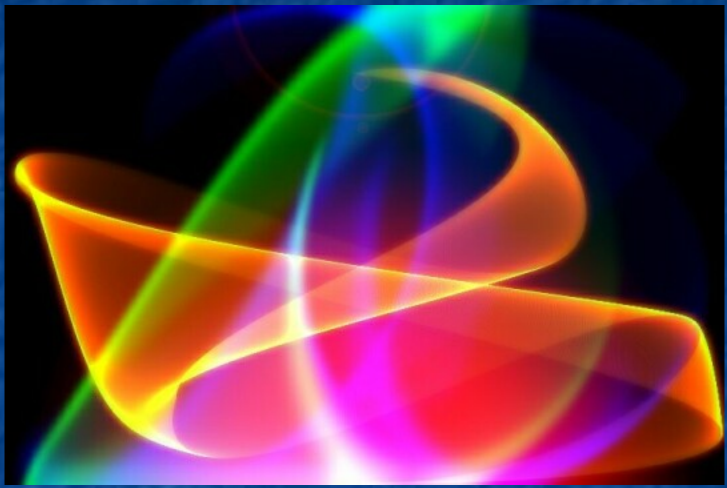
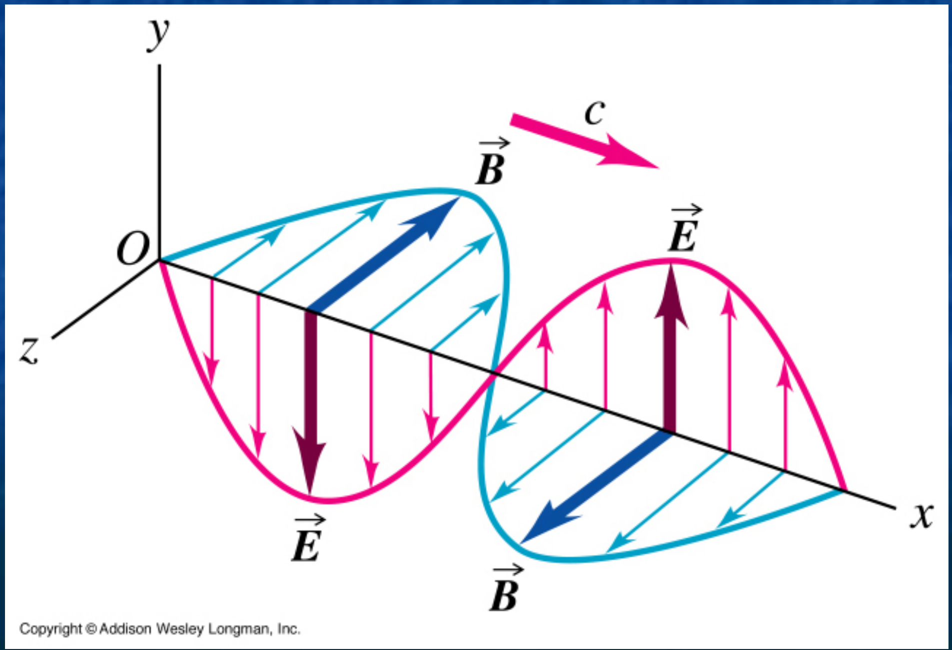
Astro 18 – Section Week 2

EM Spectrum

ElectroMagnetic Radiation

- Energy moves in waves with electrical and magnetic components



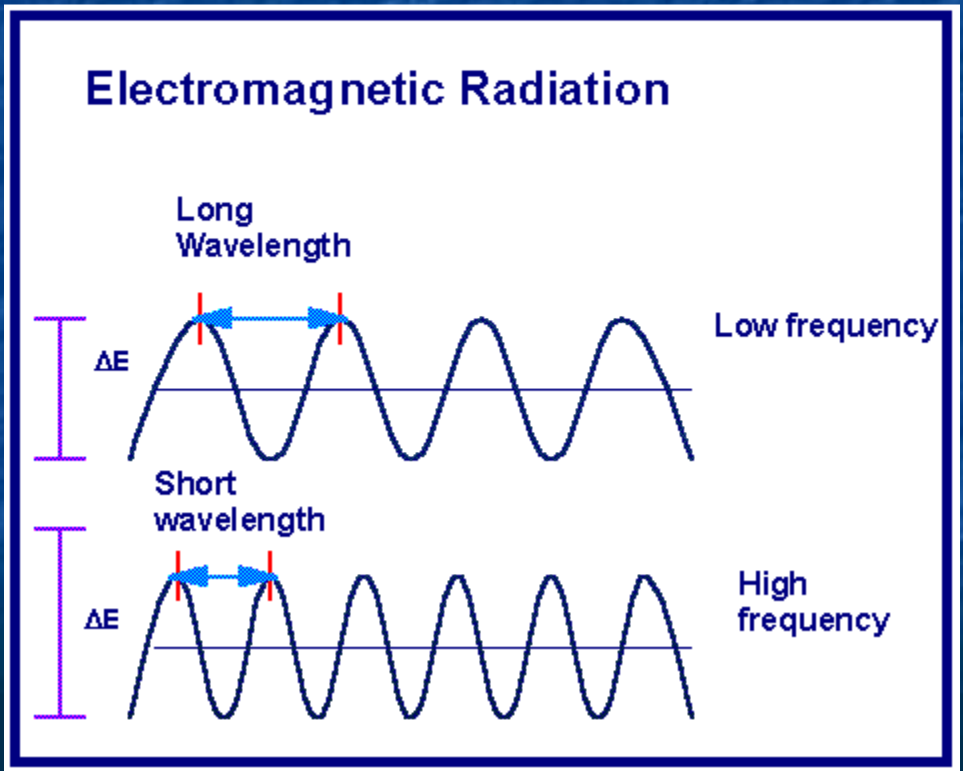


- All EMR travels at speed of light in a vacuum

ElectroMagnetic Radiation

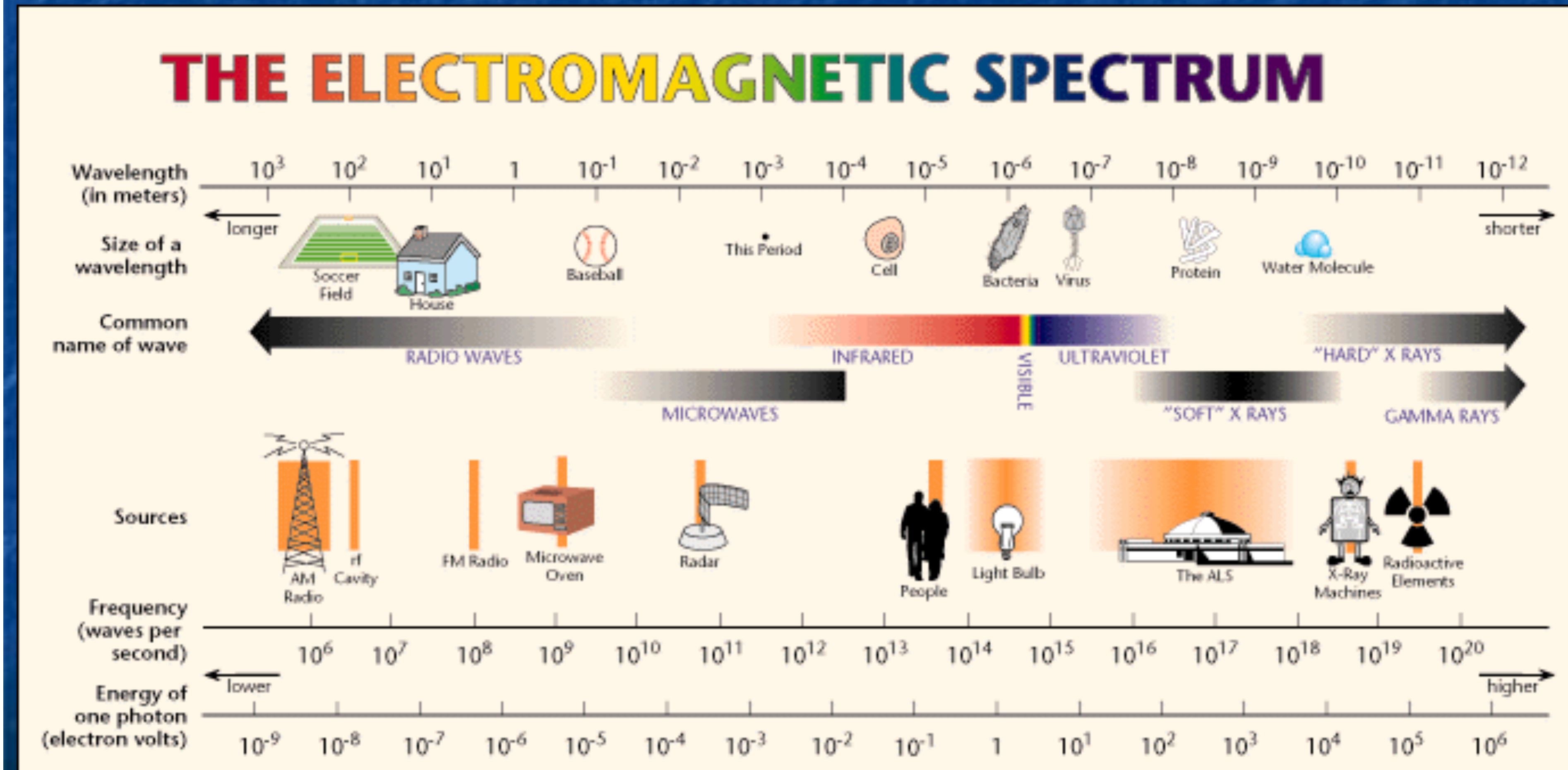
- Energy = $h\nu$ where $\nu = c/\lambda$

$h = 6.626068 \times 10^{-34}\ m^2\ kg\ /\ s$

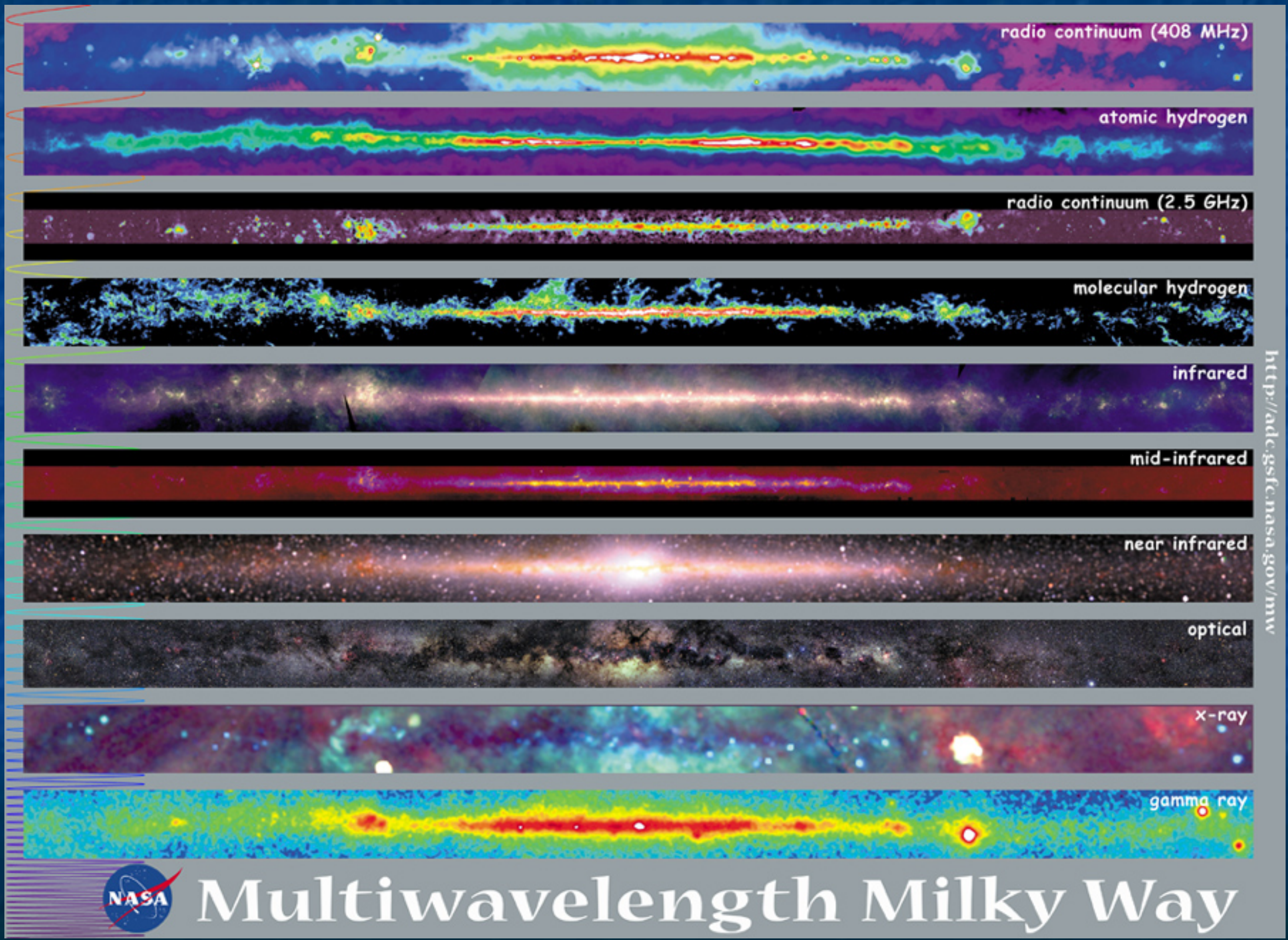


- 21cm line (HI) has what frequency & energy?
- 1427583133.3 Hz
  - Or 1.4276 GHz
- $E = 9.4592 \times 10^{-25}$ J

ElectroMagnetic Radiation

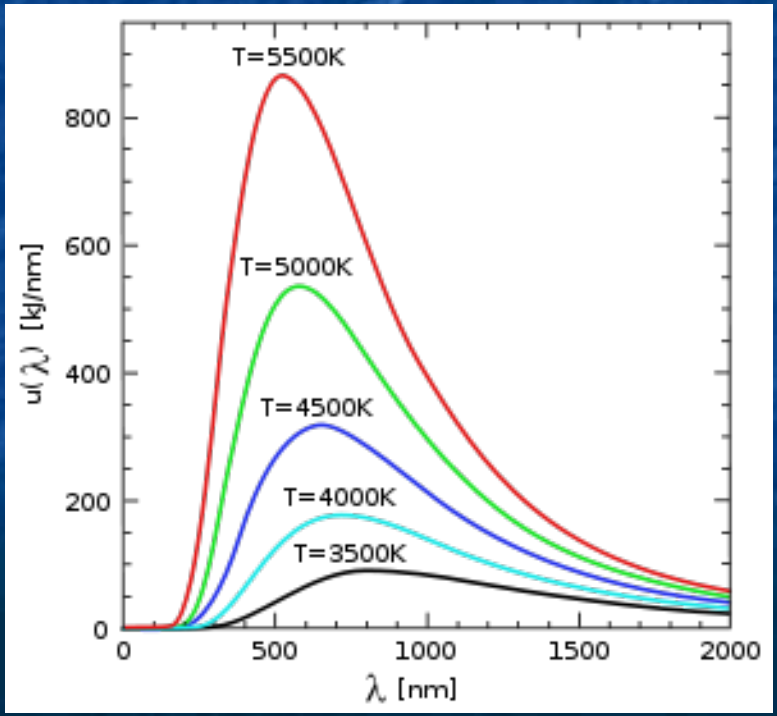


ElectroMagnetic Radiation



Wien's Law

- Distribution of radiated energy from blackbody at T_1 has same shape as distribution at T_2 except it's displaced on the graph



$\lambda_{max} = b/T$

b= 2.8977685×10^{-3} m·K

T = temp in Kelvin

Wien's Law - Sun

- First need temperature of sun
  - Total power radiated = $4*10^{26}$ Watts
  - Radius = $7*10^{8}$ meters

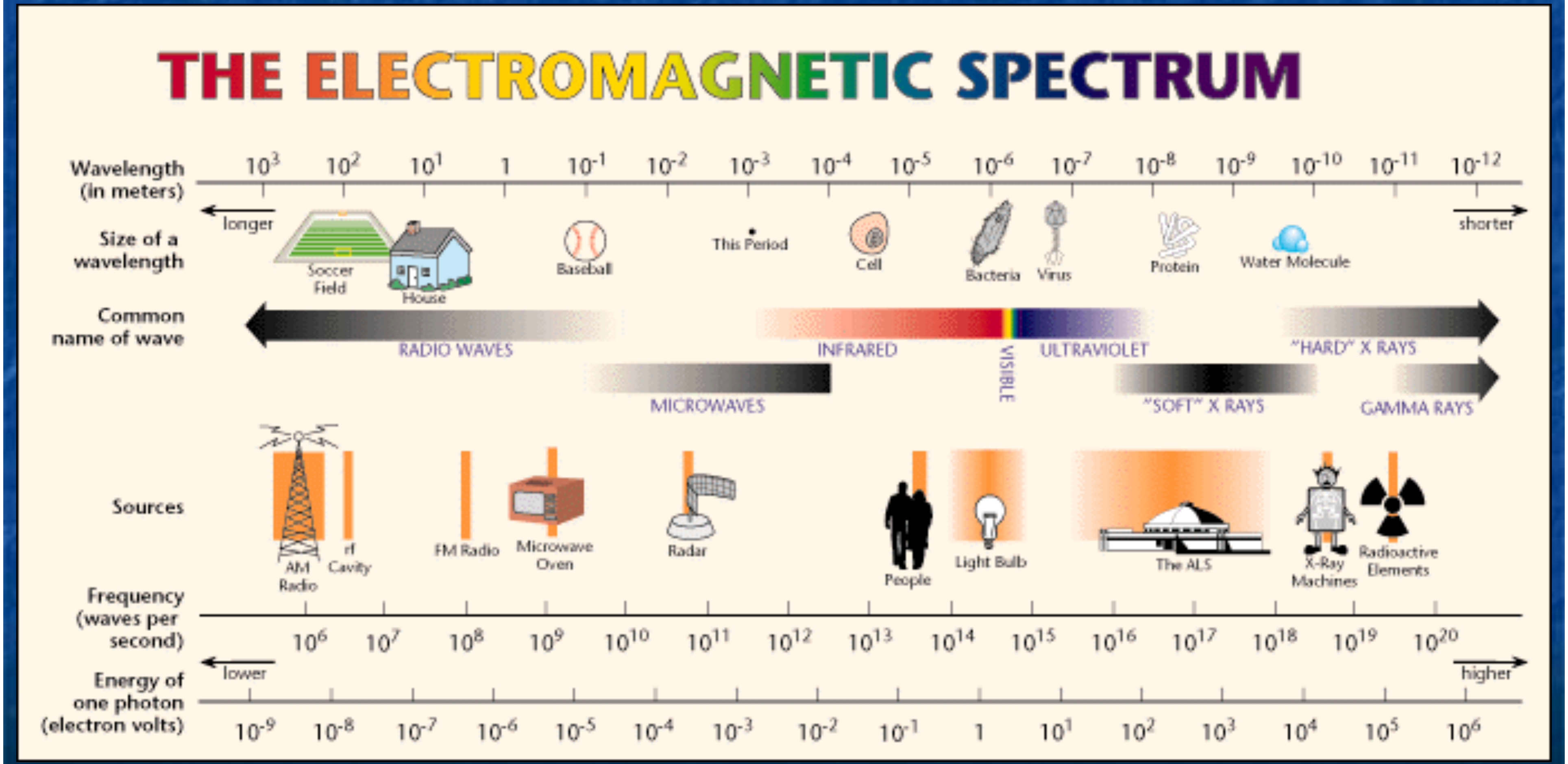
$$T = 6000K$$

- Then, $\lambda_{max} = b/T$

$b = 2.8977685\times10^{-3}$ m·K

$$\lambda_{\max} = 500 nanometers$$

Wien's Law - Sun



Wien's Law - Student

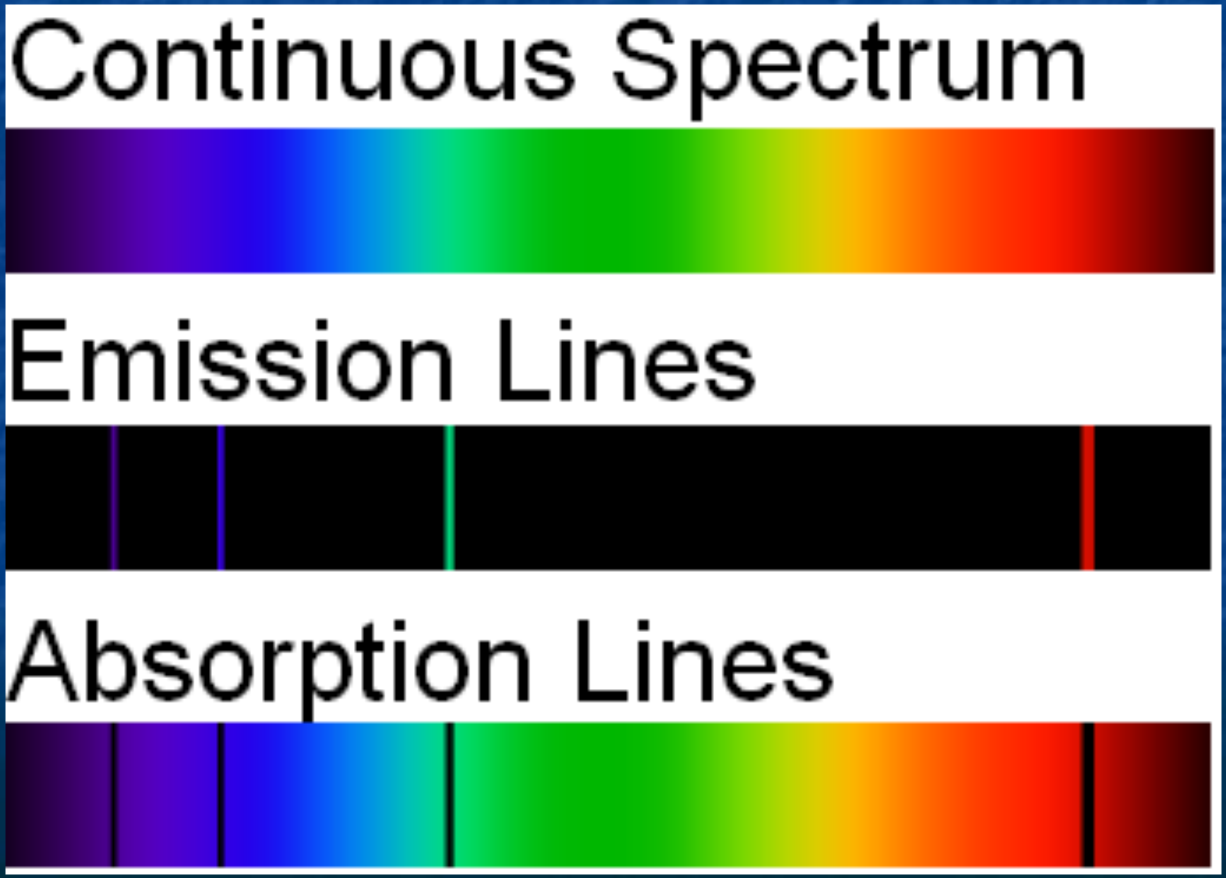
- Body temp ~ 98°F
  - Convert to Kelvin

- λ_{max} = b/T b = 2.8977685×10^{-3} m·K

- So λ_{max} = 10μm which is far-IR

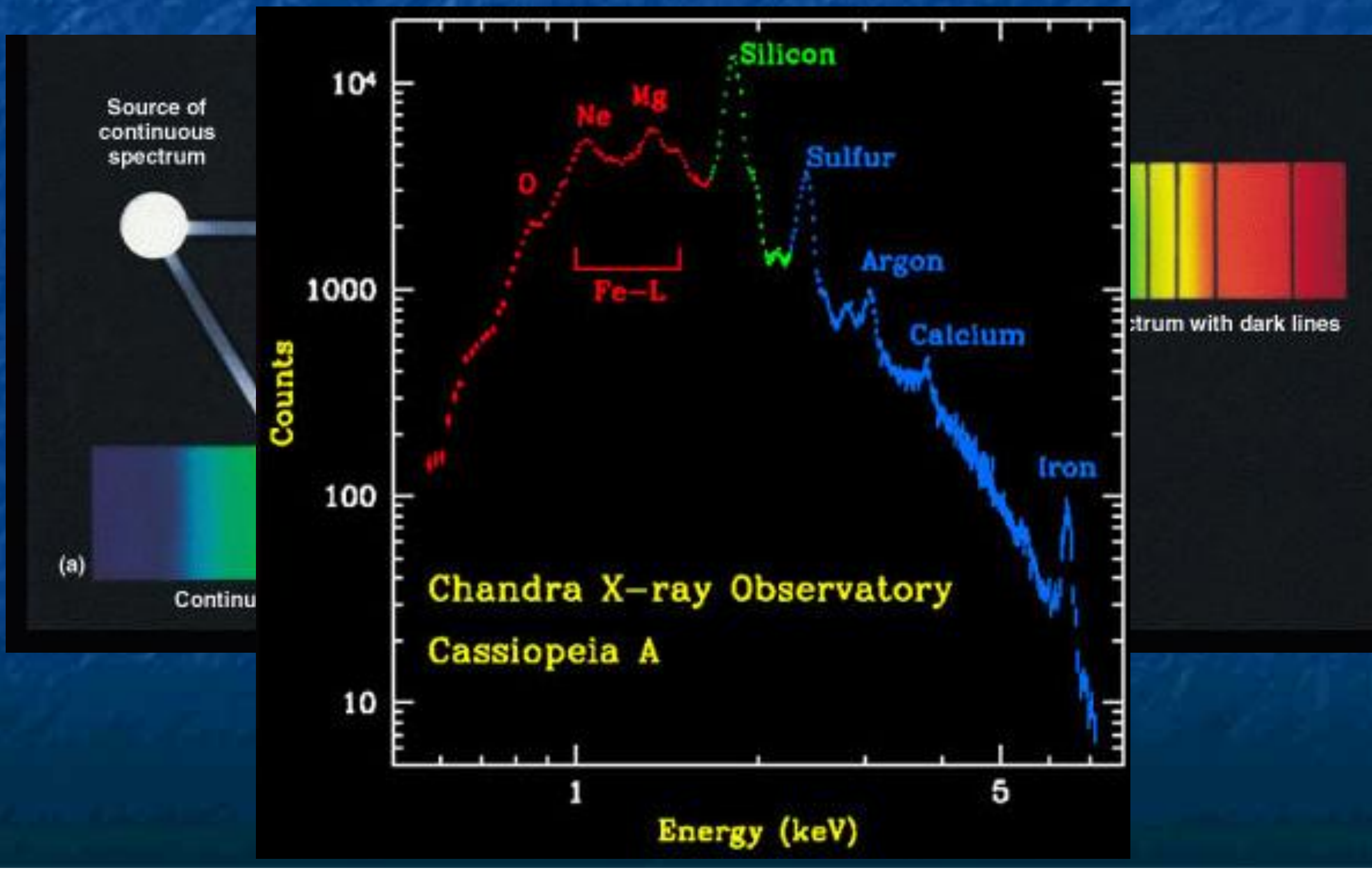
Spectral Lines

- 2 Types:
  - Emission
  - Absorption

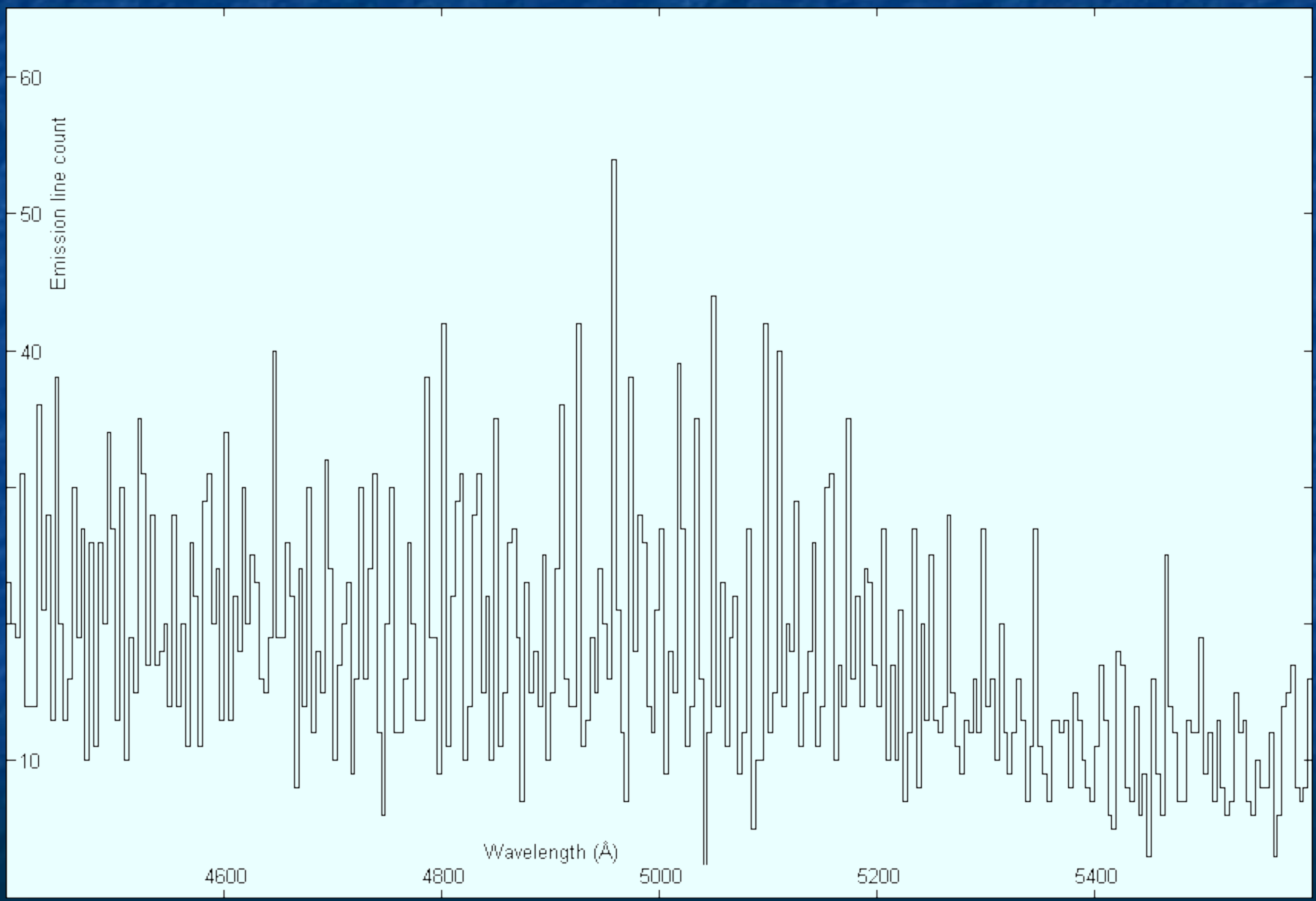


Emission Lines

- Cloud of gas, warmer than background

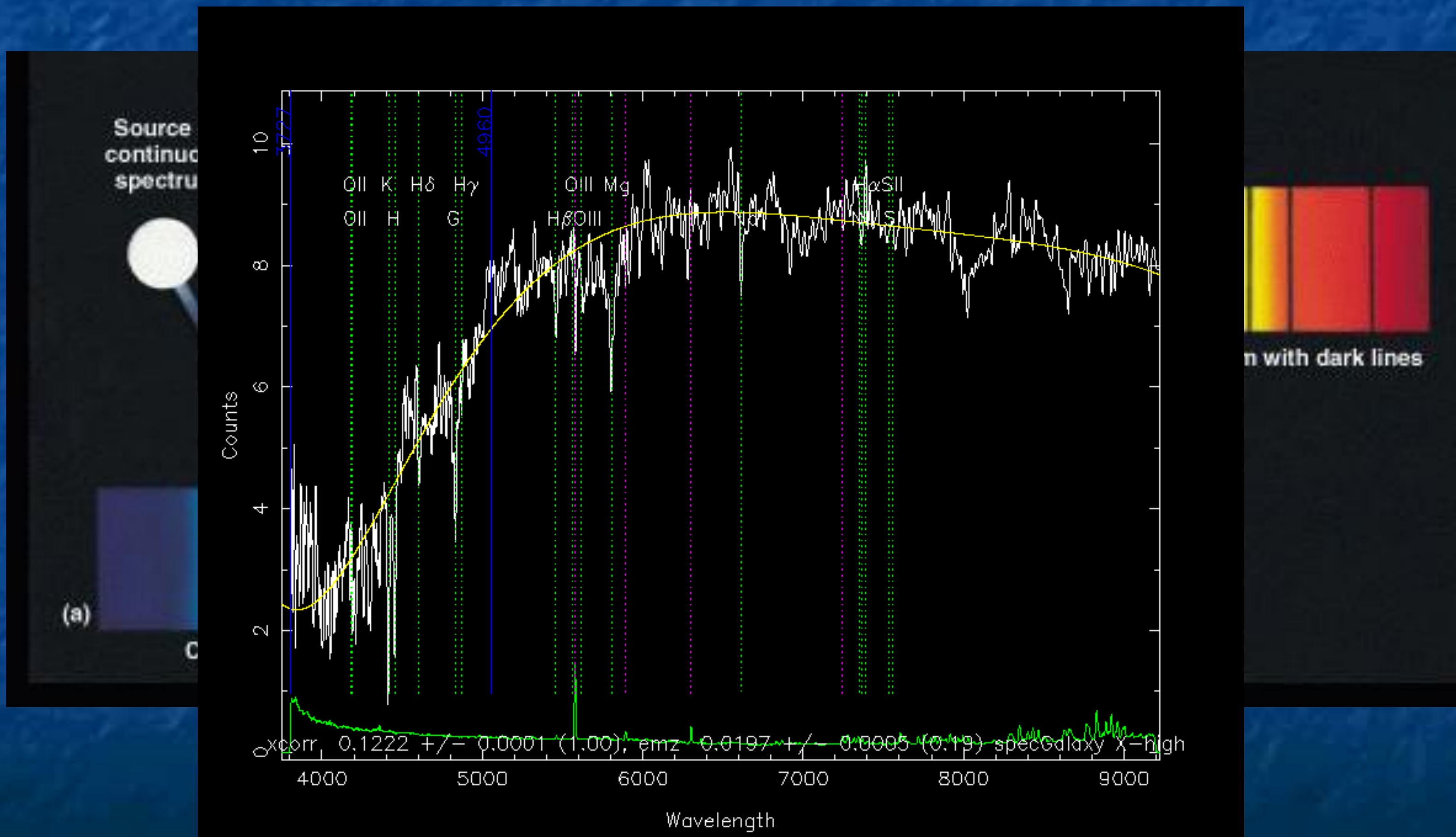


Emission Lines



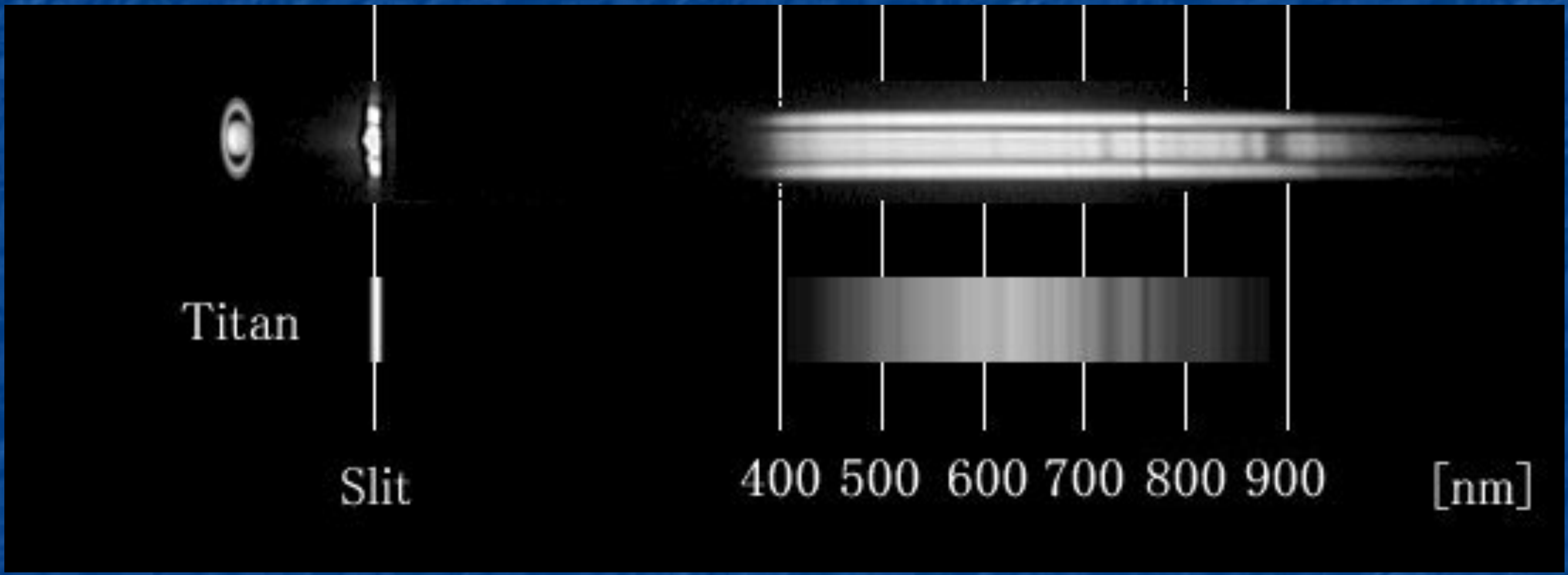
Absorption Lines

- Hot source behind cloud of cold gas



Absorption Lines

- Useful in planetary atmospheres



- The deeper absorption line at 760nm is caused by our atmosphere's oxygen molecule. The two absorption lines at 720 and 890nm (from methane) appear on Saturn and Titan, but the rings do not have them

Doppler Shift

- Classic sound example:
- Because the source of the sound is moving towards/away from you

A stationary bug producing disturbances in water.

A bug moving to the right and producing disturbances.

Doppler Shift

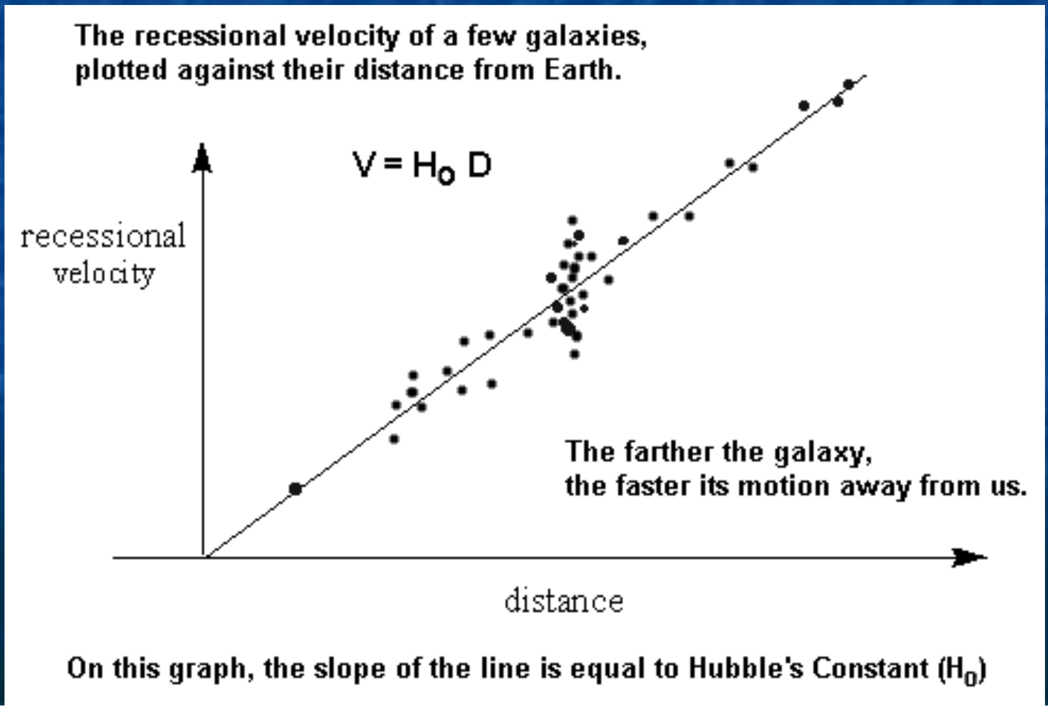
- Same thing occurs with light from stars, etc

$$z = \frac{\lambda_{obs} - \lambda_{emit}}{\lambda_{emit}} \qquad z = \frac{velocity}{c}$$

- In H, the transition from level 2 → 1 has a rest wavelength of 121.6 nm. Suppose you see this line at a wavelength of 121.3 nm in star A and 122.9 nm in star B. Calculate each star's speed and state if it's moving towards or away from us.

Red Shift & Distance

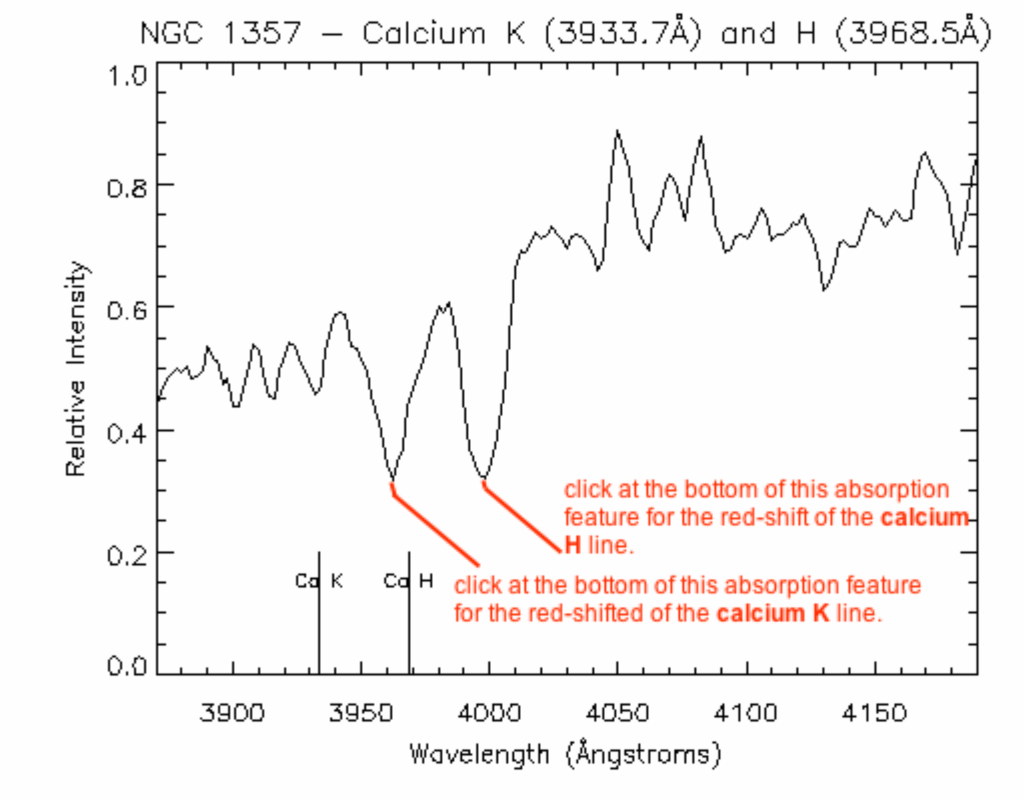
- In general everything is moving away from us - expanding universe
  - Red shift can be used to calculate distance to objects (Hubble's Law)



Redshift & Distance

$$z = \frac{\lambda_{obs} - \lambda_{emit}}{\lambda_{emit}}$$

$$z = \frac{velocity}{c}$$



- For this galaxy, the measured wavelength of the Ca K line was 3962.0 Å, rest wavelength for Ca K is 3933.7 Å

$$z = \frac{3962.0A - 3933.7A}{3933.7A} = 0.0071$$

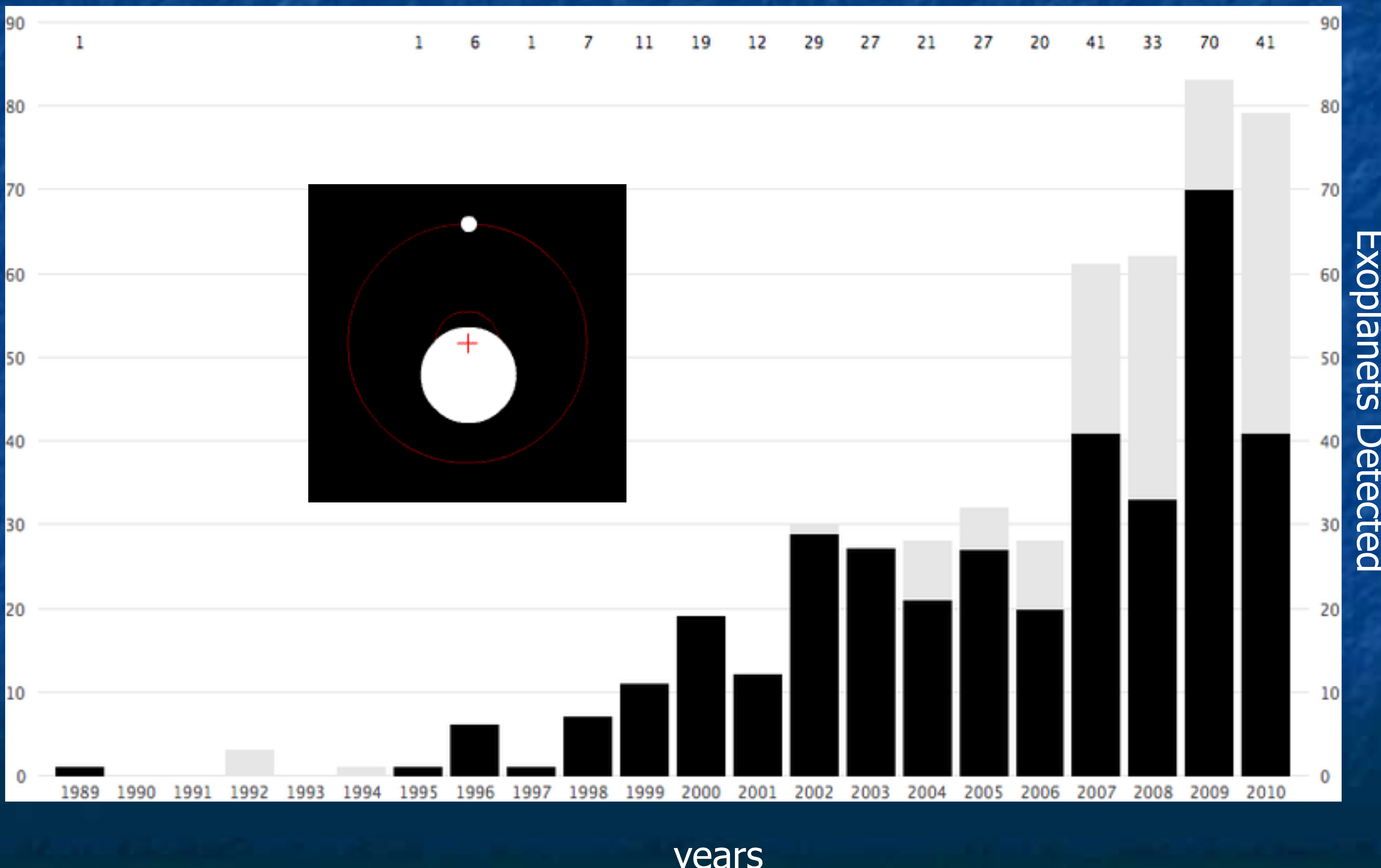
$$v = zc = 0.0071 * 3 * 10^8 m/s$$
$$= 2{,}128{,}526\text{m/s}$$

$$d = \frac{v}{H_o} = \frac{2{,}128{,}526 m/s}{70000\text{(m/sec)/Mpc}}$$
$$= 30 Mpc = 97{,}849{,}088 \text{ lightyear}$$

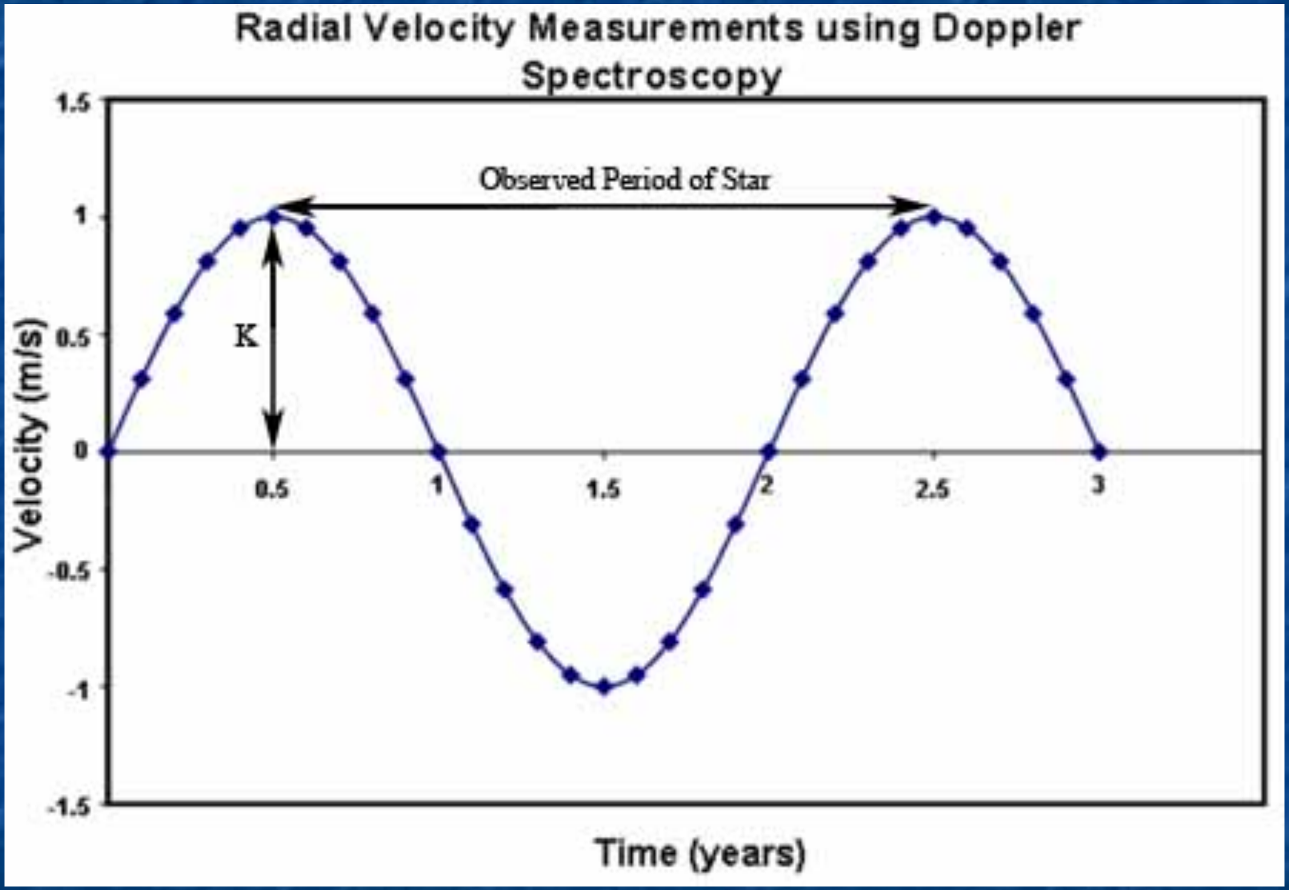
Redshift & Distance

- NGC 1357

Exoplanet Detection



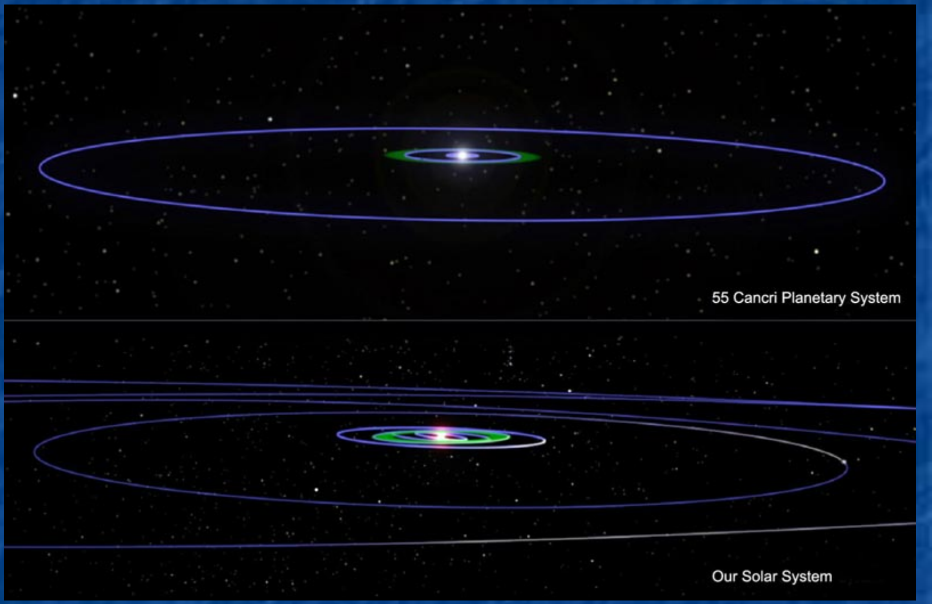
Exoplanet Detection



- star's velocity shows a periodic variance of ±1 m/s, suggesting an orbiting mass that is creating a gravitational pull on this star
- Use Kepler's third law – period of planet (equal to period of variation in star's spectrum) used to get radius

Exoplanet Detection

- Kepler: $$r^3 = \frac{GM_{star} P_{star}^2}{4\pi^2}$$
- Orbit Eqn: $$V_{pl} = \sqrt{\frac{GM_{star}}{r}}$$
- Mass Eqn: $$M_{pl} = \frac{M_{star} V_{star}}{V_{pl}}$$



Exoplanet Detection

- Planet orbiting 51Peg has an orbital period of 4.23 days, the star's mass is 1.06M_{sun}. What is the planet's orbital distance?

$$r = 7.81 * 10^{9}\, m \;\; or \;\; 0.052 AU$$

- And it's mass?

$$m = 8.97 * 10^{26}\, kg \;\; or \;\; 150 M_{earth}$$

Exoplanet Detection