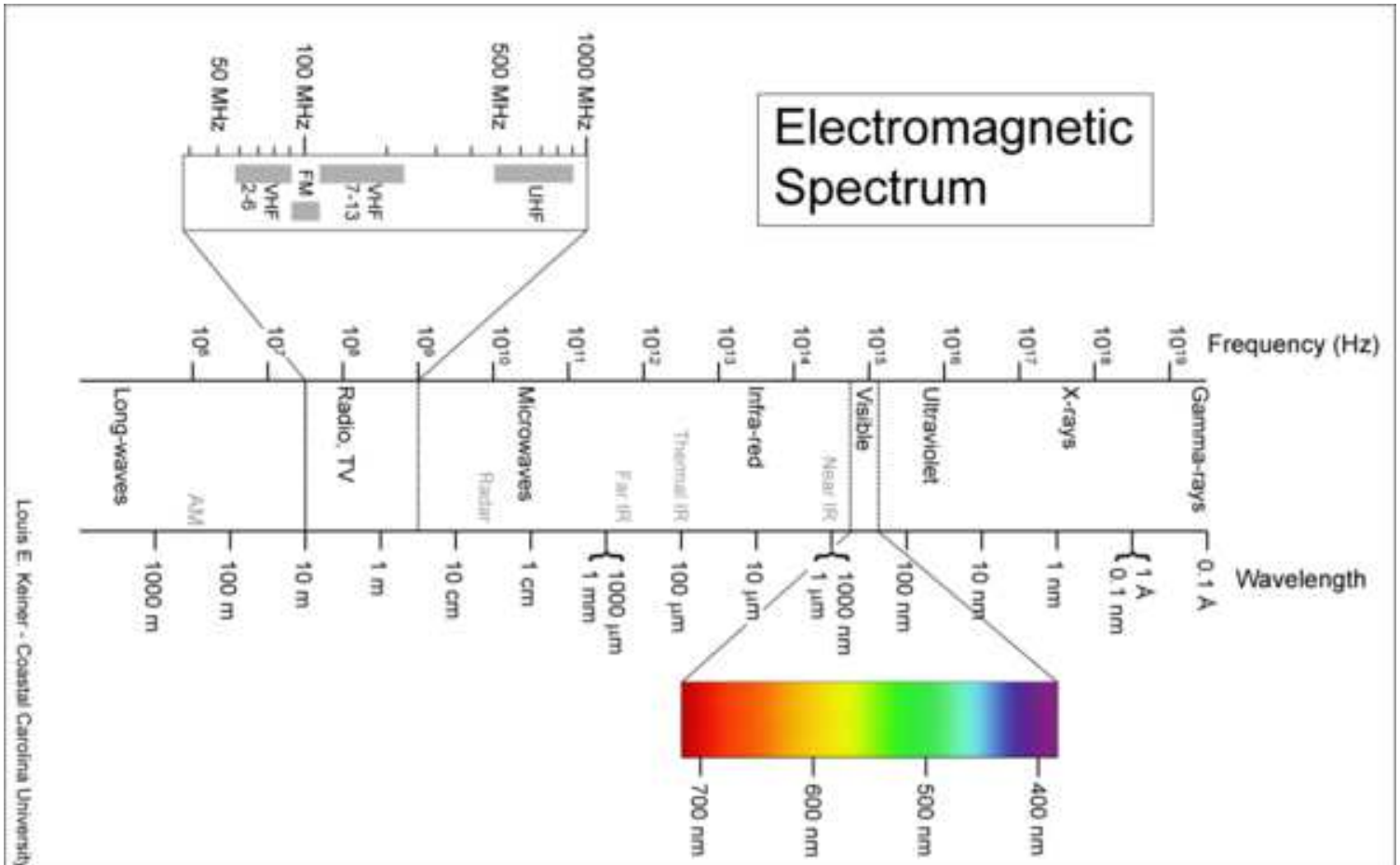
# *Properties of Light and Radiation*

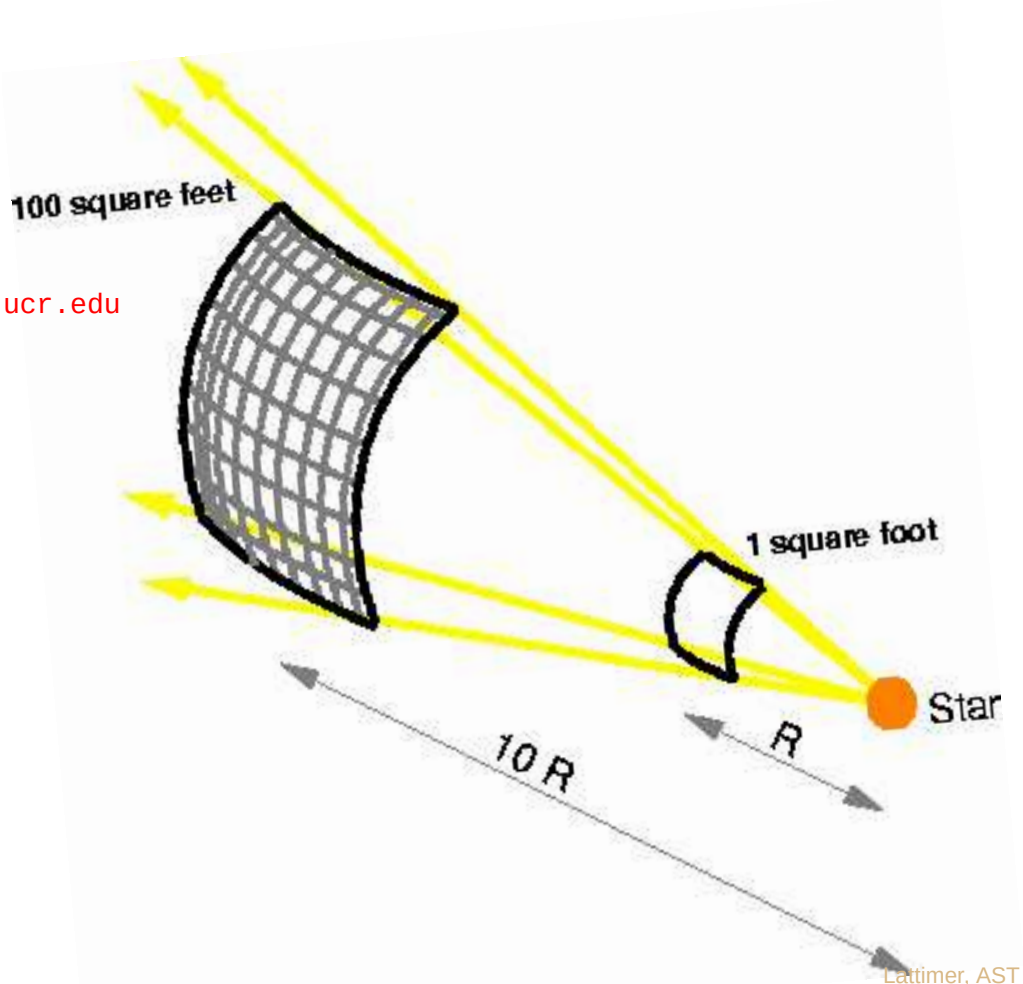
- Speed is $c = 3 \times 10^{10}$ cm/s = 186,000 mi/s = $6.7 \cdot 10^{8}$ mph.
- Distance traversed in 1 year is called a light-year.
- Has properties characteristic of both waves and particles.
- Wave nature: Wavelength $\times$ Frequency = $c$ (Speed) $\lambda \times \nu = c$
- Wavelengths range from $\gamma-$ rays ($\lambda \sim 10^{-13}$ cm) to radio ($\lambda \sim 10^{3}$ cm).
- Visible light is optical radiation, $3 \times 10^{-5}\ \mathrm{cm} < \lambda < 7 \times 10^{-5}\ \mathrm{cm}$.



- Particle nature: Smallest unit of radiation is a photon.
- Photon energy is proportional to frequency $E = h\nu$
  ($h$ is Planck's constant, $6.6 \cdot 10^{-27}$ cm$^2$ g s$^{-1}$)
- Brightness ($B$) is apparent flux from an object while Luminosity ($L$) is the intrinsic or absolute power output.
- Inverse square law of brightness – brightness diminishes as distance squared:

$$B = L/D^2$$

Jose Wudka physics.ucr.edu

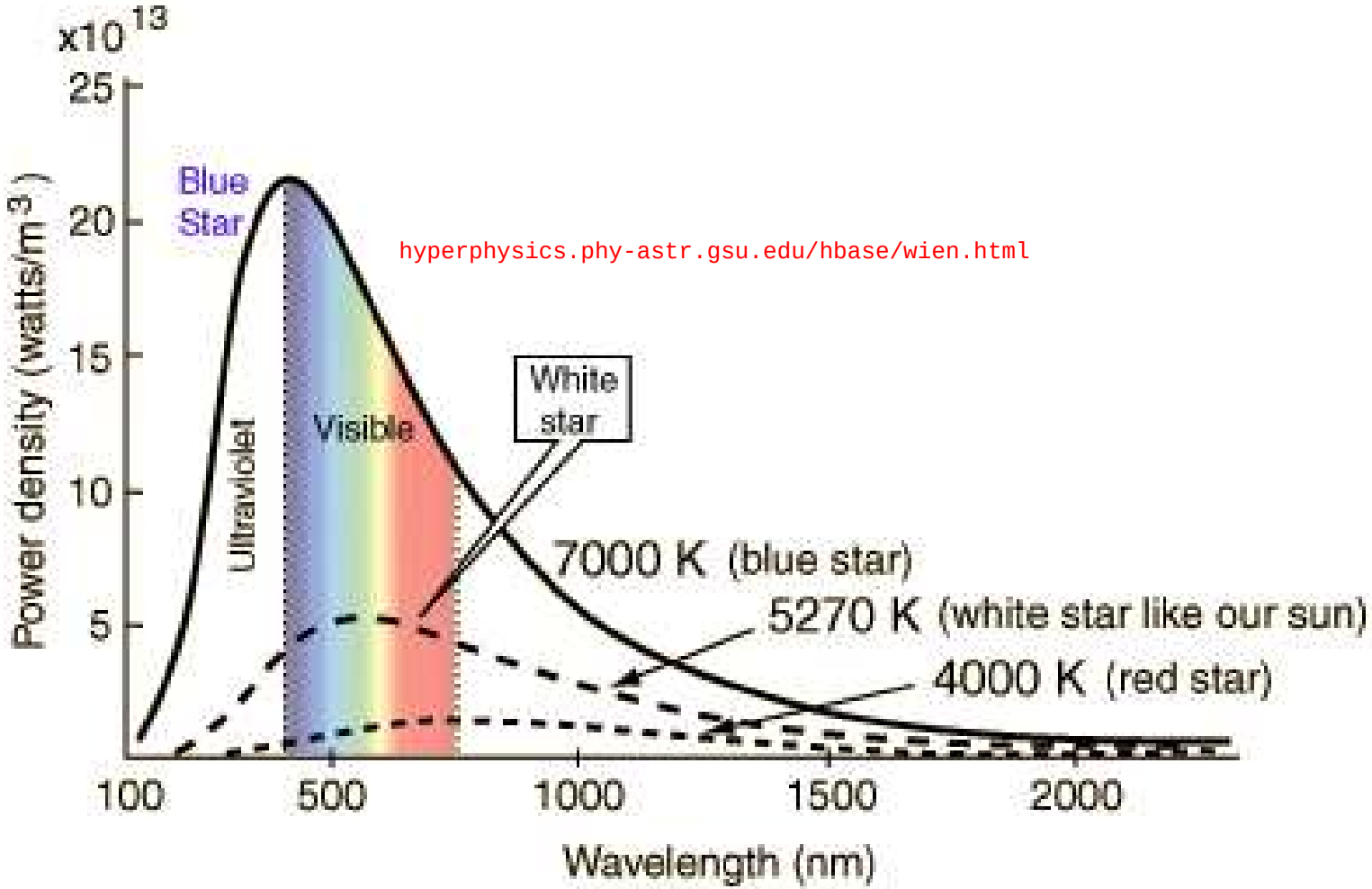


- Radiation from a luminous object is emitted at virtually all wavelengths, but peak wavelength of distribution is inversely proportional to temperature

$$\lambda = 0.29 \text{ cm}/T^{\circ} \text{ K}$$

AKA **Wien's Law**

- Therefore the color of a star is a measure of its temperature.

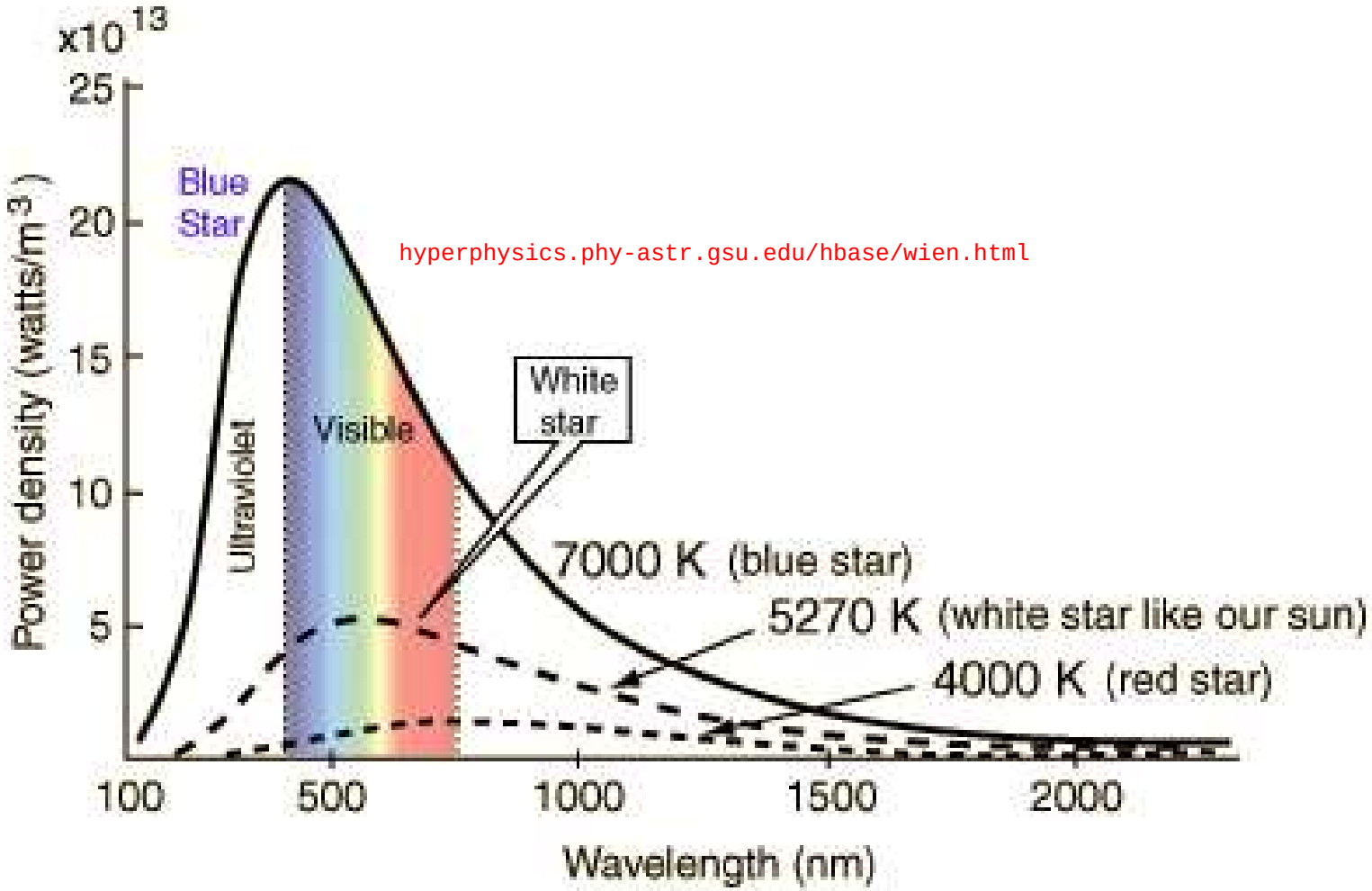


- Total power (luminosity) emitted by a luminous object (e.g., a star) is dependent upon both temperature $T$ and object size or radius $R$:

$$L = 4\pi R^2 \sigma T^4$$

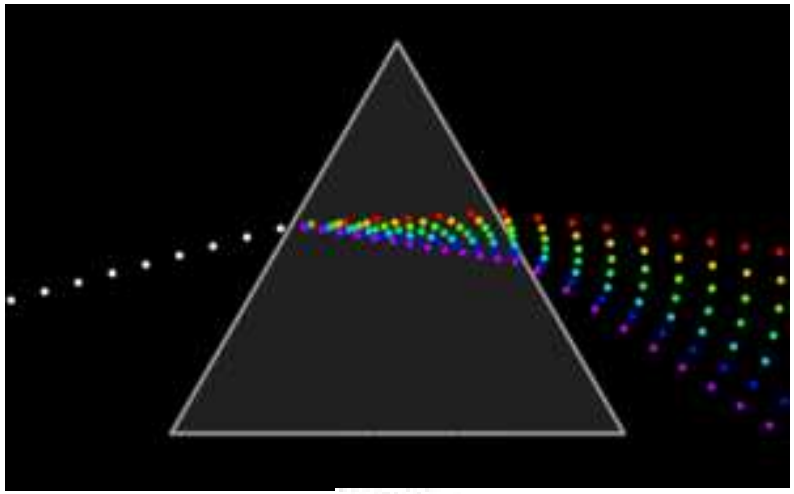
$\sigma = 5.567 \cdot 10^{-5}\ \mathrm{erg\ cm^{-2}\ K^{-4}}$ is radiation constant

- This is seen by examing the total area under the emitted power density curves

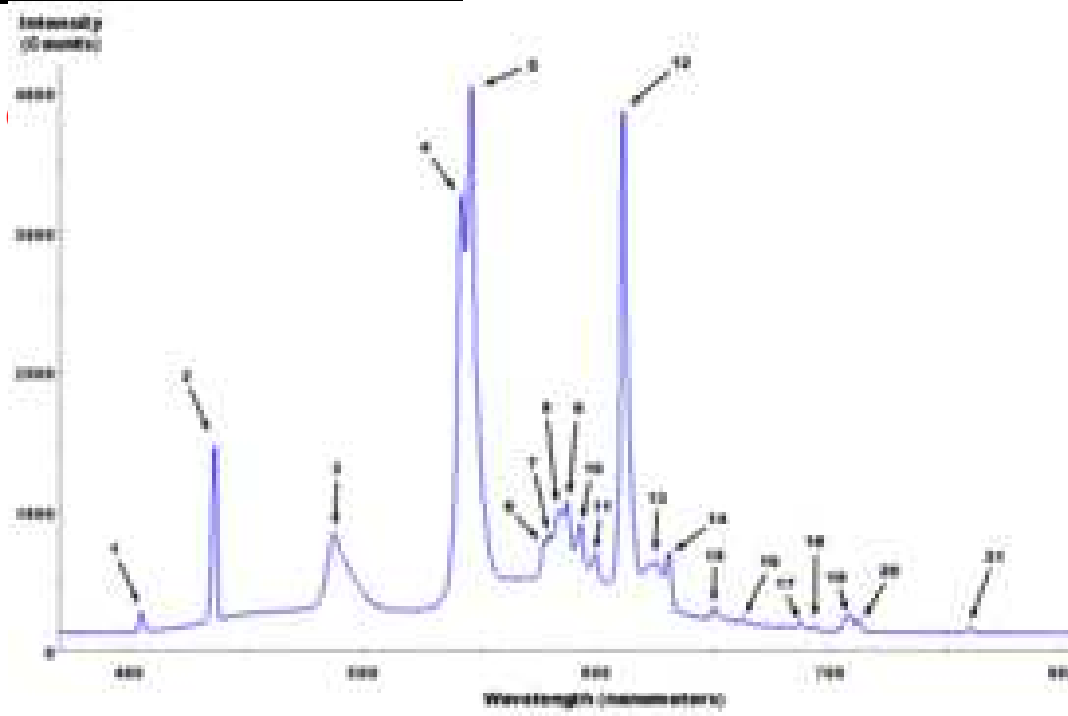


# *Spectroscopy*

- A prism can spread light into a spectrum.



- Spectra have absorption and/or emission lines, each characteristic of an electronic transition in an atom or molecule. Can deduce elemental or chemical composition of stars.

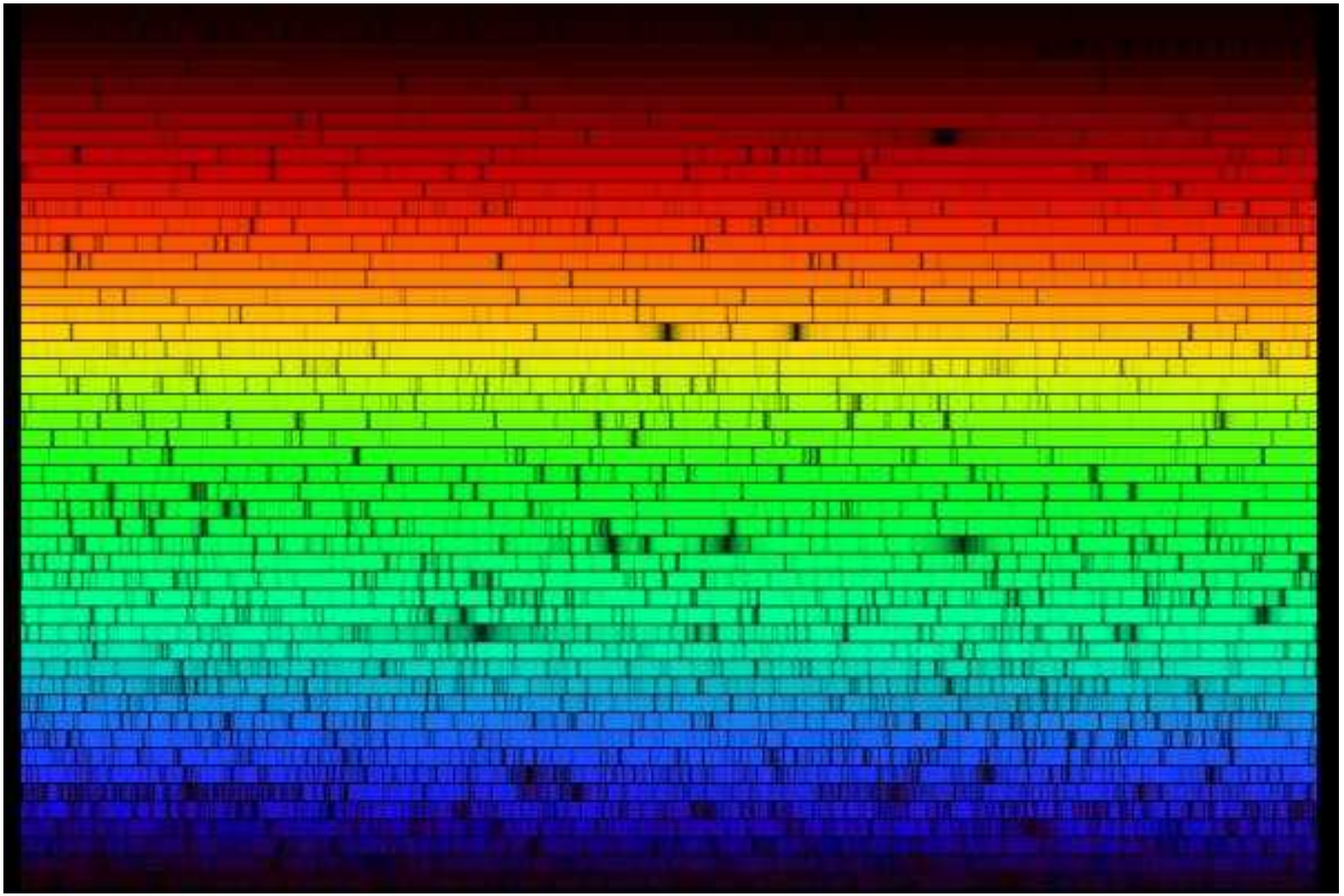


Spectrum of fluorescent light

Wikipedia figures

# *Solar Spectrum*

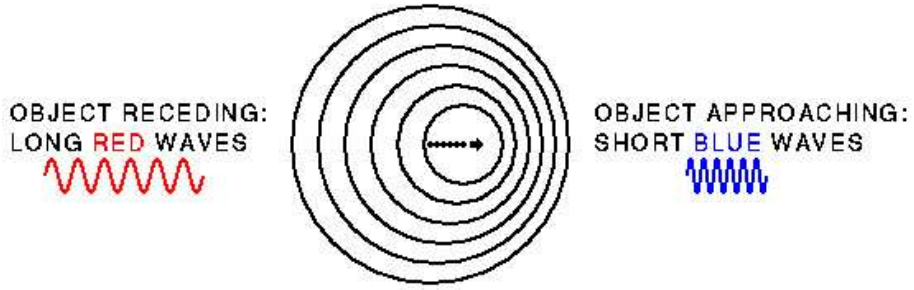
*Nigel Sharp NOAO*



Dark lines are absorption lines produced by cooler gas above the hot solar surface, and each is due to a specific element (atom) or molecule. Most, but not all, spectral lines have been identified. The chemical composition and temperature of the absorbing gas can therefore be determined.

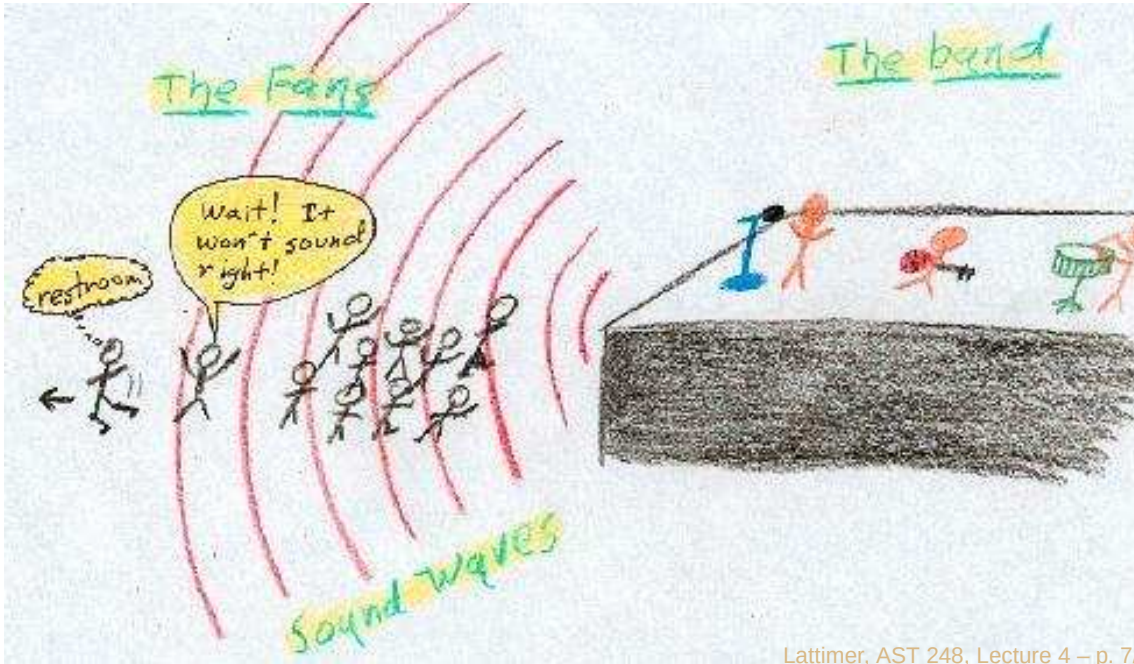
# *Doppler Effect*

- Speed of light is independent of source's velocity (Einstein's Special Theory of Relativity)
- The observed wavelength of a photon or a spectral line is dependent upon the relative velocities of the source and the observer.
- The observed change in the wavelenght, called a Doppler shift, is proportional to the net relative speed difference between the source and observer

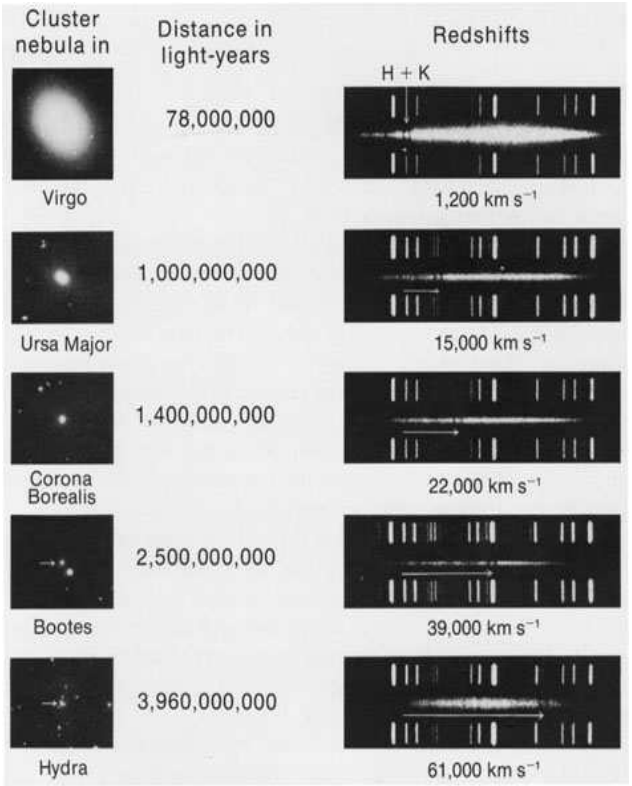



$$\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$$

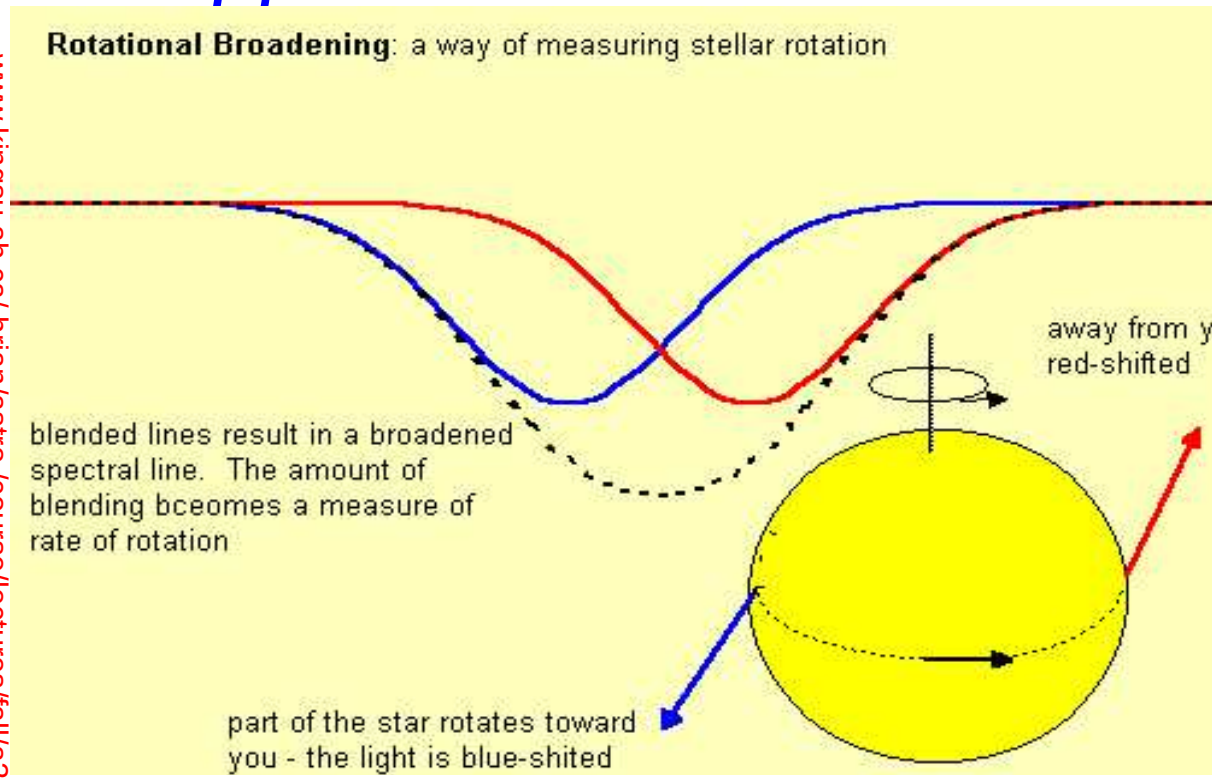
- If the source is moving towards you, you observe a blueshift
- If the source is moving away, you observe a redshift. Here is a song about the Doppler shift that explains it all: *www.astrocappella.com/doppler.shtml*



# *Doppler Effect Applications*




www.kingsu.ab.ca/ brian/astro /course/lectures/fall/a200110g.htm




For an interesting demo about the Doppler effect in binary stars, see

*instruct1.cit.cornell.edu/courses /astro101/java/binary/binary.htm*