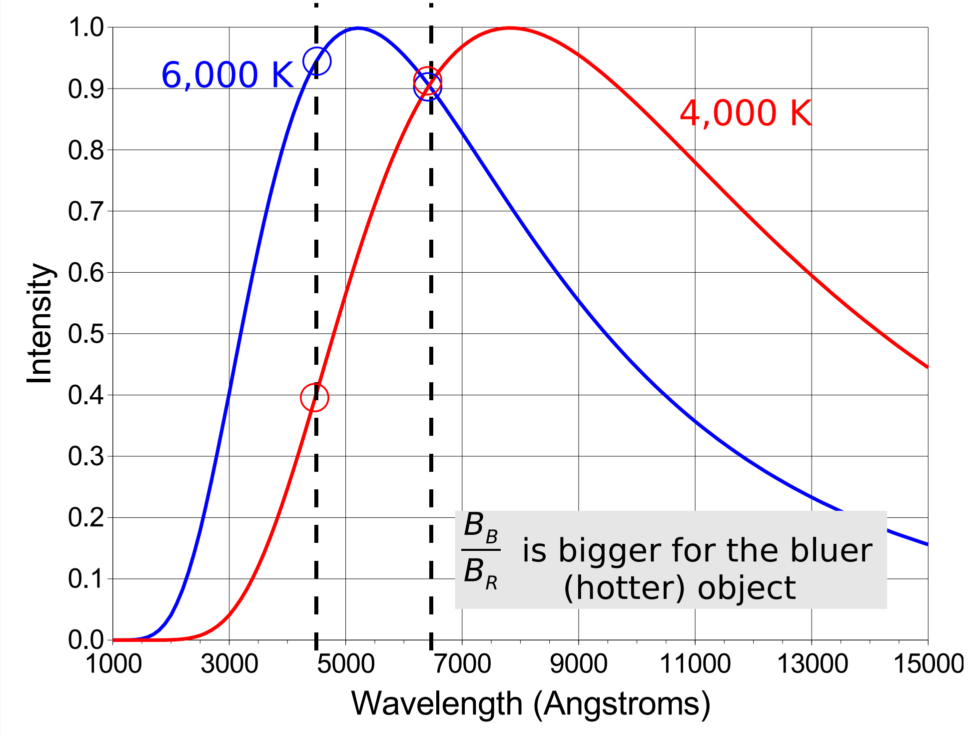
$$L = (4\pi R^2)\,\sigma\, T^4 \qquad B = \frac{L}{4\pi d^2}$$

Measure color by measuring
brightness through different *filters*

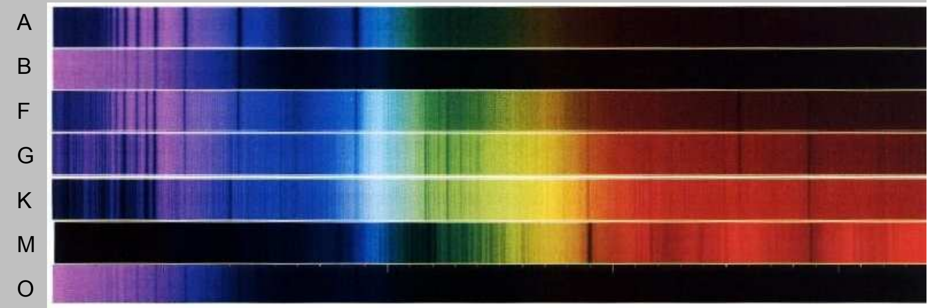
B_B : blue filter brightness

B_V : "visual" (yellow-green) filter brightness

B_R : red filter brightness

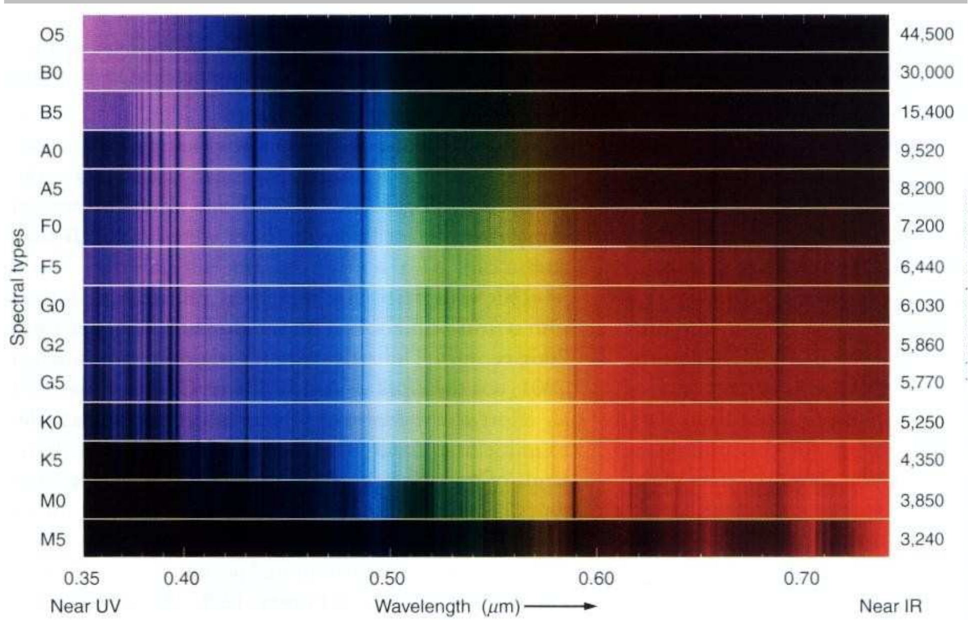


Stars are classified by their *absorption lines* – which lines appear and how strong they are. Classification is indicated with a letter.



Which type of star has the *lowest* (coolest) temperature?

A Stars of type A.
B Stars of type B or O.
C Stars of type F.
D Stars of type G.
E Stars of type M.



O B A F G K M

Hotter, Bluer ← → Cooler, Redder

O, B: Very hot, blue stars

A, F: “White” stars (Vega)

G: Sun-like “Yellow” Stars (Sun = G2

K: Orange stars

M: Cool red stars

O B A F G K M

Oh Be a Fine Girl, Kiss Me

Only Boys Accepting Feminism Get Kissed Meaningfully

Officially, Bill Always Felt Guilty Kissing Monica

Over-Budget Answer for Grads: Kraft Macaroni