Astro 301/ Fall 2005

(48310)

Introduction to Astronomy

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TAs: David Fisher, Donghui Jeong, and Miranda Nordhaus

Lecture 18+19 = Tu Nov 1 + Th Nov 4

http://www.as.utexas.edu/~sj/a301-fa05/

Lecture 18: Announcements

-- Homework 4 handed out today

-- Quiz 4 today based on Lectures 14 to 17 + movie

-- Exam 2 on Nov 10.

<u>Recent and Upcoming topics in class</u>

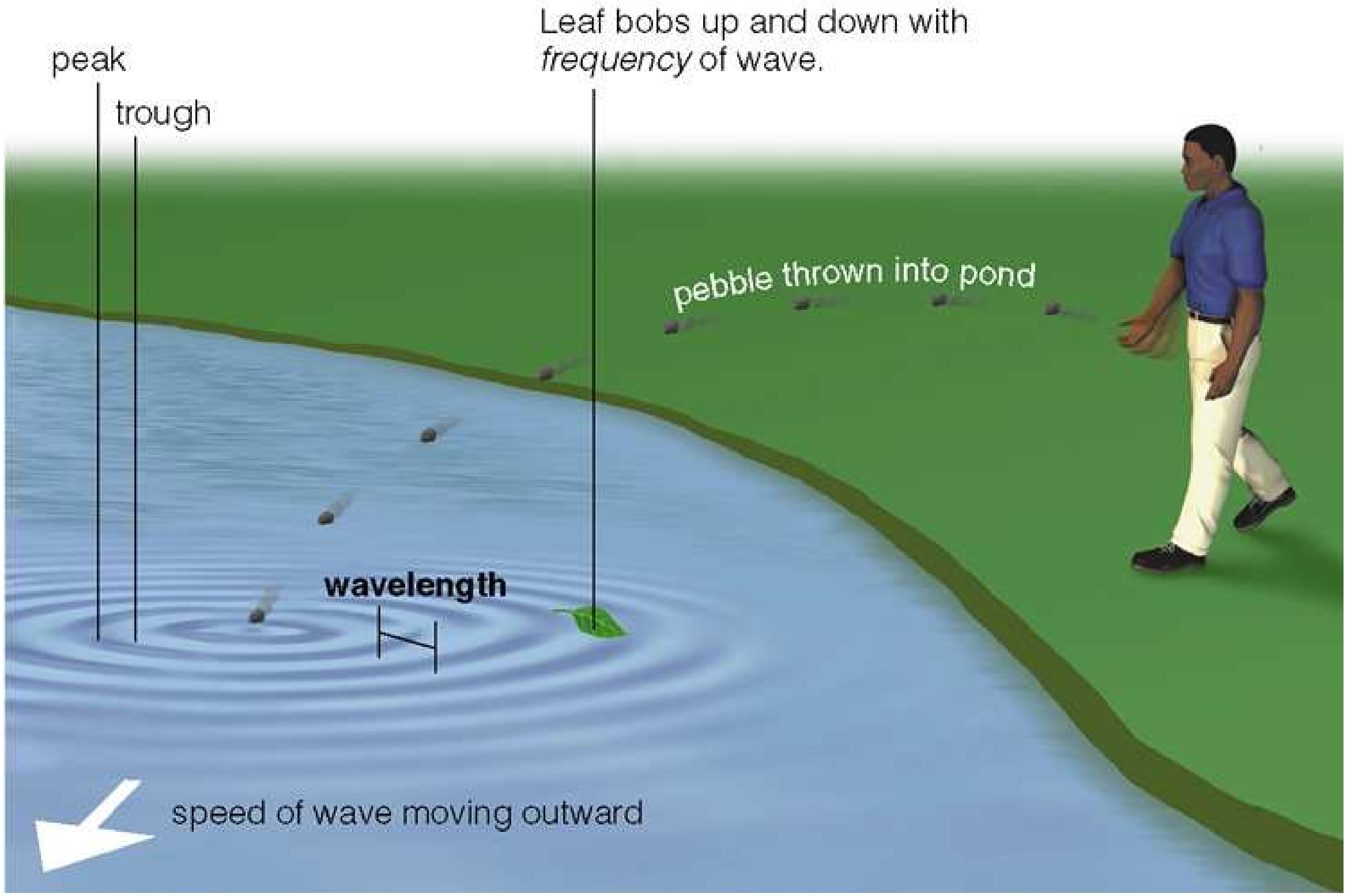
-- Waves
-- Basic properties of waves: Wavelength, Frequency, Speed, Energy
-- Types of waves: sound, surface, electromagnetic

-- Light as Electromagnetic Waves
-- Dual nature of light: light as electromagnetic waves or as photons
-- The electromagnetic spectrum: wavelengths, frequency, speed
-- Processing of Electromagnetic Waves
-- Luminosity and Total Flux of a distant object
-- Using the continuum spectrum of a star to estimate its surface temperature, total surface flux and radius
  à Wien's Law: Relating surface temperature and color of the continuum emission
  à Stefan-Boltzmann law: Relating surface temperature and surface continuum flux

-- Using the particle model of light and the discrete energy levels in an atom to explain emission and absorption lines
- Light as a steam of photons.
- Dependence of a photon's energy on its wavelength or frequency
- Discrete energy levels in an atom
- Using emission and absorption lines to trace chemical composition of a star

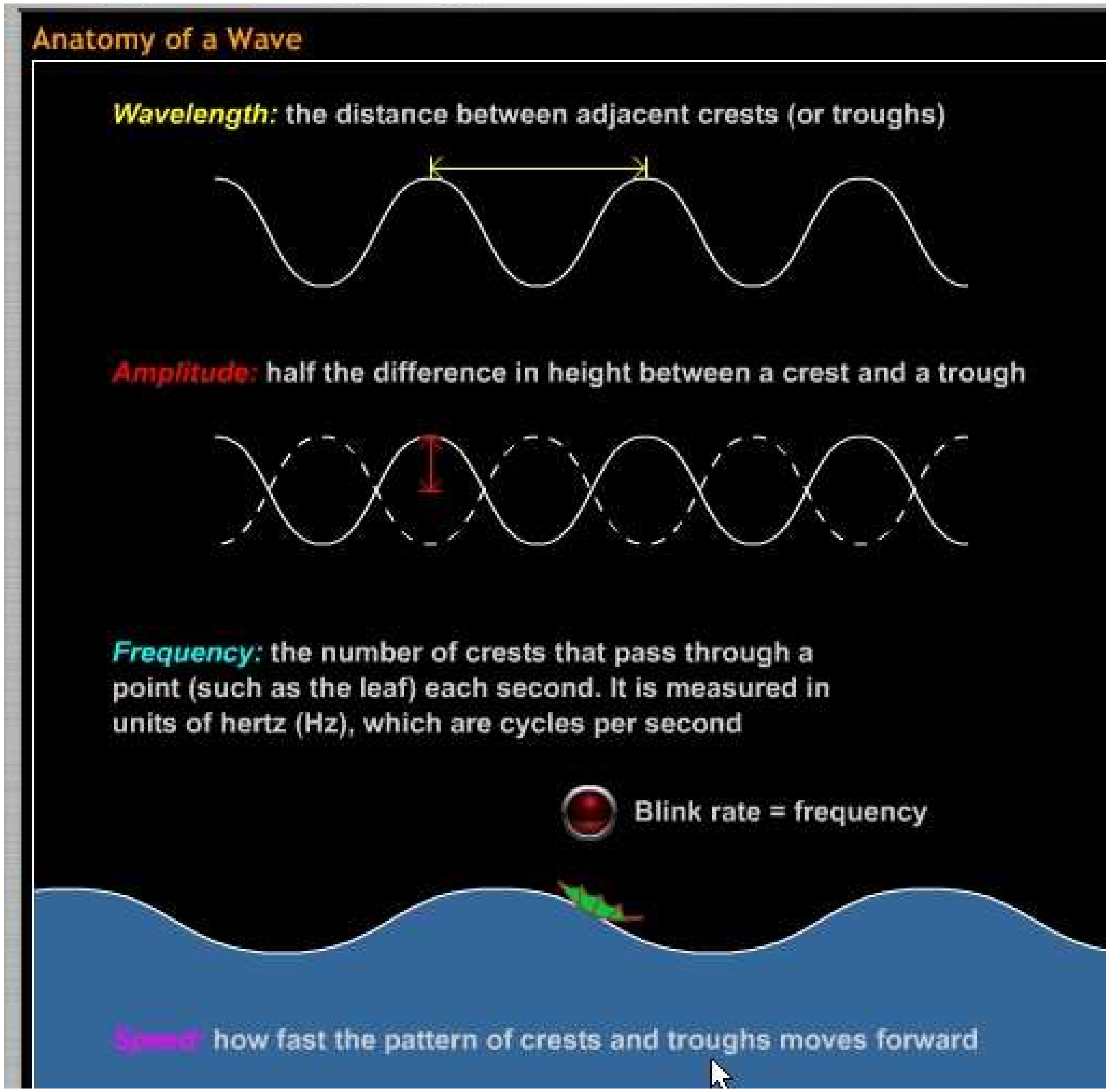
Waves

Waves



Different types of waves: surface wave, sound waves, EM (light) waves,

Waves: Wavelength, Frequency, Speed, Energy

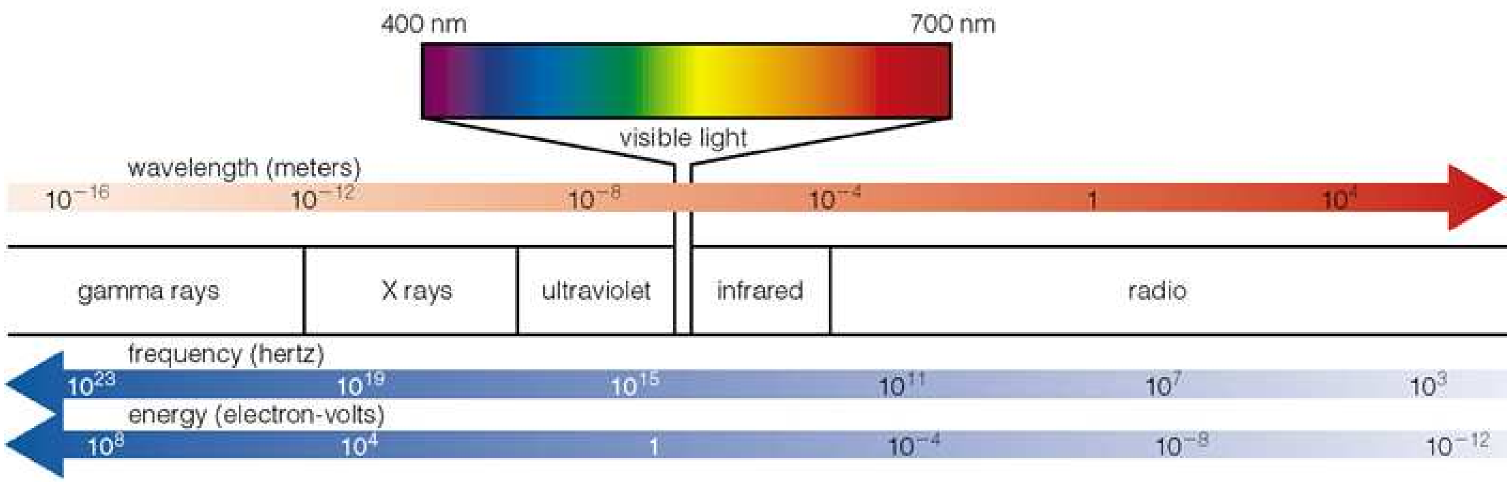


In-class animation : Anatomy of   wave

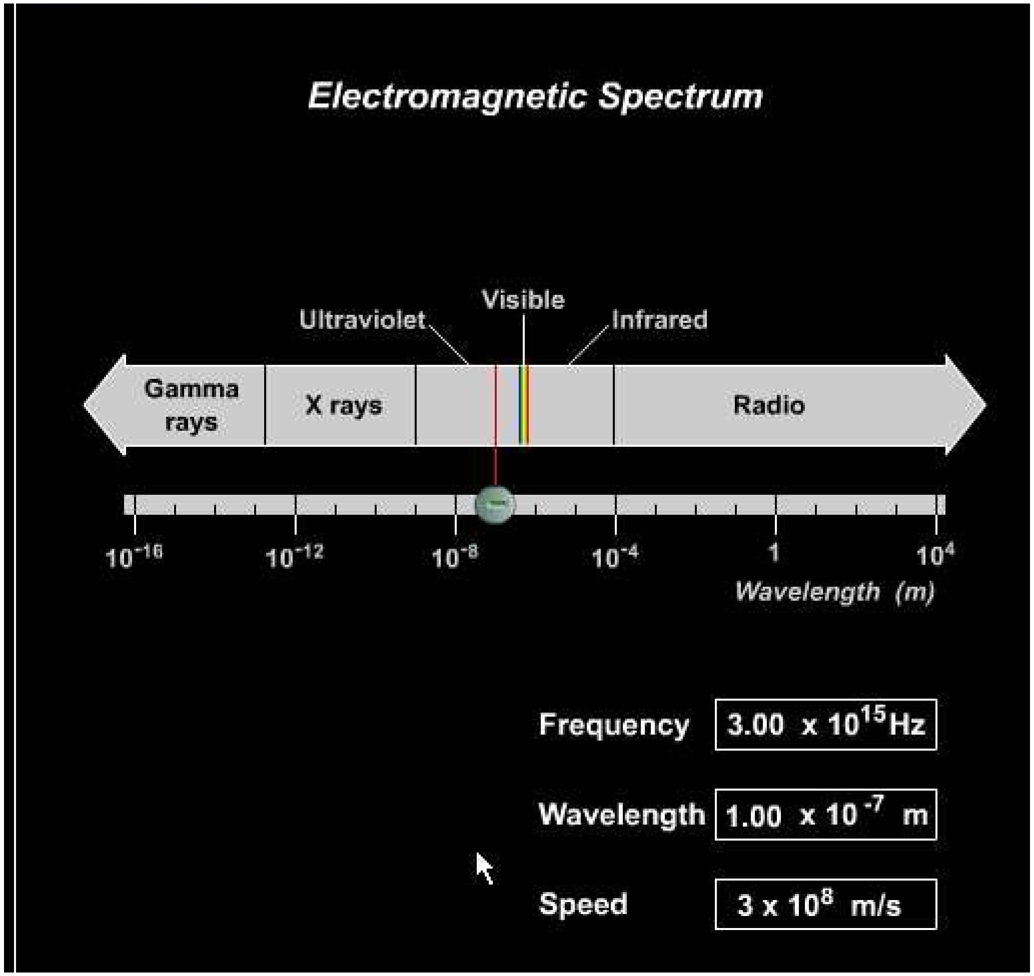
Light as Electromagnetic Waves

Light as Electromagnetic Waves

Type of EM wave	TYPICAL WAVELENGTH
Gamma rays	10^{-16} m
X rays	10^{-12} m
Ultraviolet	3×10^{-7} m
Visible	4 to 9×10^{-7} m = Violet, blue, green, yellow, orange, red
Infrared	10^{-6} m to 10^{-4} m
Radio	10^{-3} m to m

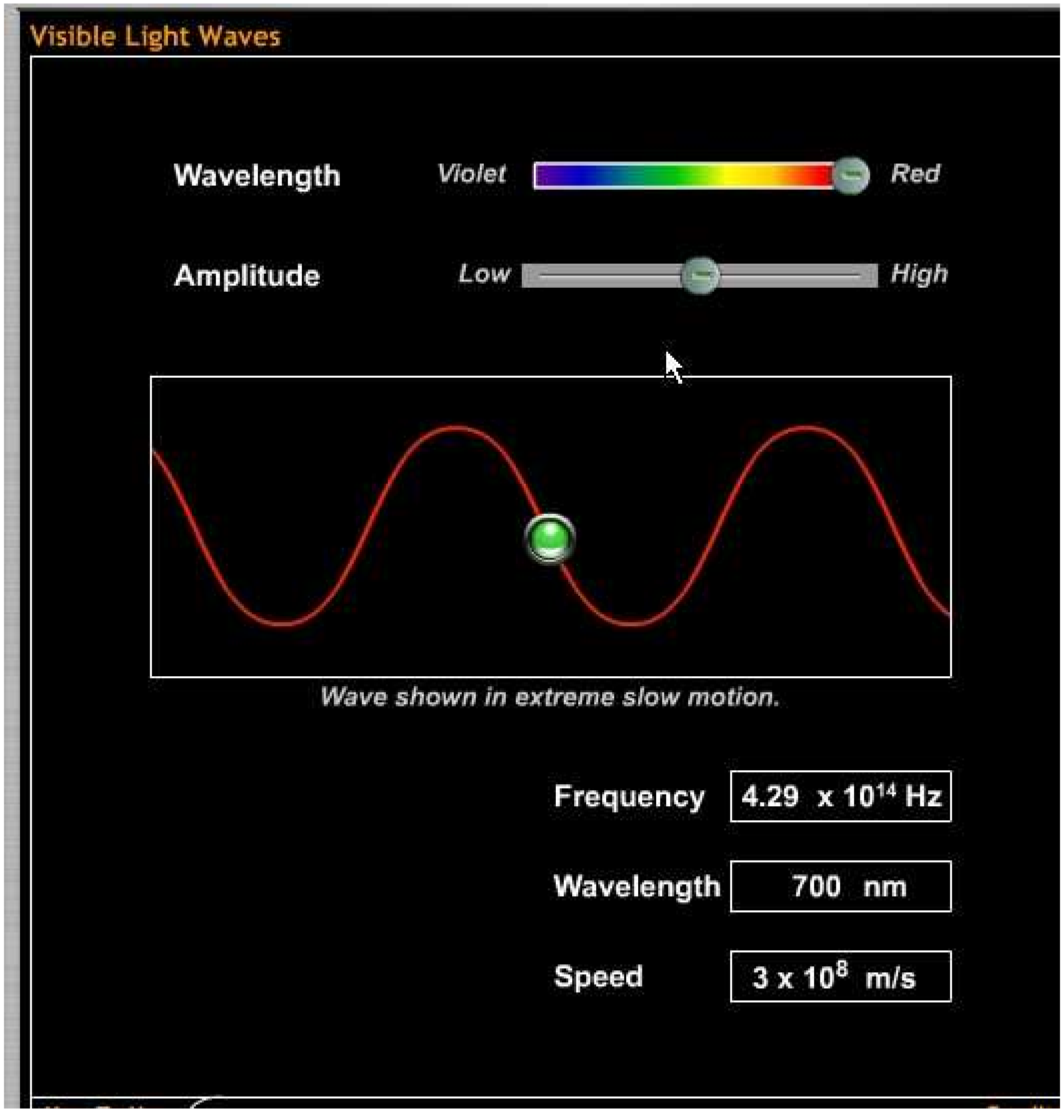


Light as Electromagnetic Waves



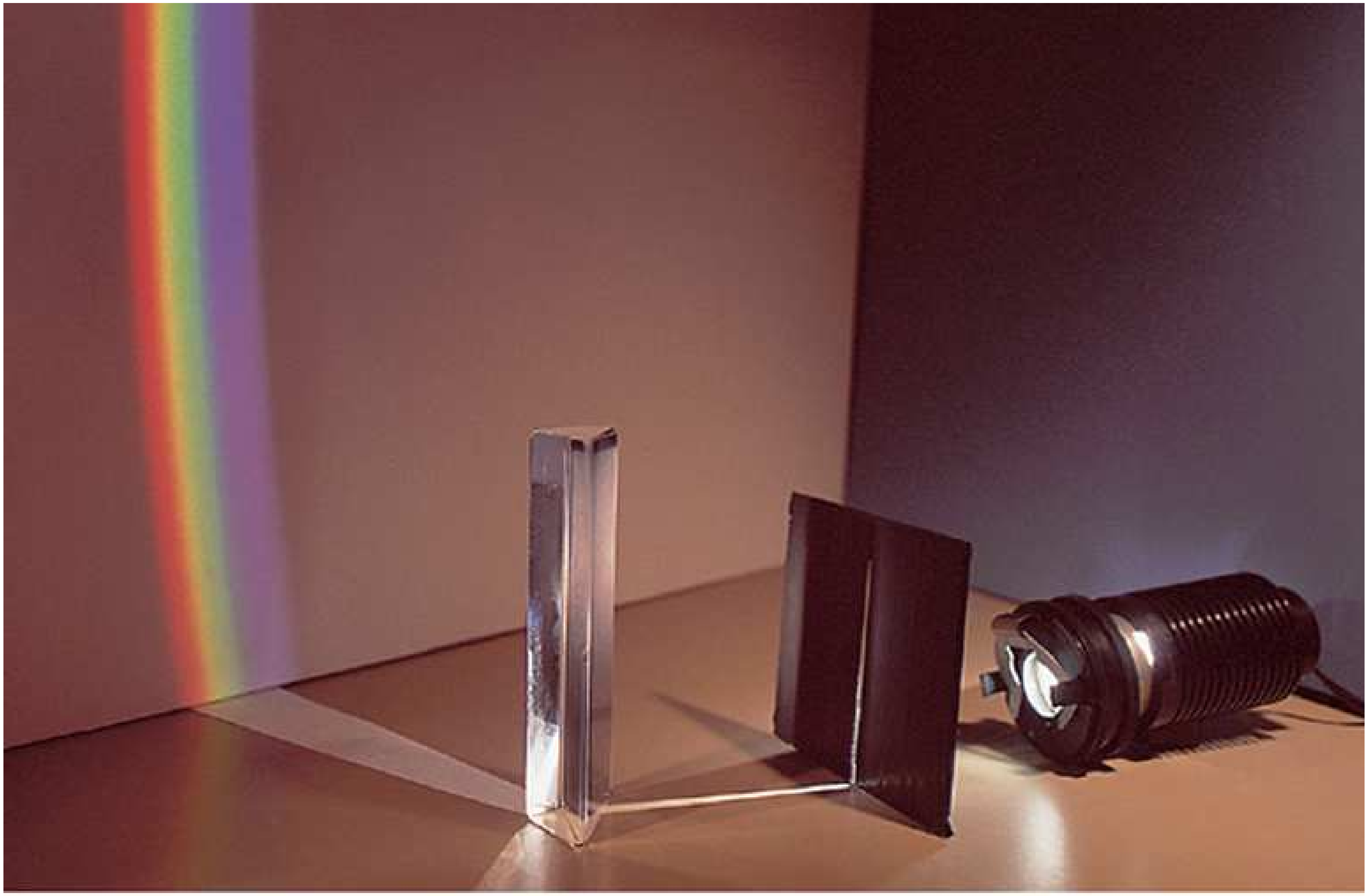
à in-class demo: Electromagnetic Spectrum

Visble Part of Electromagnetic Spectrum



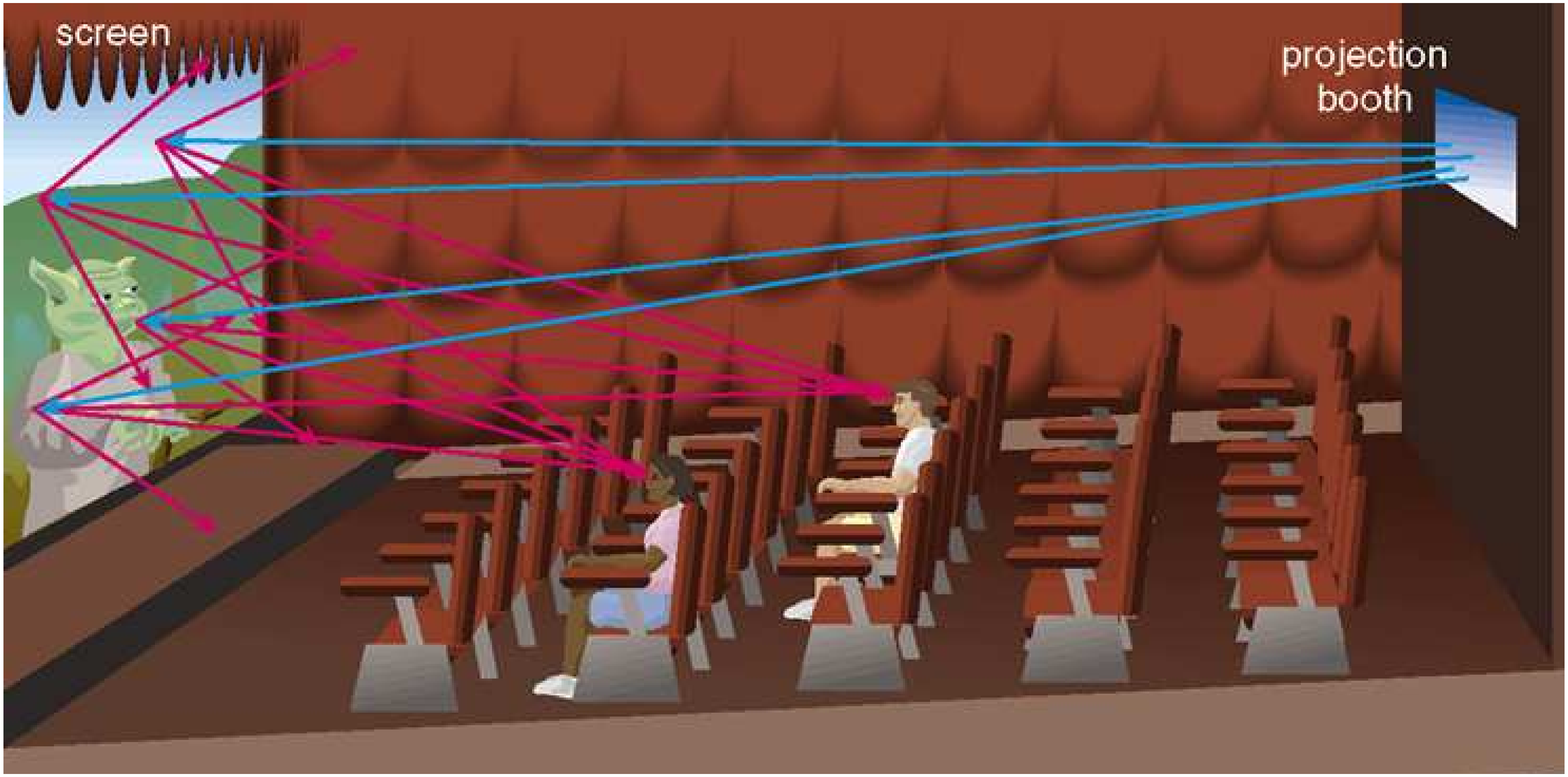
à In-class animation : Visible light

Processing Electromagnetic Waves

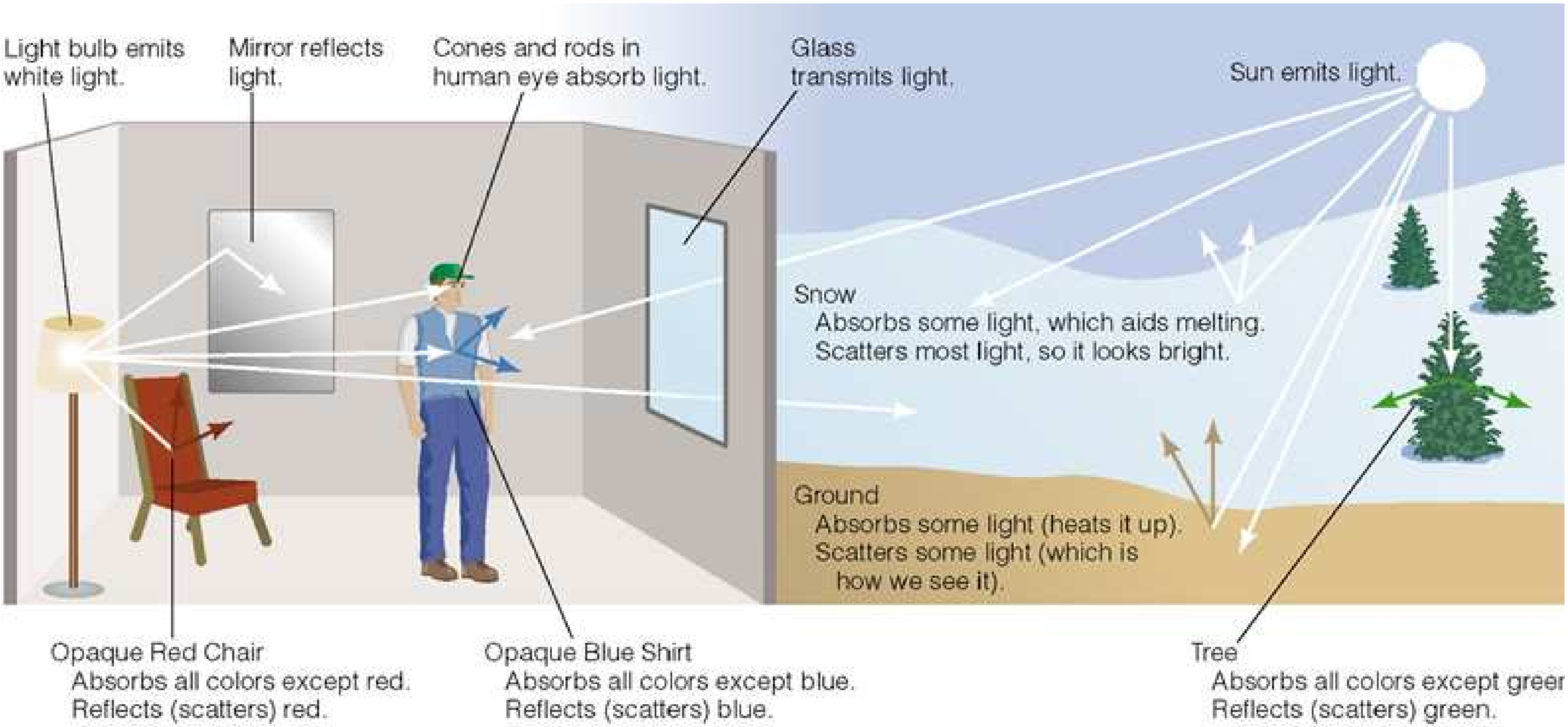


Dispersing while light into its basic colors

Processing Electromagnetic Waves



Concept of ‘color’ of an object



Lecture 19: Announcements

-- Group email sent to class regarding typo on question 1a. The mass of nucleus should read 19.9162×10^{-27} kg.

-- I will leave immediately after class today for a committee meeting
IF YOU NEED TO TALK TO ME PLEASE DO SO BEFORE CLASS OR DURING OFFICE HOURS TODAY.

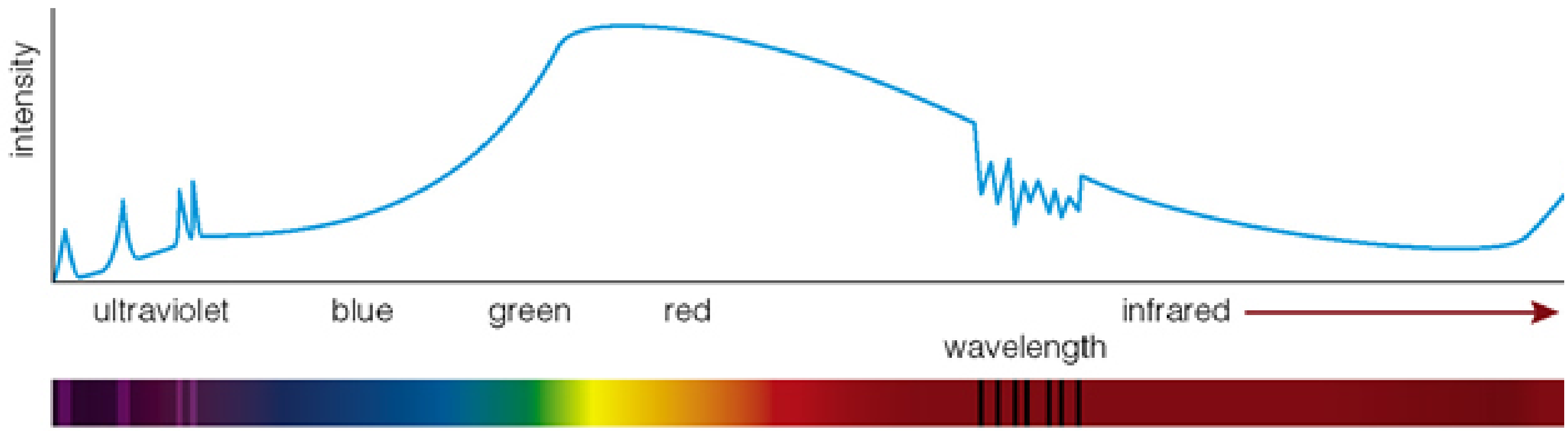
-- Exam 2 on Nov 10.

Luminosity and Total Flux of an object

1. Demo : Bright star-near-or-lum

2. in –class notes

<u>*A Spectrum*</u>



1) When the total flux from an object is separated <u>into the flux at different wavelengths</u>, and the intensity of the flux is plotted against wavelength, we get a <u>spectrum</u> for that object e.g., The figure above shows a spectrum.

2) The spectrum has 3 types of features:

   <u>continuum ermission , emission lines, absorption lines</u>.

3) Amazingly, these features in the spectrum of an object can reveal to us

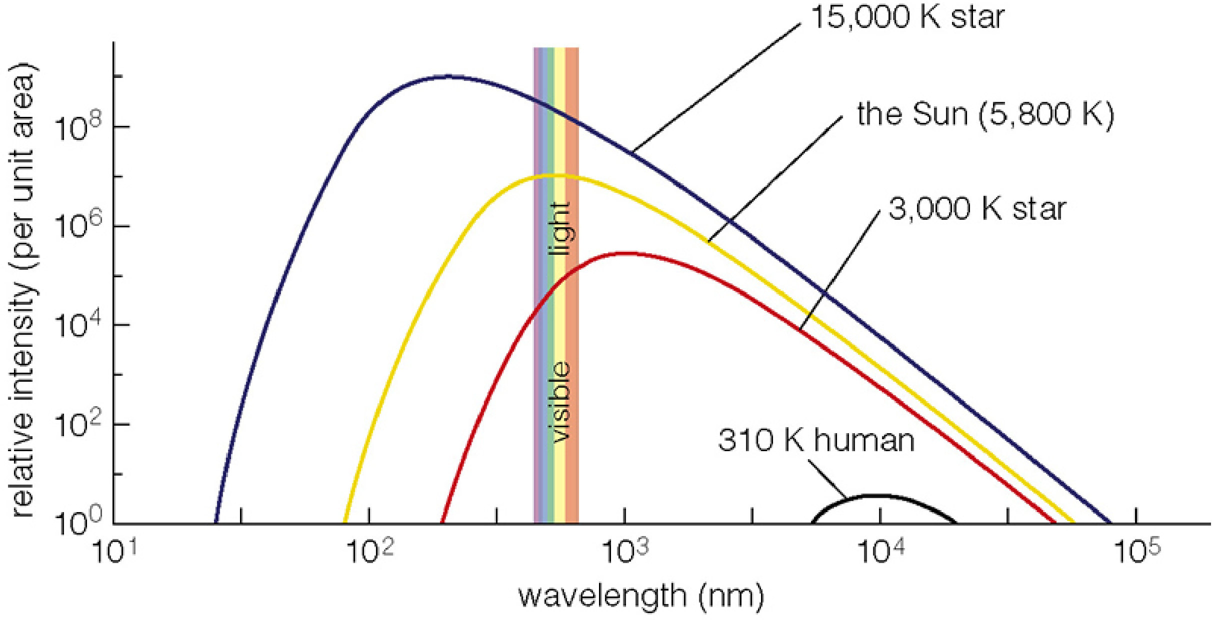
   à its temperature , its total flux

   à its chemical composition, (like a DNA genetic code)

   à its recession speed, its distance

Using the continuum spectrum of a star to estimate its surface temperature, total surface flux and radius

Wien's Law: Relating surface temp. and color of continuum !



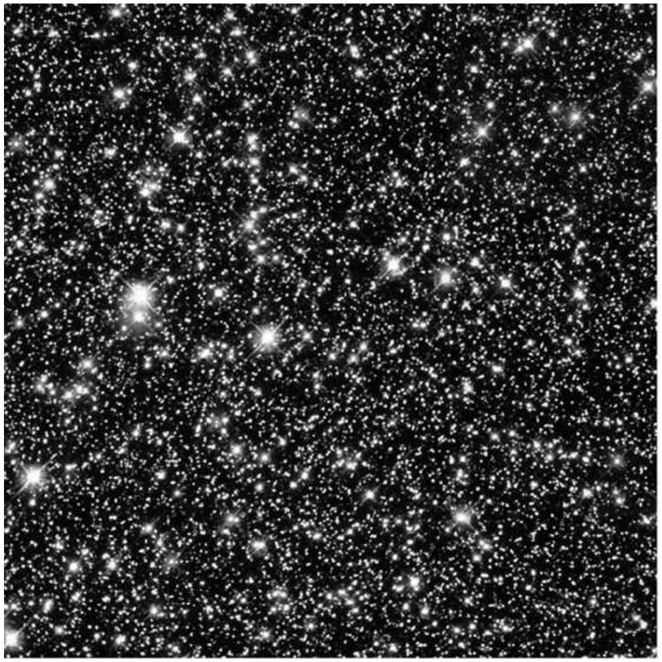
- The spectrum of a star has a shape that depends only on its temperature T !

- Wien's law: A star will emit its maximum flux at a wavelength λ_{peak} that depends inversely on its temperature and is given by $\lambda_{peak} = W/T$ where W = Wien's constant = 2.9 x 10^{-3} m K

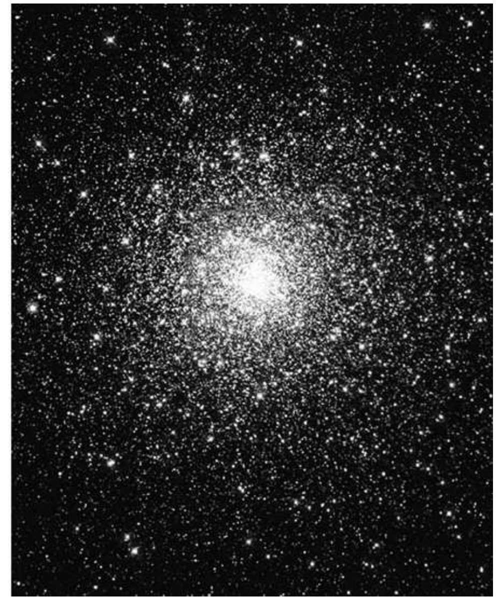
à For the Sun T=5800 K at surface: λ_{peak} = 5 x 10^{-7} m = ….color?

à Hot stars have shorter λ_{peak} and tend to be bluer !

Temperature and Color of Stars:



Center of M Way (HST)



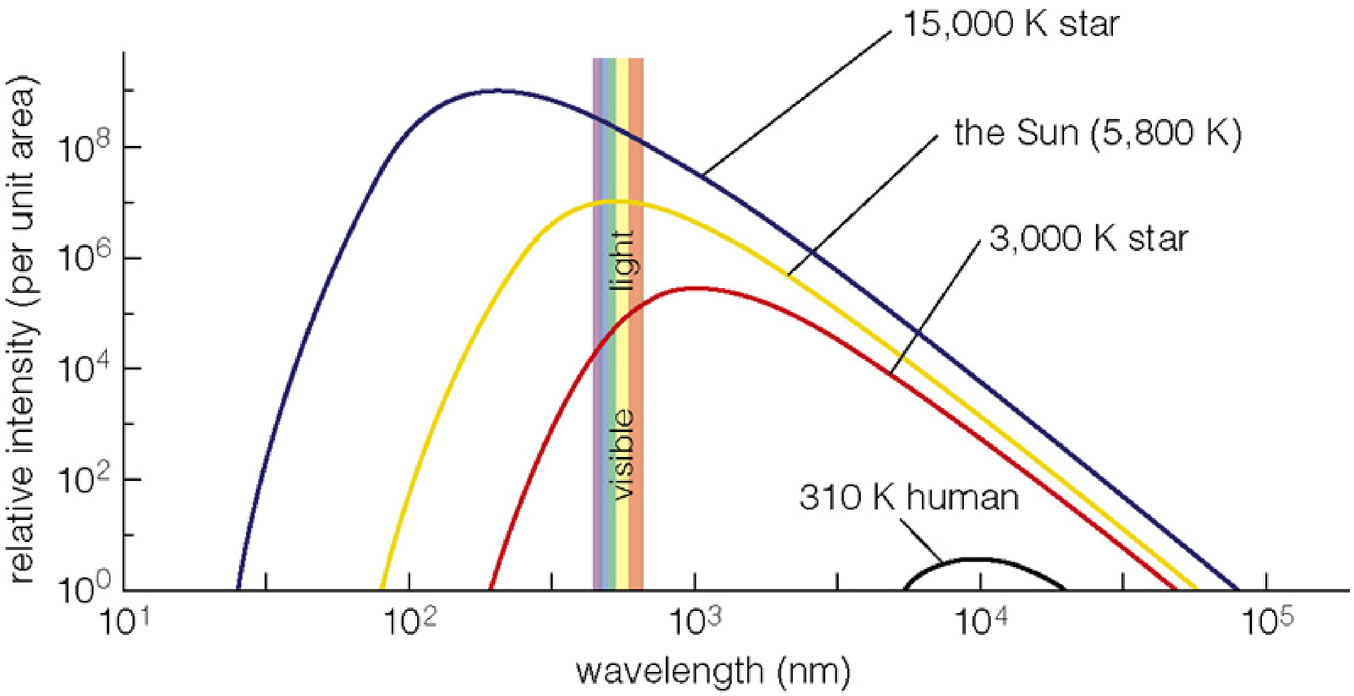
M80 globular cluster (HST)

Pleiades

à From Wien's law: blue stars are hotter while red stars are cooler. The temperature in turn may tell us something about age and mass of stars (e.g., massive stars tend to be hot and blue)

à BUT sometimes dust can cause an intrinsically hot blue star to look red by scatterring its light,

Stefan-Boltzmann law: Relating surface temp. and surface flux

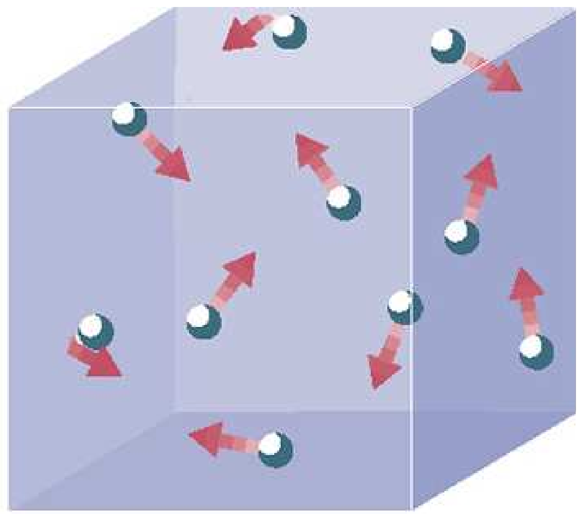


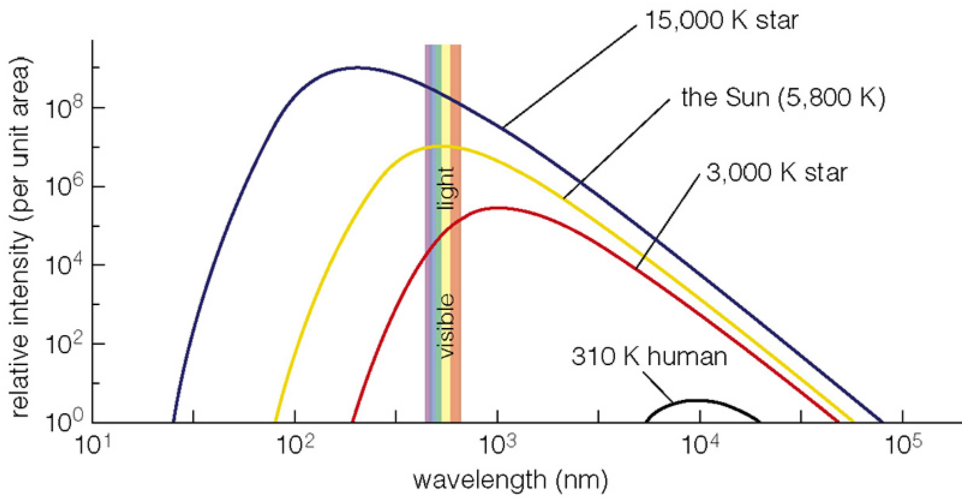
- Wien's law describes at what wavelength a star emits most of its flux.

- Stefan-Boltzmann law describes the TOTAL flux of the star over ALL wavelengths

à The total flux (energy pr second per unit area) emitted over ALL wavelengths at the surface of a star (or black body) depends only on its surface temperature T of the star and is equal to σ T4 where σ is the Stefan-Boltzmann constant

Physical reason for Wien's law and Stefan-Boltzmann law?





In a macroscopic body (blackbody) at a temperature T:

à Atoms have a thermal energy due to their non-zero temperature T.

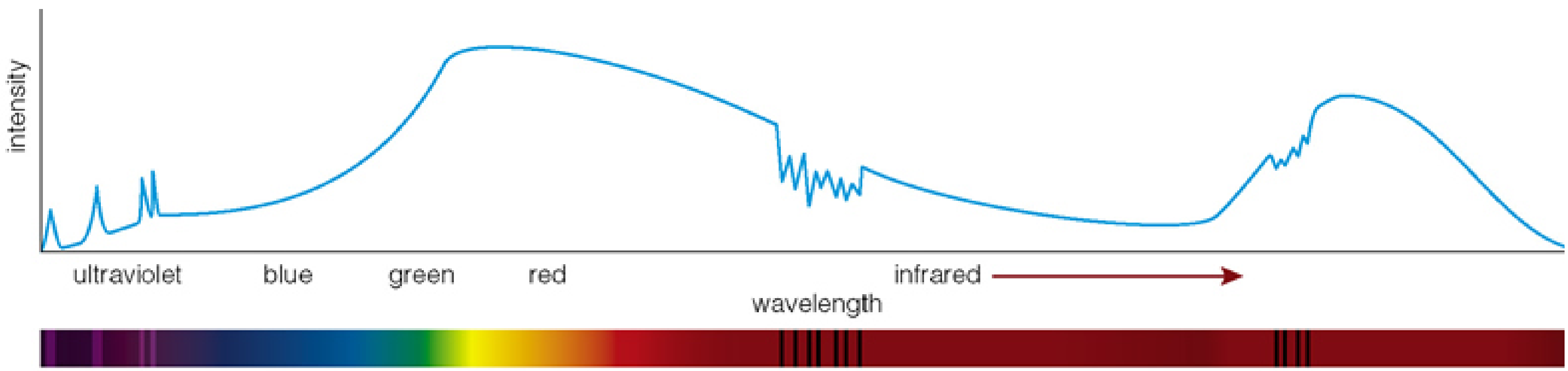
à This thermal energy causes them to move randomly around and collide

à When many atoms (with bound e-) collide at many different speeds, the electromagnetic interactions between charged particles (e-, H+) lead to the emission of **photons with a continuous range of wavelengths.**

à **The shape of resulting thermal or blackbody spectrum depends only on T.**

Using the particle model of light and the discrete energy levels in an atom to explain emission and absorption lines

How to explain emission and absorption lines?



à the underlying continuum emission emitted over a continuous range of wavelengths is thermal radiation emitted by the body, according to its temperature T

à the discrete emission lines are due to the emission of photons at specific wavelengths … what accounts for such emission at these specific wavelentgths?

How do such emissions tell us about **the chemical composition of the source!**

à the discrete absorption lines are due to the absorption of photons at specific wavelengths… what accounts for such absorption at these specific wavelengths?