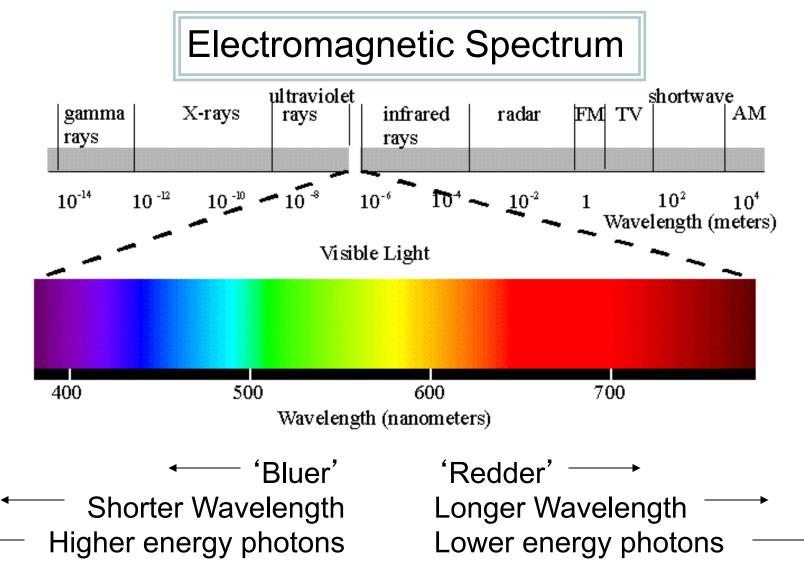
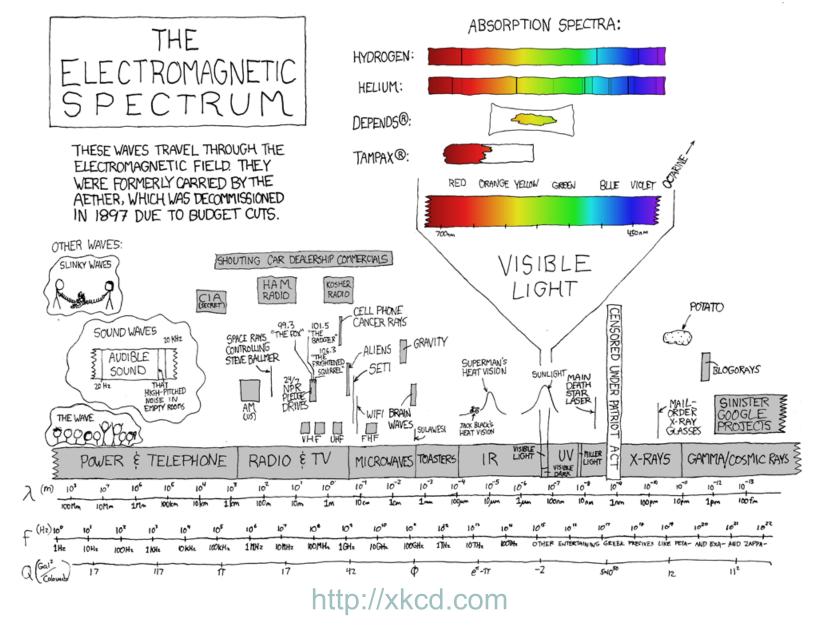
## Solar Heating & Energy Transport



## Solar Heating & Energy Transport



### Planck's Law for Black Body Radiation

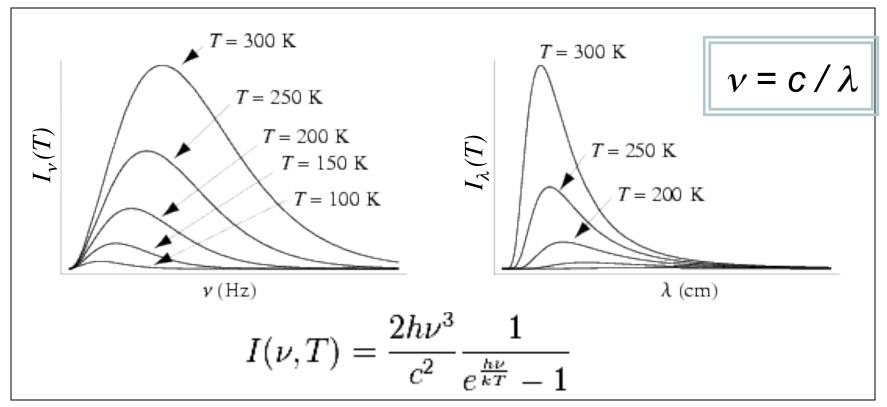


Figure modified from Eric W. Weisstein

Specific Brightness:

$$B_{\nu}(T) = \frac{2h\nu^{3}}{c^{2}} \frac{1}{e^{\frac{h\nu}{kT}} - 1}$$

#### Limits for Planck's Law

Specific Brightness: 
$$B_{\nu}(T) = rac{2h\nu^3}{c^2} rac{1}{e^{rac{h
u}{kT}} - 1}$$

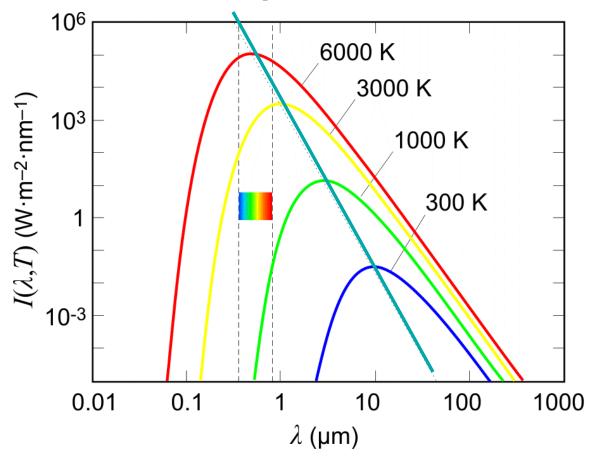
1. Rayleigh-Jeans Law: In the limit where  $h_V << kT$ , most applicable for long wavelengths (such as in the radio part of the spectrum) and temperatures in the range of planetary bodies.

$$B_{\nu}(T) \approx \frac{2\nu^2}{c^2} kT$$
 where  $e^{h\nu/(kT)} - 1 \approx h\nu/(kT)$ 

2. The Wien Law: When  $h_V >> kT$ 

$$B_{\nu}(T) \approx \frac{2h\nu^3}{c^2} e^{-h\nu/(kT)}$$

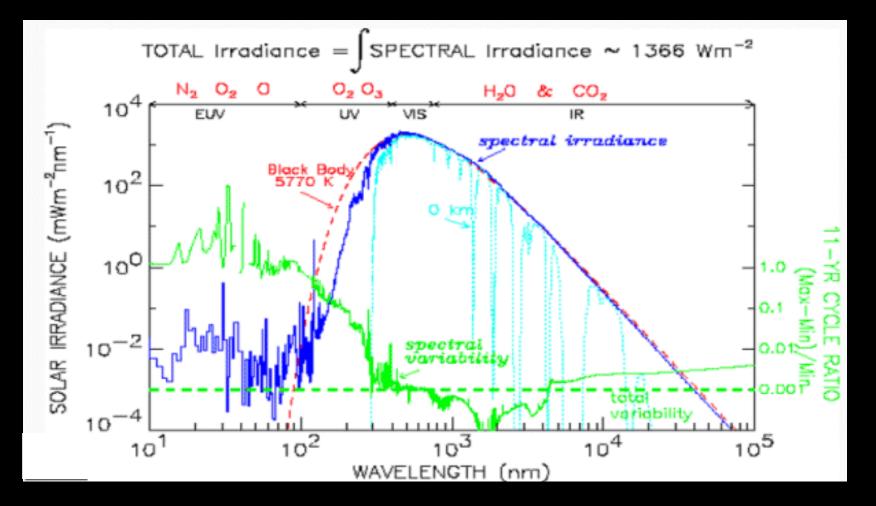
Wien's Displacement Law



Setting the derivative of Planck's Law with respect to  $\lambda$  (wavelength) equal to zero, we determine the peak wavelength with respect to temperature.

$$v_{max} = 5.88 \times 10^{10} T$$
, where  $v_{max}$  is in Hz

## Solar Spectrum, Variability, and Atmospheric Absorption



# Luminosity

A useful way to describe the amount of energy emitted by an object is the luminosity (often used in astronomy to relate the energy, size and temperature of stars and intercompare their properties).

Luminosity (L) = Energy flux x Area and has units J/s or W

### Hertzsprung-Russell (H-R) diagram

60 M<sub>Sun</sub> 106 30 Ms. β Centauri 105 SUPERGIANTS **Betelgeuse** Spica Lifetime 10 *M*. Canopus Antares 104 10<sup>7</sup> yrs Polaris MAIN 10<sup>3</sup> GIANTS ENCE Lifetime cturus 10<sup>8</sup> yrs 10<sup>2</sup> Pollux Sirius (solar units) 10 Lifetime ntauri A 10<sup>9</sup> yrs luminosity ( 0. entauri B Lifetime 1010 yrs 99.50 ese 725 A Sirius B WHITE 10.2 Gliese 725 B 0.1 M<sub>Sut</sub> Lifetime DWARFS Barnard's Sta Ross 128 10<sup>11</sup> yrs 10-3 Wolf 359 Proxima Centauri Procyc DX Cancri 10-4 10-5 0 F G в A Μ ĸ 30,000 10,000 6,000 3,000 increasing temperature decreasing surface temperature (Kelvin) temperature

The Sun in Perspective