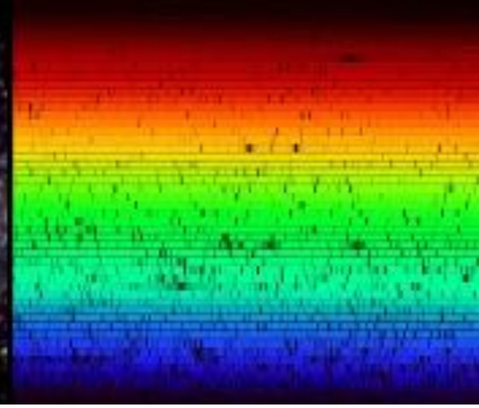
ASTR/PHYS 2500: Foundations Astronomy



Week 7: Still Stars

Today: Stars cont.
Midterm 1 Review

Tomorrow: VP Debate

Thursday: Midterm 1 Exam

HEAP Jamboree

Video available on Ubox:
https://uofu.app.box.com/s/7upgc6vn7q92l35xfogrwutapsutvjrm

VP Debate - Science Policy

- The science that gets done in the US is the science that gets funded
  - Astronomy is primarily funded through the NSF, NASA, and DOE
    - NASA is 0.5% of the total budget, science activities make up <10% of that
- If a candidate does not choose to listen to scientists, they will make uninformed policy decisions that affect the progress of humanity
  - Human-induced climate change exacerbates droughts and storms (hence the increase in fires and hurricanes), costing billions
    - The scientific consensus about this is comparable to that on gravity
  - While how COVID-19 spread was somewhat unclear early on, it is better understood now and masks and social distancing are known to be effective

- Science is a METHOD: observe, theorize, explain, predict, argue; transparently

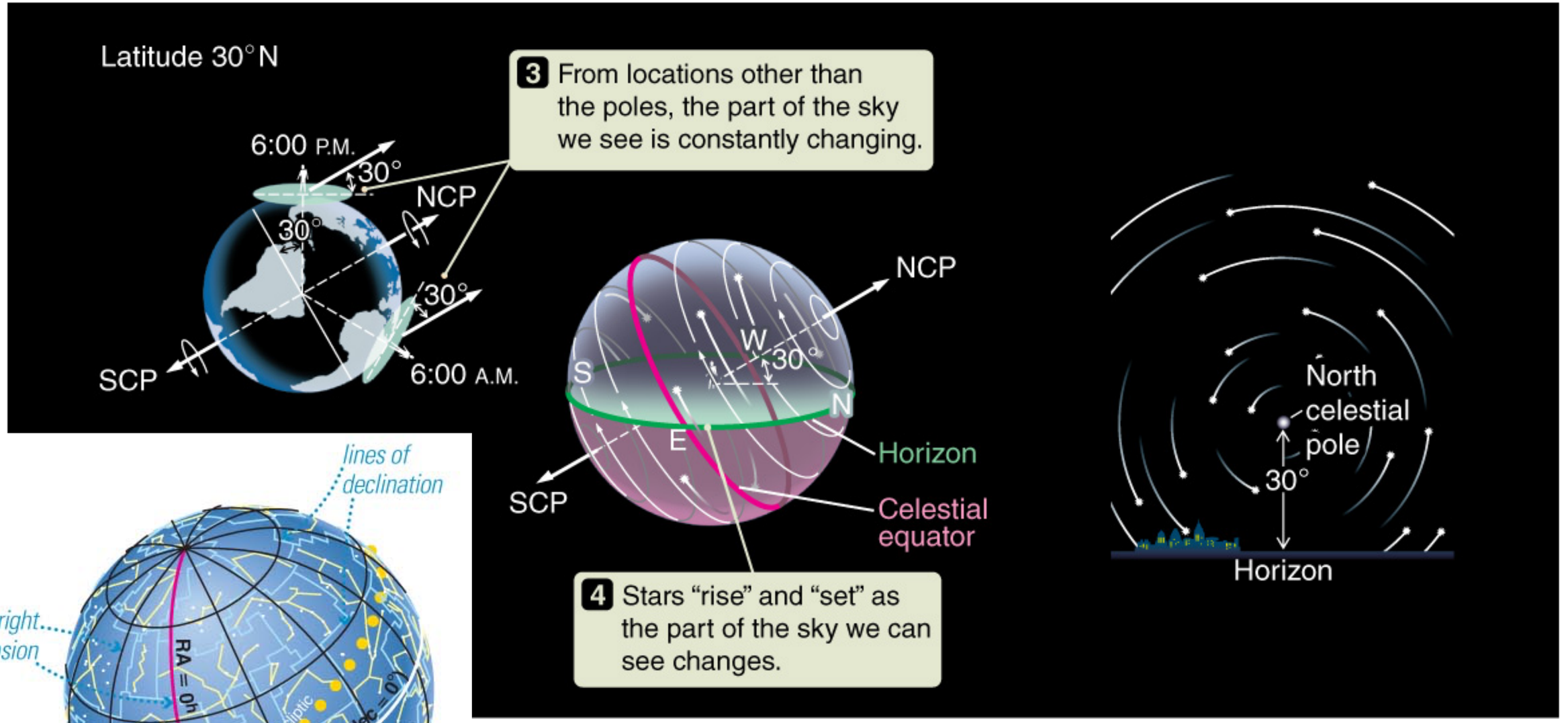
Breakout Discussion

http://www.astro.utah.edu/~wik/courses/astr2500fall2020/slides/week6.pdf

Then

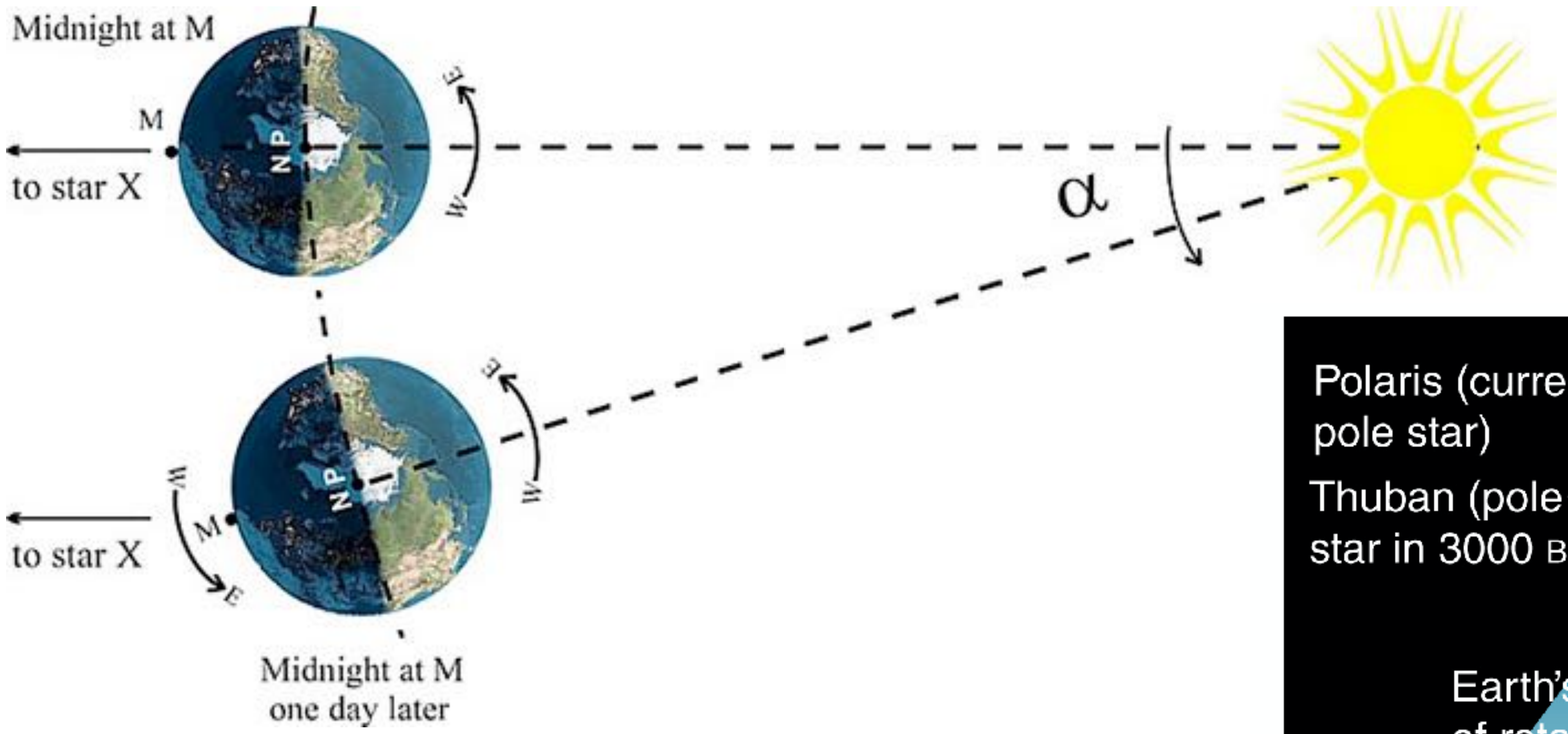
Whiteboard

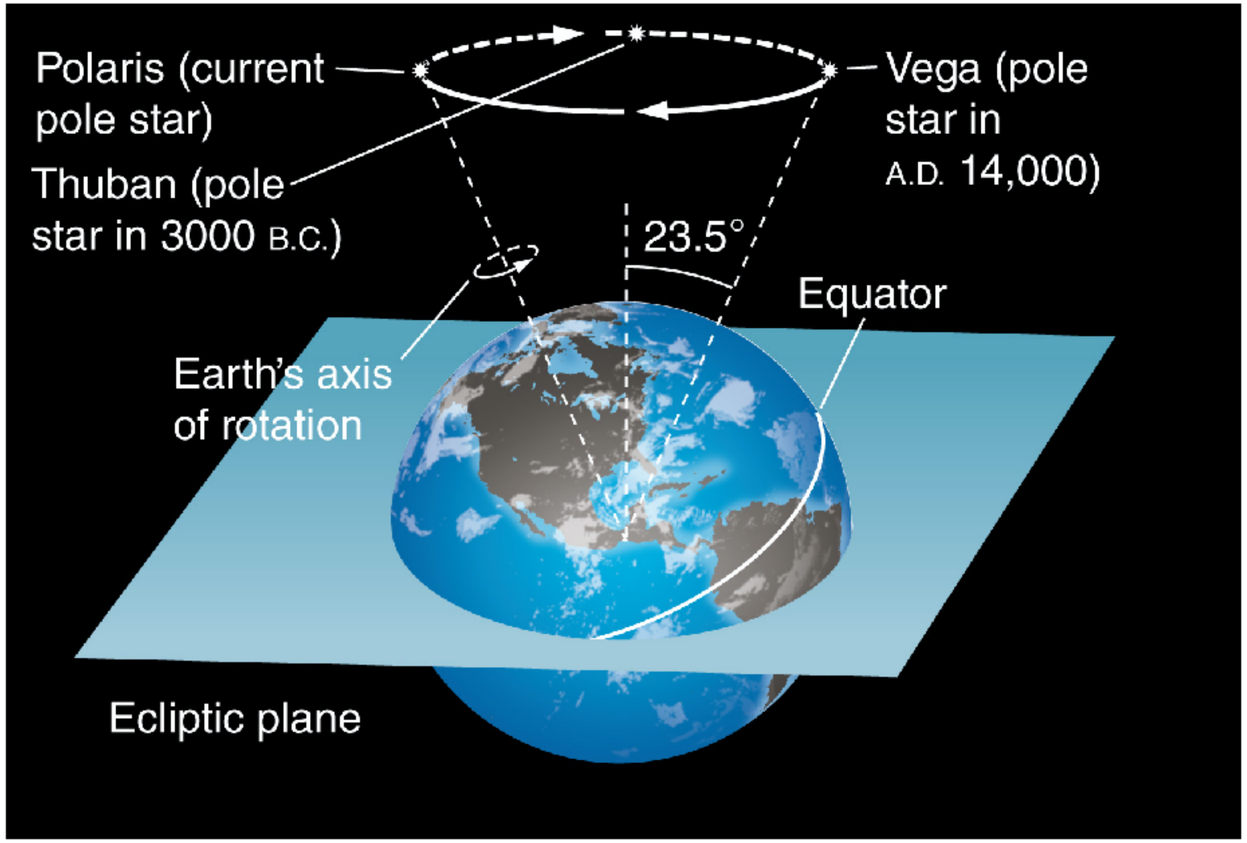
Midterm 1 Review!



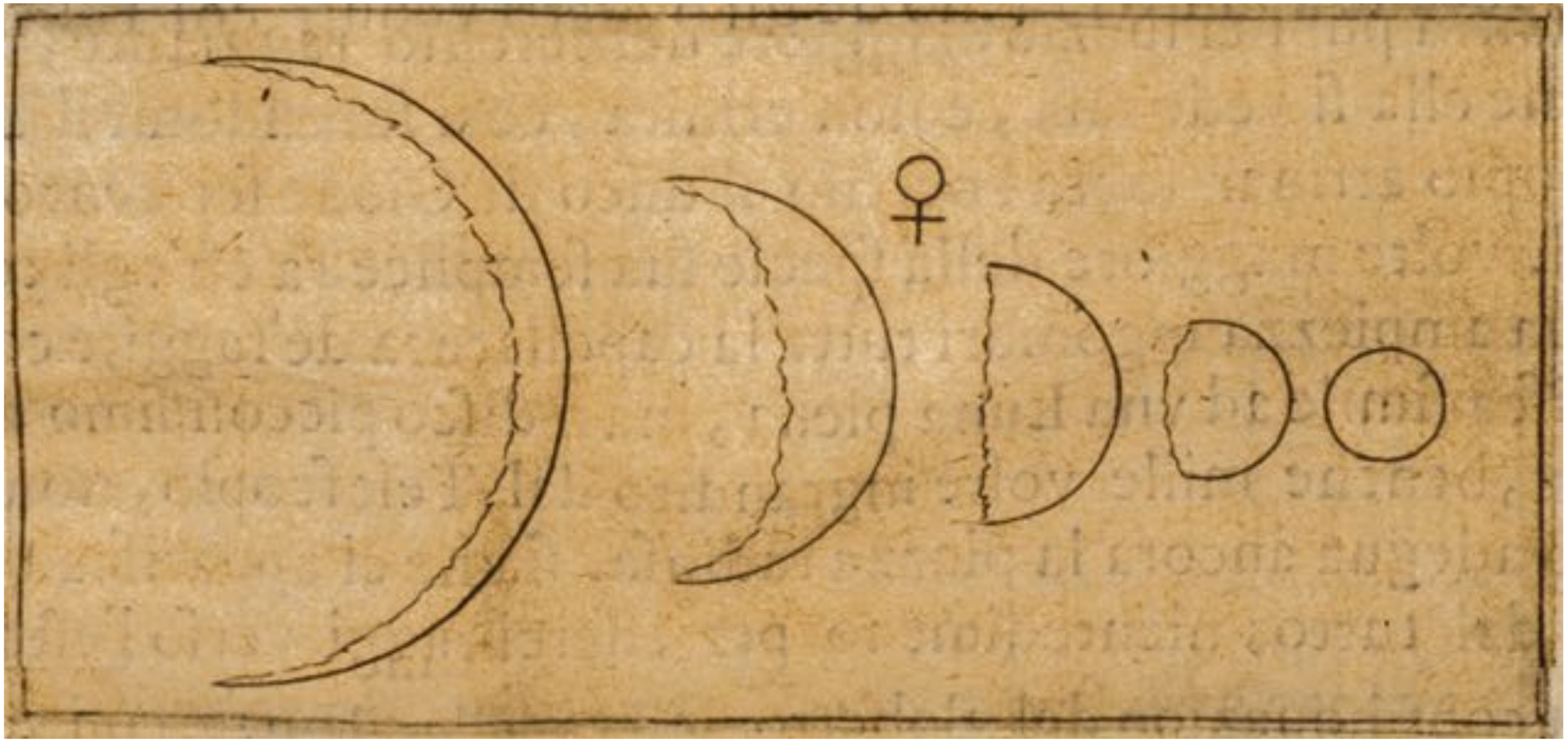
Sky Coordinates (RA/Dec)

Rise/Set Times & Precession



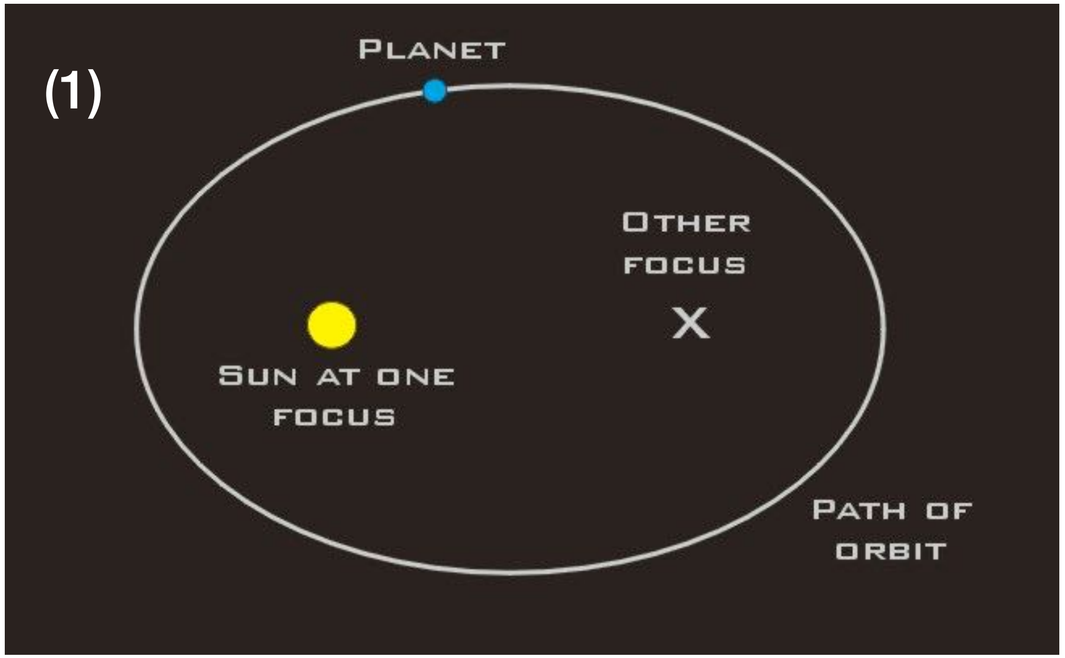


How do Galileo's observations of Venus support the heliocentric model of the solar system?

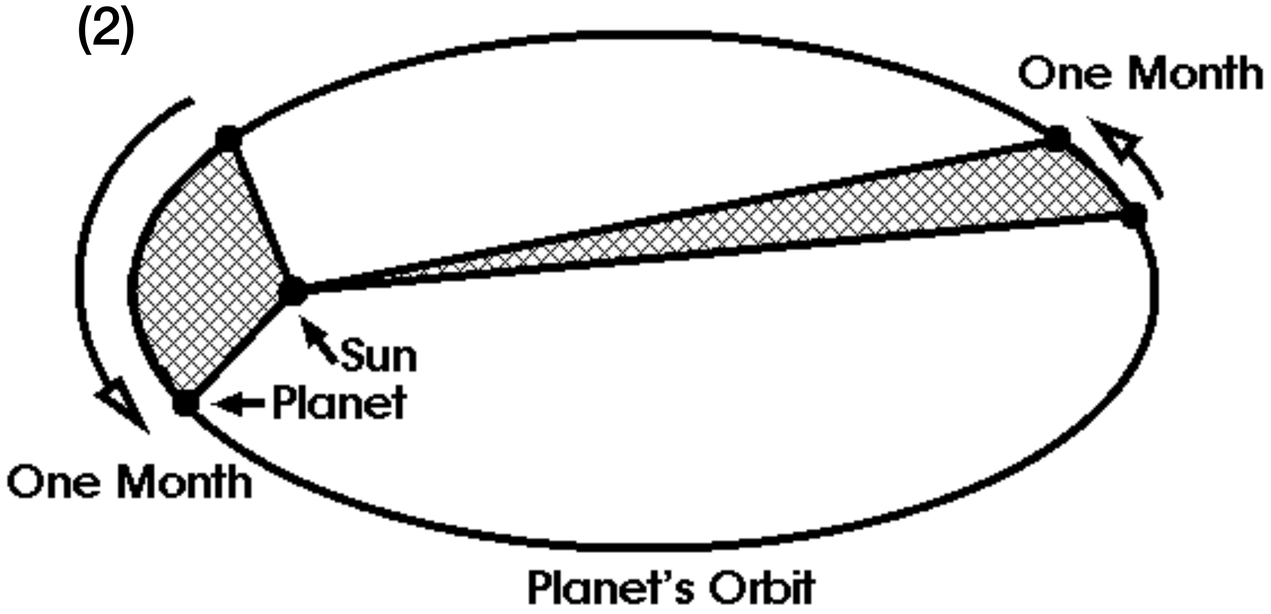


Kepler's 3 Laws

(1)



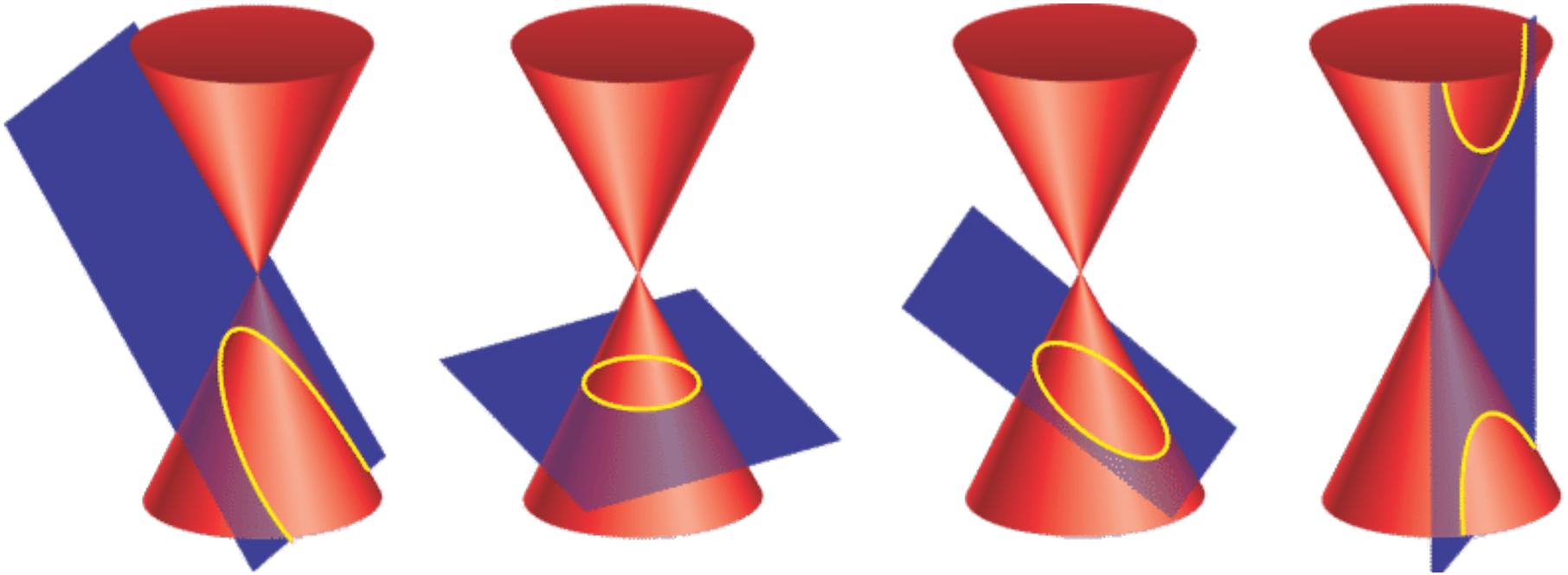
(2)



(3) $$P^2 = \frac{4\pi^2}{G(M+m)}a^3$$

Generic Orbits & Energetics

$$E = \frac{1}{2}mv^2 - \frac{GMm}{r}$$



Parabola
$e = 1$
$E_{tot} = 0$

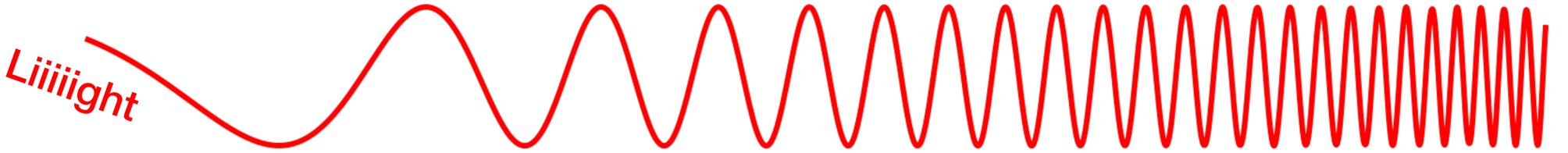
Circle
$e = 0$
$E_{tot} < 0$ (minimum for a given L)

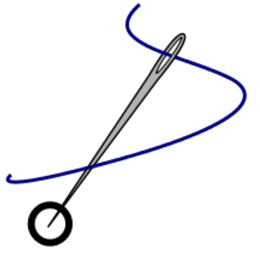
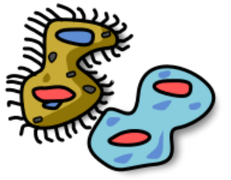
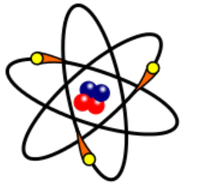
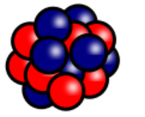
Ellipse
$0 < e < 1$
$E_{tot} < 0$

Hyperbola
$e > 1$
$E_{tot} > 0$

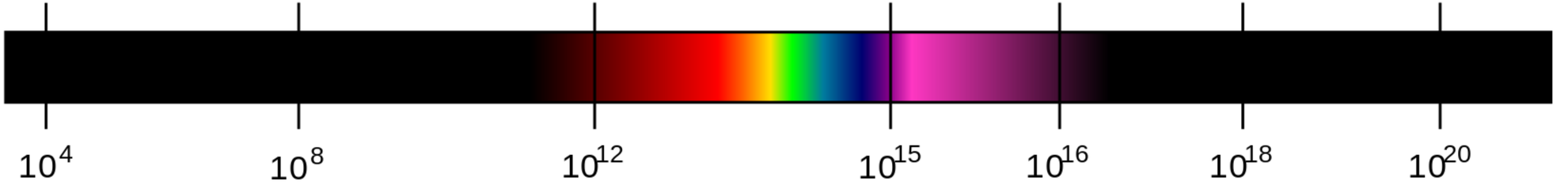
Penetrates Earth's Atmosphere?

Y		N		Y	N

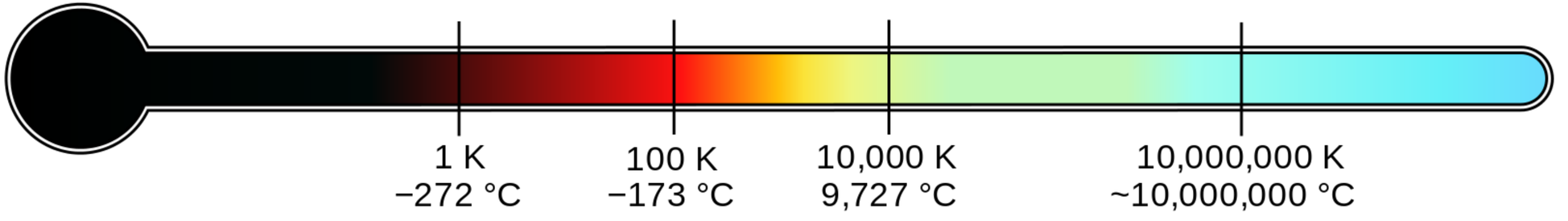


Radiation Type	**Radio**		**Microwave**	**Infrared**	**Visible**	**Ultraviolet**	**X-ray**	**Gamma ray**
Wavelength (m)	10^{3}		10^{-2}	10^{-5}	0.5×10^{-6}	10^{-8}	10^{-10}	10^{-12}
Approximate Scale of Wavelength								
	Buildings	Humans	Butterflies	Needle Point	Protozoans	Molecules	Atoms	Atomic Nuclei

Frequency (Hz)



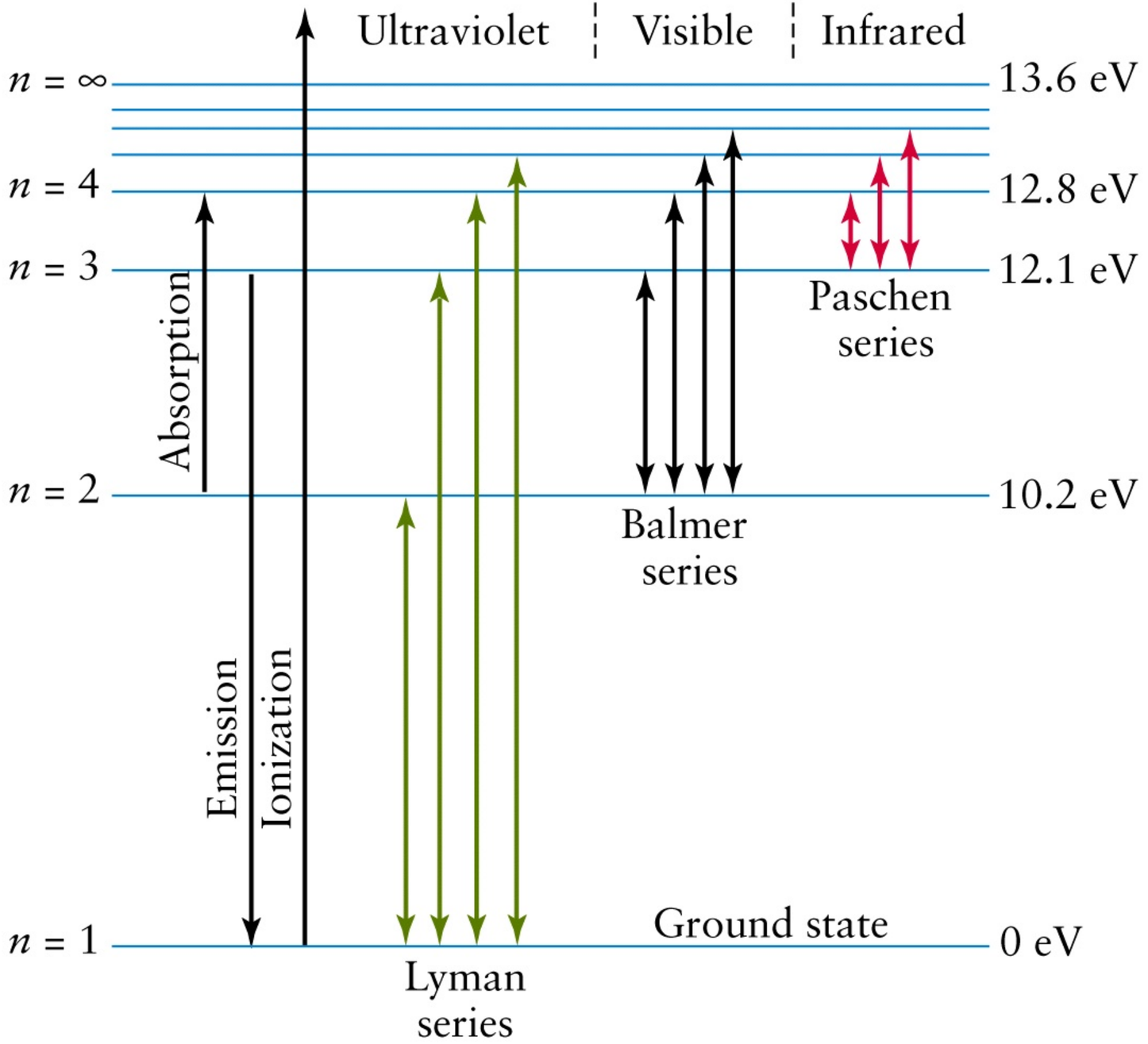
Temperature of objects at which this radiation is the most intense wavelength emitted



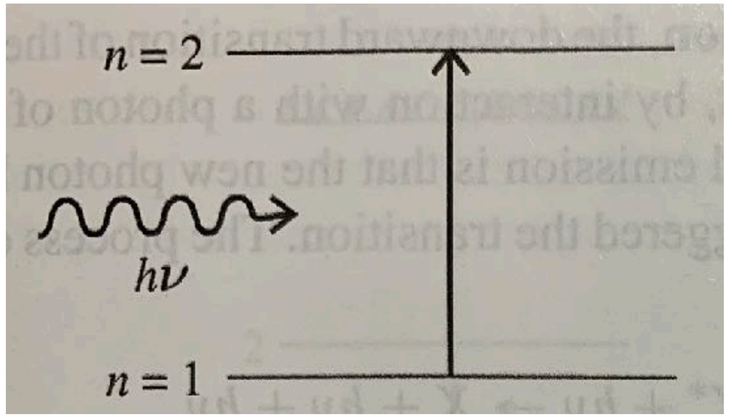
Energy Levels

$$\Delta E = E_n - E_{n'} = (13.6\ \text{eV})\ Z^2 \left[\frac{1}{(n')^2} - \frac{1}{n^2}\right]$$

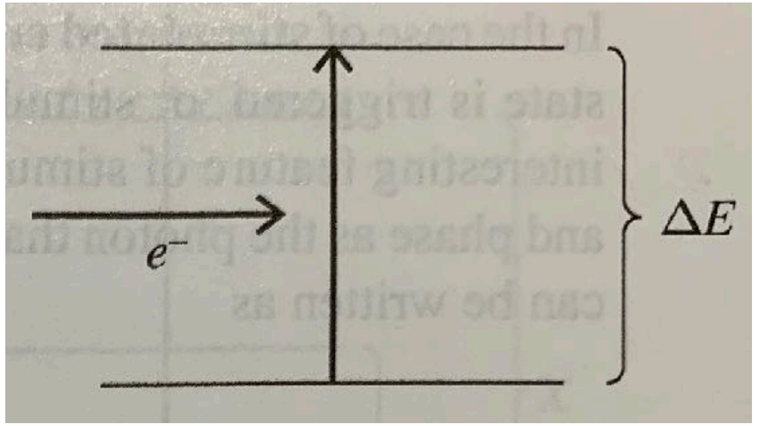
(Energies correspond to neutral hydrogen)



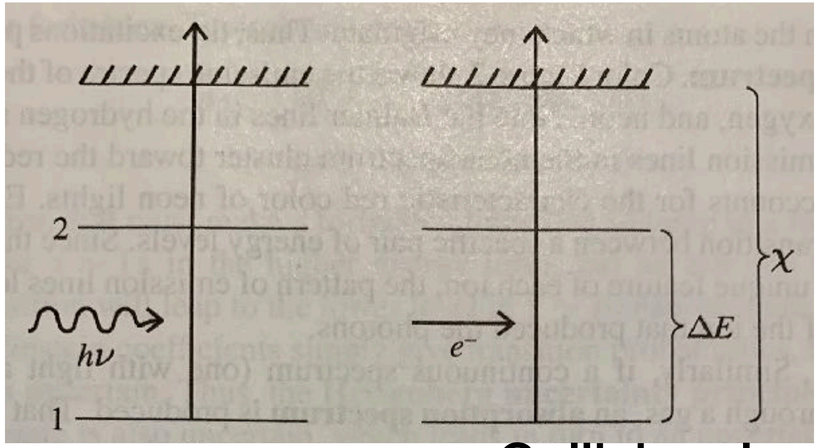
Emission / Absorption Processes



Photoexcitation

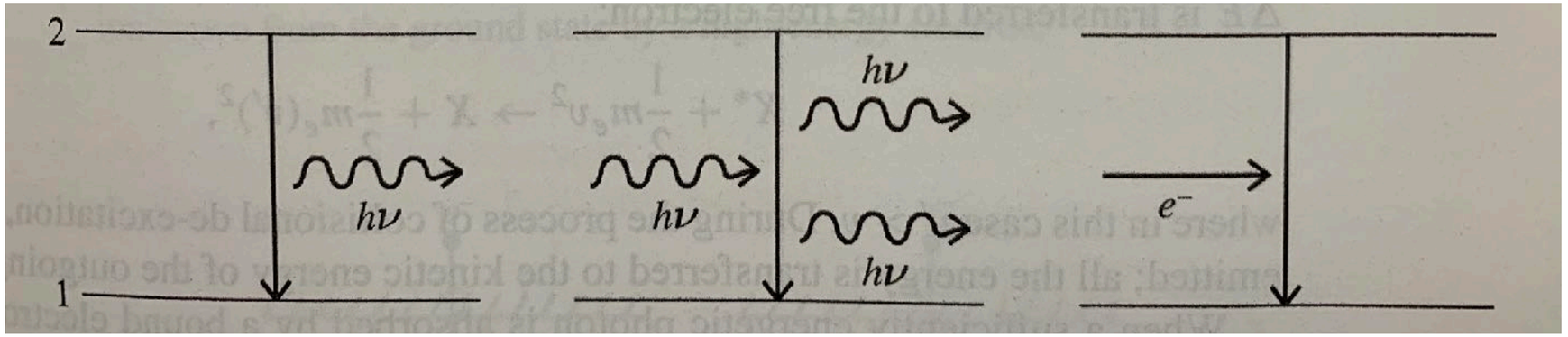


Collisional Excitation



Photoionization

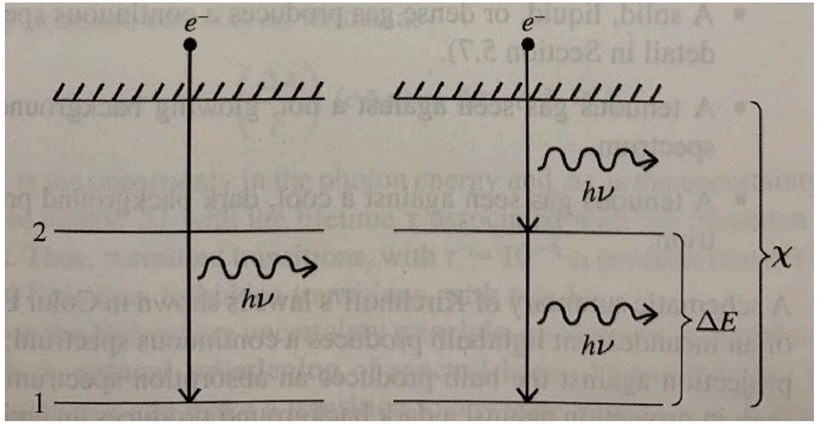
Collisional Ionization



Spontaneous Emission

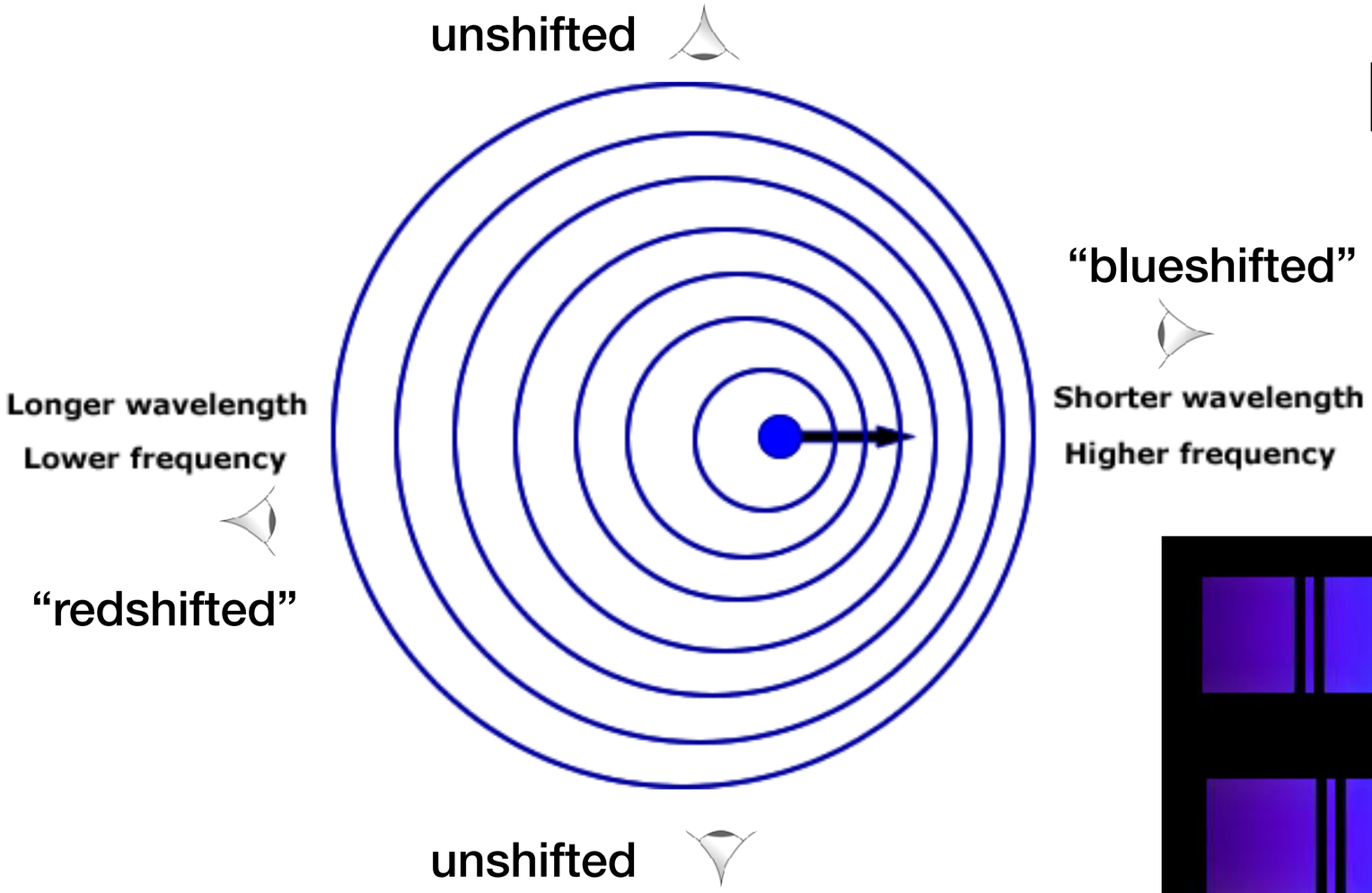
Stimulated Emission

Collisional De-excitation

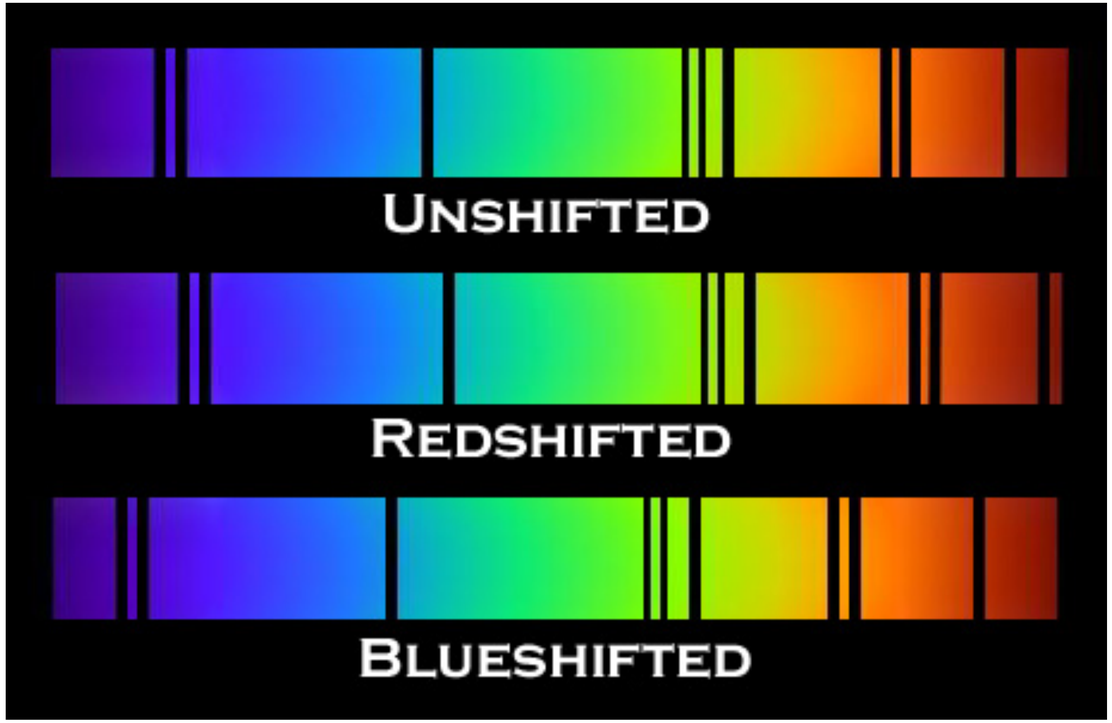


Radiative Recombination

Doppler Shift



$$z = \frac{\Delta\lambda}{\lambda} = \frac{\Delta\nu}{\nu}$$



Allows us to infer motions
along the "line of sight"

Lines are not delta functions!

i.e., the difference b/t energy levels is NOT exact

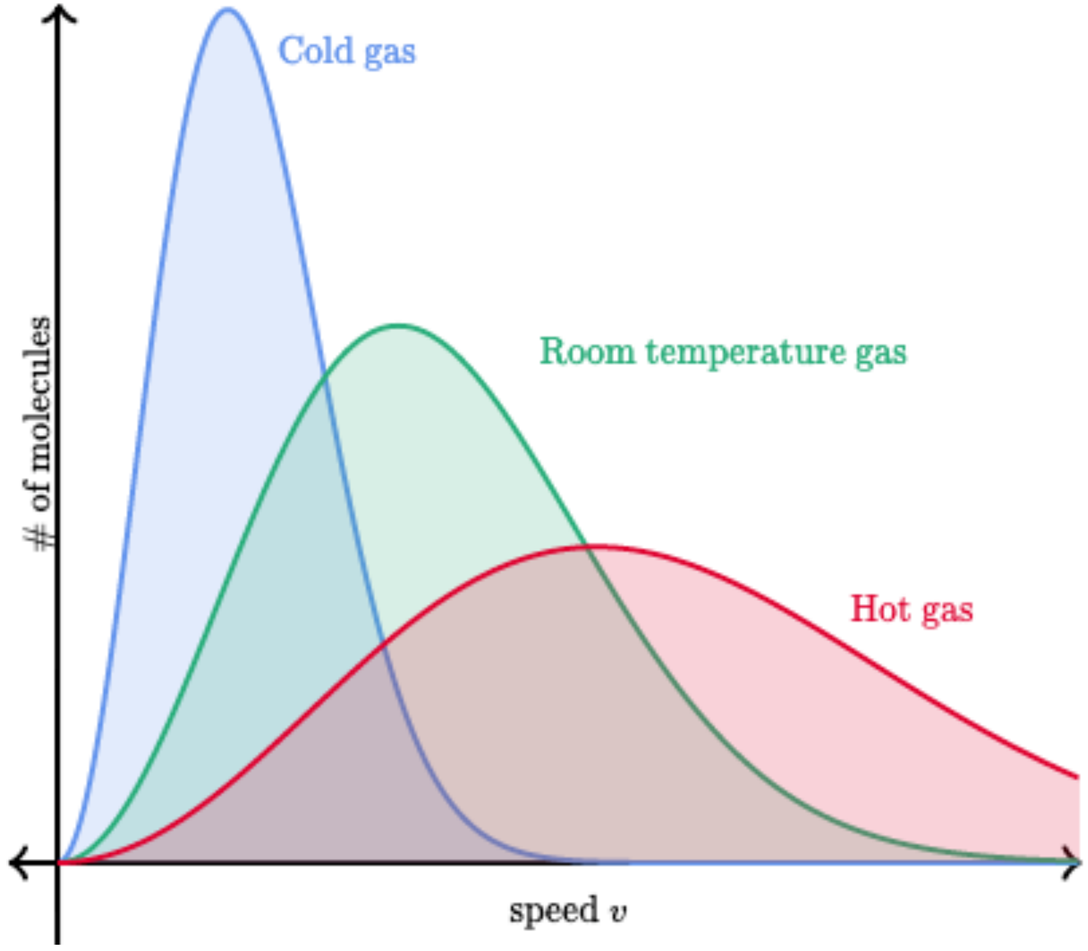
Motion-induced Broadening (small Doppler shifts cause lines to appear more broad)

- Thermal Broadening
- Rotational Broadening
- Turbulent Broadening

Other Types of Broadening

- Natural Broadening
- Pressure Broadening
- Zeeman Broadening

Velocity distribution of particles in thermal equilibrium have a Maxwell-Boltzmann distribution



$$F(v)dv = 4\pi \left(\frac{m}{2\pi kT}\right)^{3/2} v^2 \exp\left(-\frac{mv^2}{2kT}\right) dv$$

$$F(E)dE = F(v)\frac{dv}{dE} = \frac{2}{\sqrt{\pi}kT}\left(\frac{E}{kT}\right)^{1/2} \exp\left(-\frac{E}{kT}\right)$$

$$\langle x \rangle = \int x f(x) dx$$

$$\langle v \rangle = \sqrt{\frac{8kT}{\pi m}}$$

Avg. particle speed

$$\langle E \rangle = \frac{3}{2}kT$$

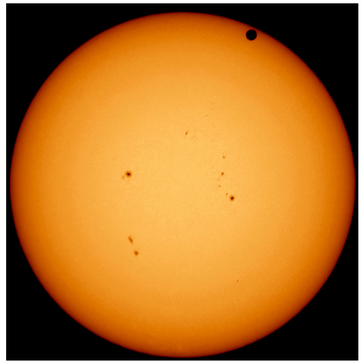
Avg. particle kinetic energy

Radiative Transfer / Optical Depth / LTE

$$I_\nu = I_{0,\nu} \exp[-\tau_\nu(x)]$$

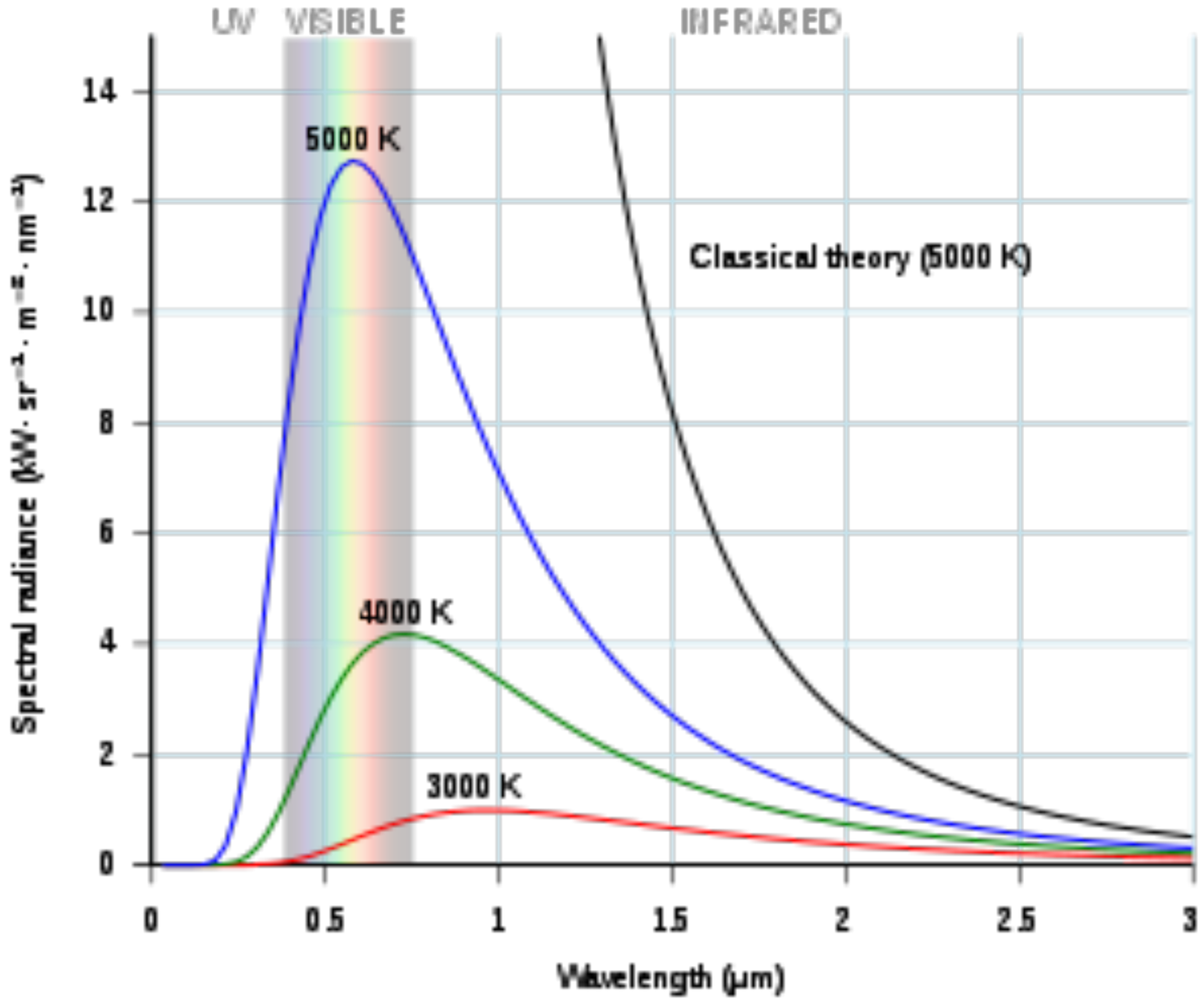
$$\tau = n\sigma x$$

$$\text{m.f.p. } \ell = \frac{1}{n\sigma}$$

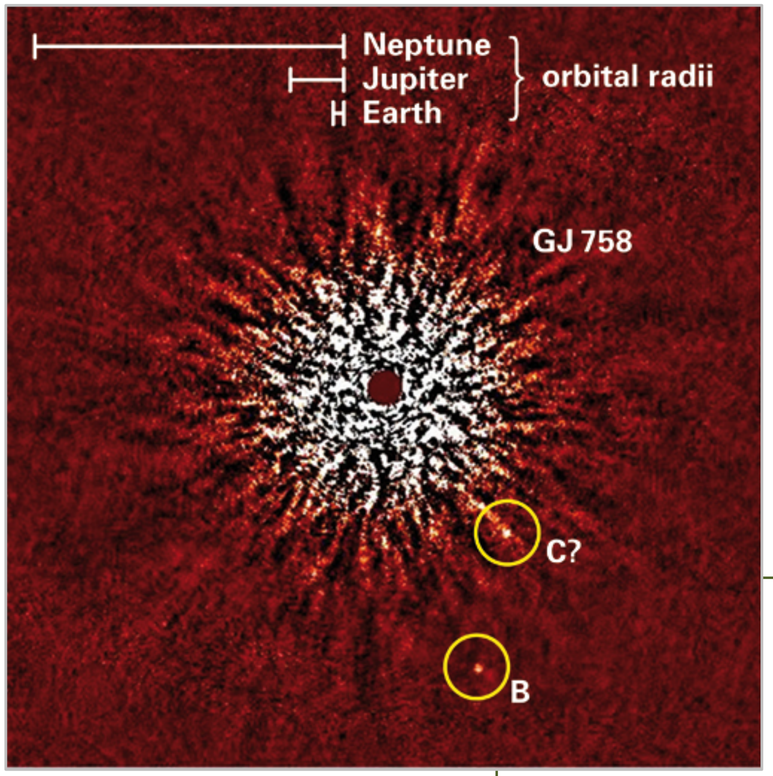


$$J_\nu = \frac{2h\nu^3}{c^2} \frac{1}{e^{h\nu/kT} - 1}$$

$$L = 4\pi R^2 \sigma_{\rm SB} T^4$$

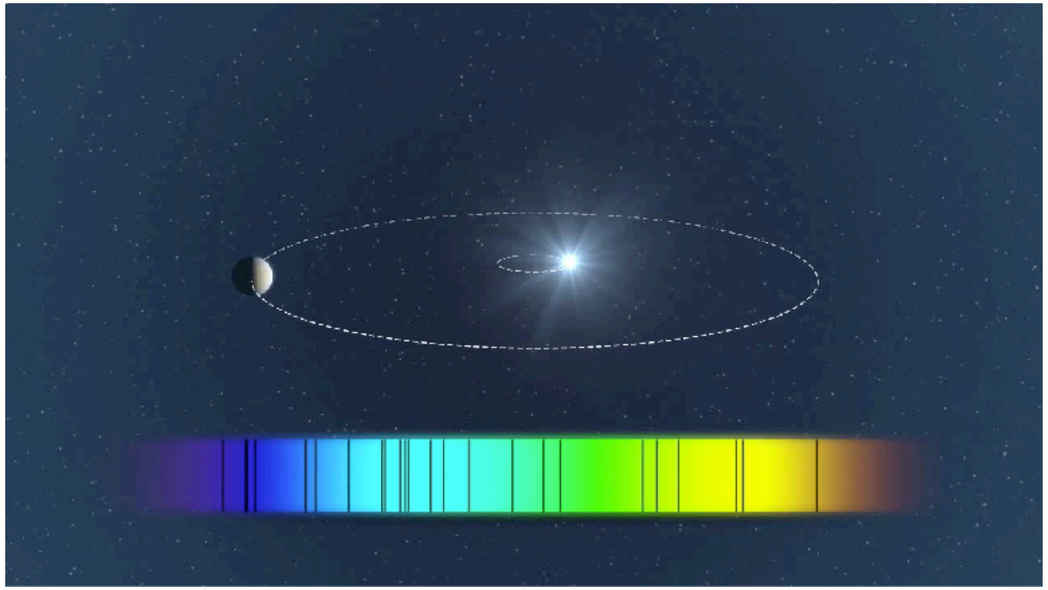


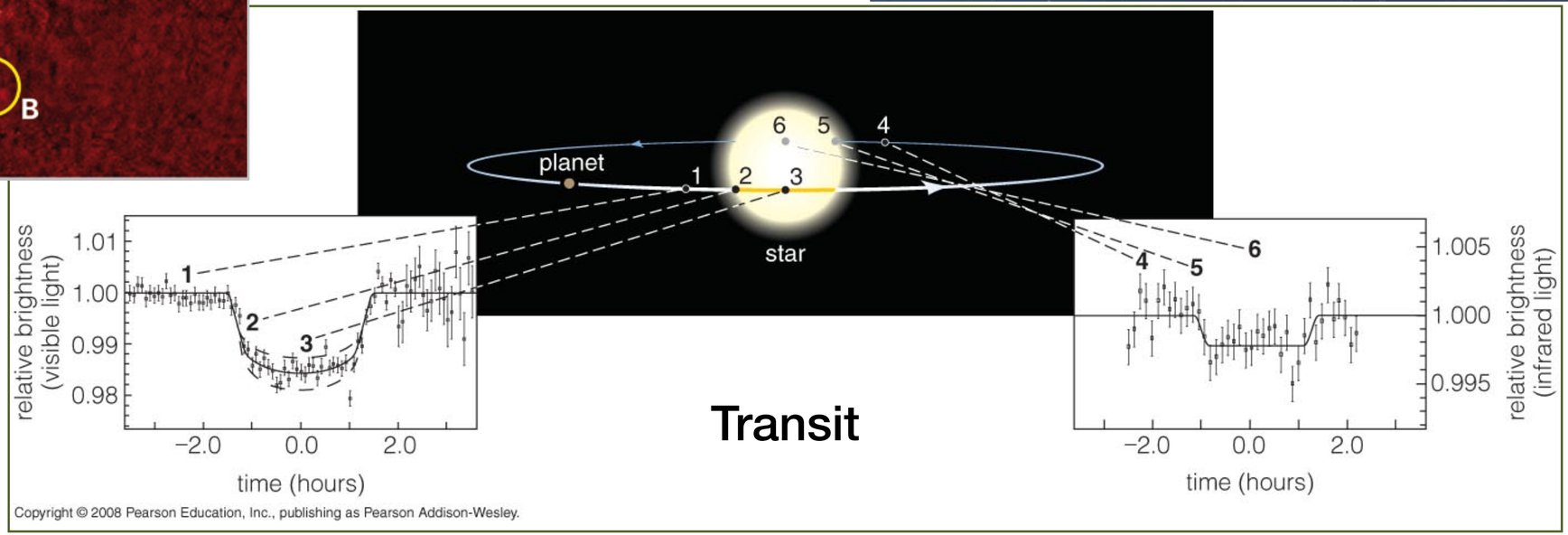
Exoplanet Detection



Direct

Radial Velocity





Transit

Measuring Stars

Parallax

$$d = \frac{1 \text{ pc}}{\pi''}$$

Inverse Square Law

$$F = \frac{L}{4\pi d^2}$$

Effective Temperature

$$T_{\text{eff}} = \left(\frac{L}{4\pi R^2 \sigma_{\text{SB}}} \right)^{1/4}$$

$$m_2 - m_1 = 2.5 \log(F_1/F_2)$$

Apparent Magnitude

$$m = C - 2.5 \log(F)$$

Absolute Magnitude

$$M_{\text{bol}} = 4.74 - \log\left(L/L_{\odot}\right)$$

Distance Modulus

$$m - M = 5 \log\left(\frac{d}{10 \text{ pc}} \right)$$