Review: Light and Spectra

- Light is a wave
  - It undergoes diffraction and other wave phenomena.
- But light also is made of particles
  - Energy is carried by *photons*

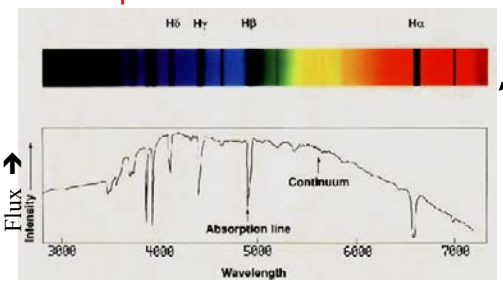
$$\text{Wavelength} \propto \frac{1}{\text{energy}}$$

of each photon

  - Computer simulation next week will feature photons arriving one-by-one.

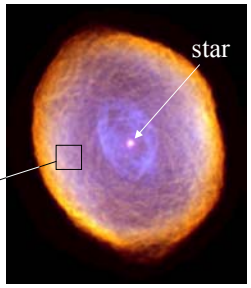
Absorption and Emission Lines

- Absorption Lines

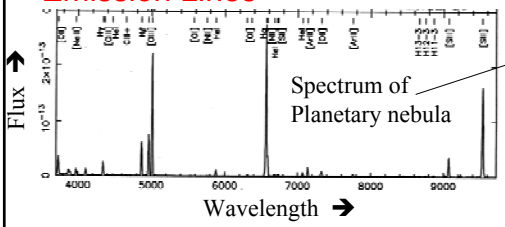


Spectrum of a star

IC 418 – shell of gas blown off central star.



- Emission Lines

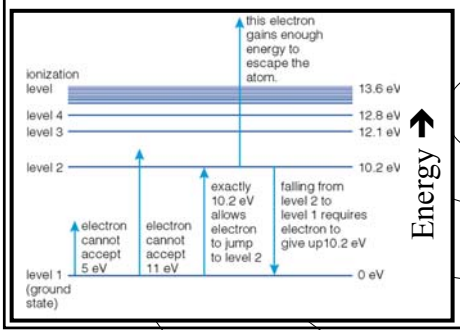


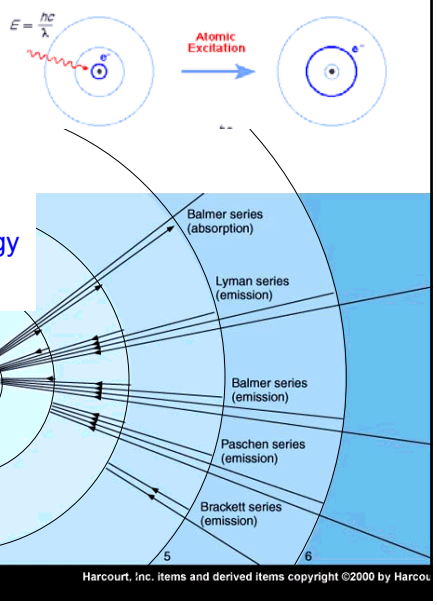
Spectrum of Planetary nebula

Absorption Lines = Atomic Excitation

Bohr's Model of the Atom

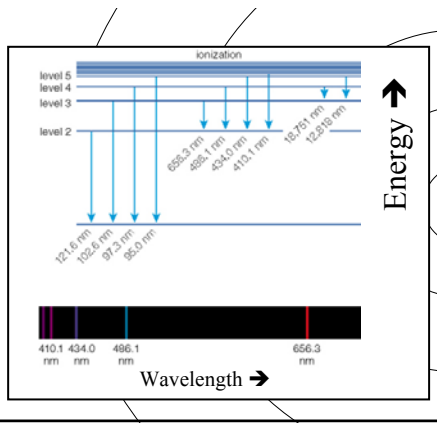
- Each electron orbit has its own distinct energy.
- For electron to move from inner orbit to one further out, it must gain exactly the energy difference between the orbits.
  - Can absorb photon with correct energy

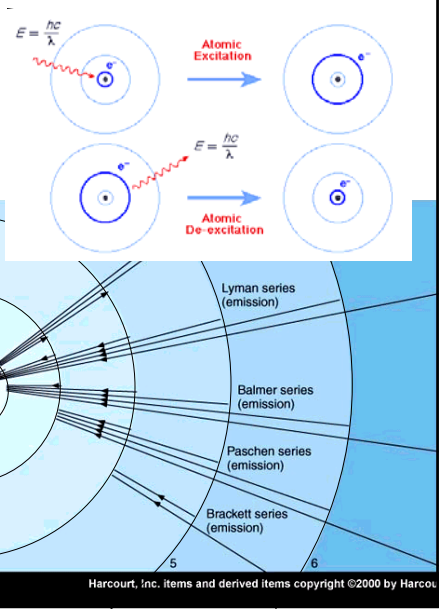




Emission Lines = De-Excitation

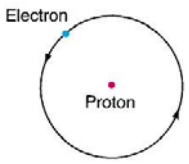
- For electron to fall back in towards nucleus, it must *lose* exactly the energy difference between the orbits.
  - Can *emit* photon with correct energy

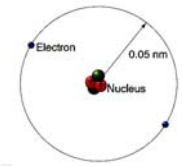


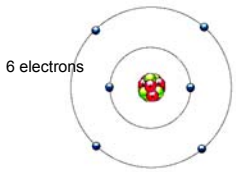


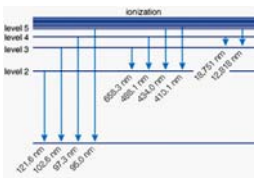
Different chemical elements have different configurations of electron orbits

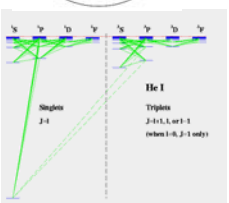
Hydrogen | Helium | Carbon











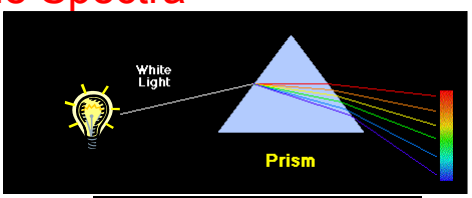
(too messy to think about)

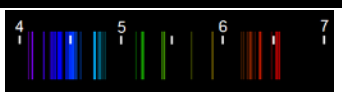
➔ different sets of energy levels with different energy spacings

➔ different sets of emission lines.

Observing Emission Line Spectra

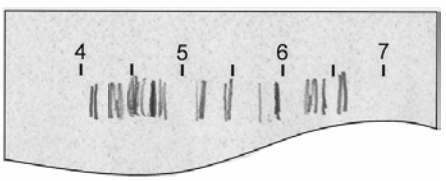
(today's experiment)





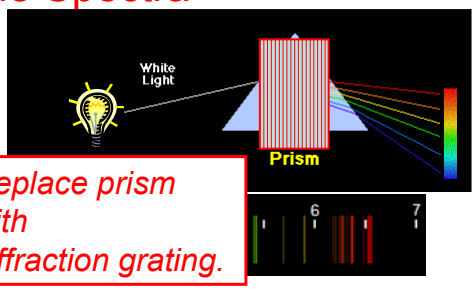
- Look at spectrum of 4 different lamps, each of which produces emission lines from a different element.

- *Quickly* sketch each spectrum



- Come back into Planetarium Theater and take quiz to identify chemical compositions of different gases from their emission-line spectra.

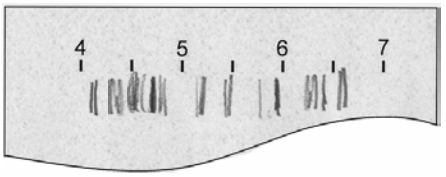
Observing Emission Line Spectra
(today's experiment)



- Look at spectrum of 4 different lamps, each of which produces emission lines from a different element.

Replace prism with diffraction grating.

- *Quickly* sketch each spectrum



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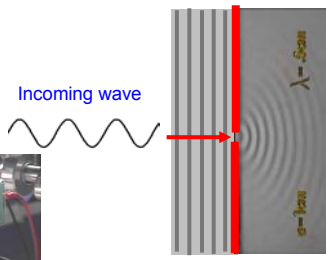
Waves: Diffraction



When parallel waves pass through a narrow slit, they spread out into a circular pattern.

Use ripple tank to study water waves.

Light waves do this same thing.

Waves: Diffraction + Interference

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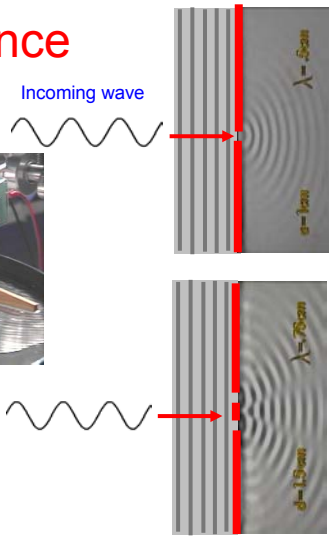

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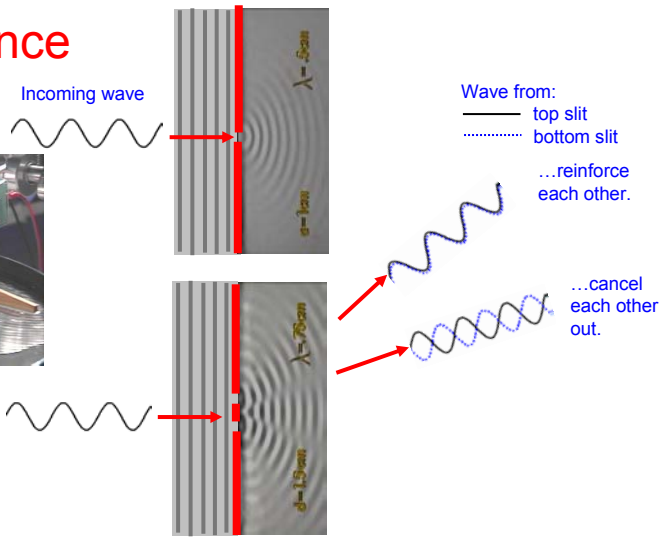

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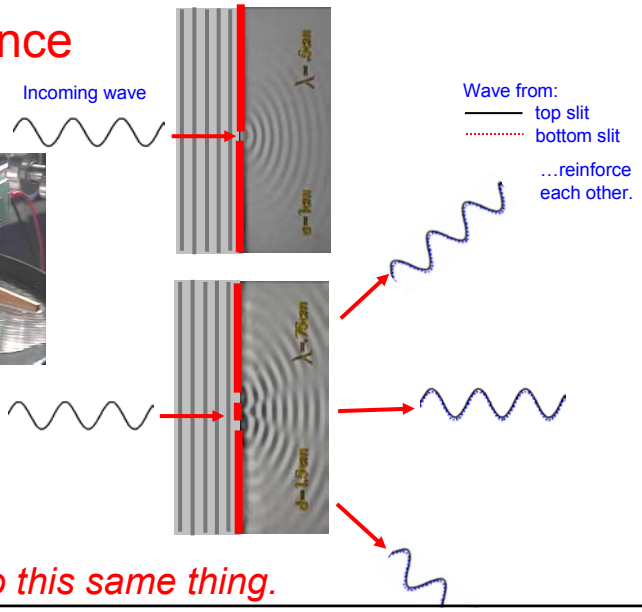

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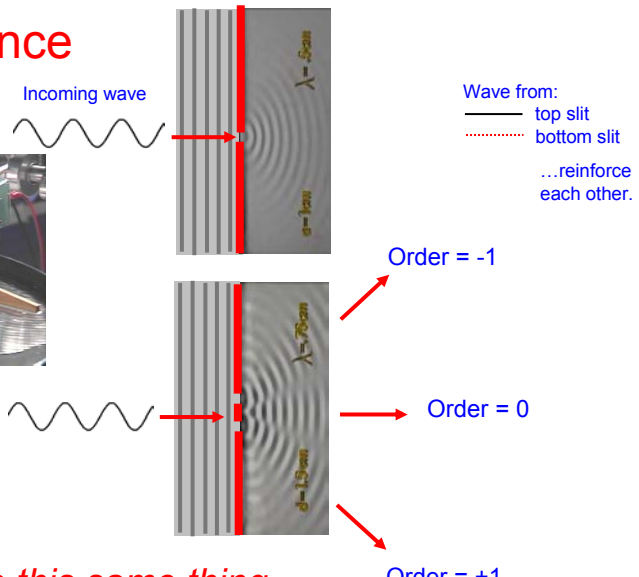

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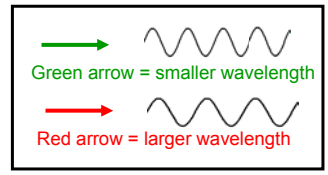

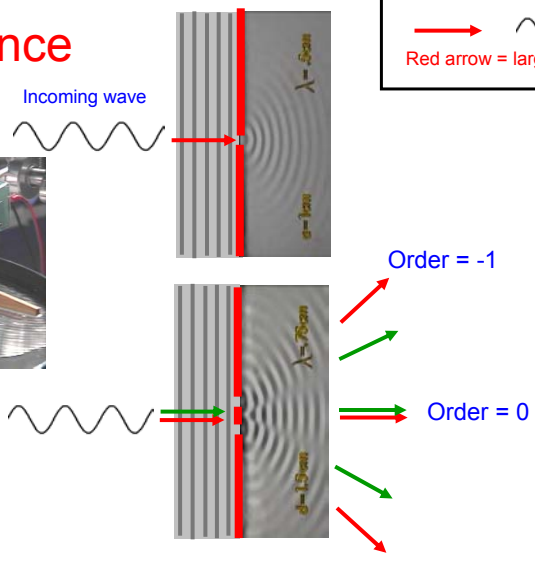

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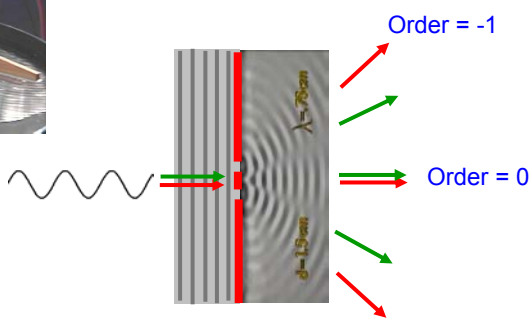

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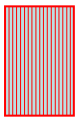
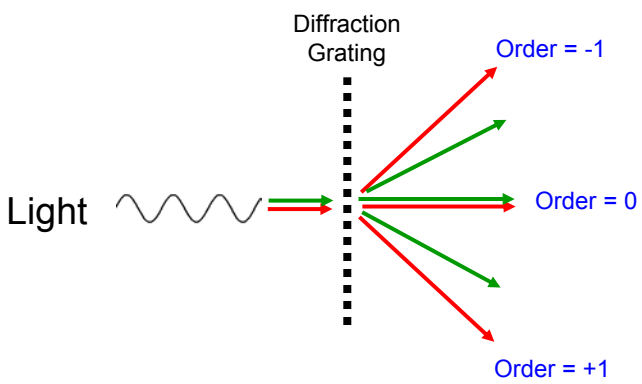
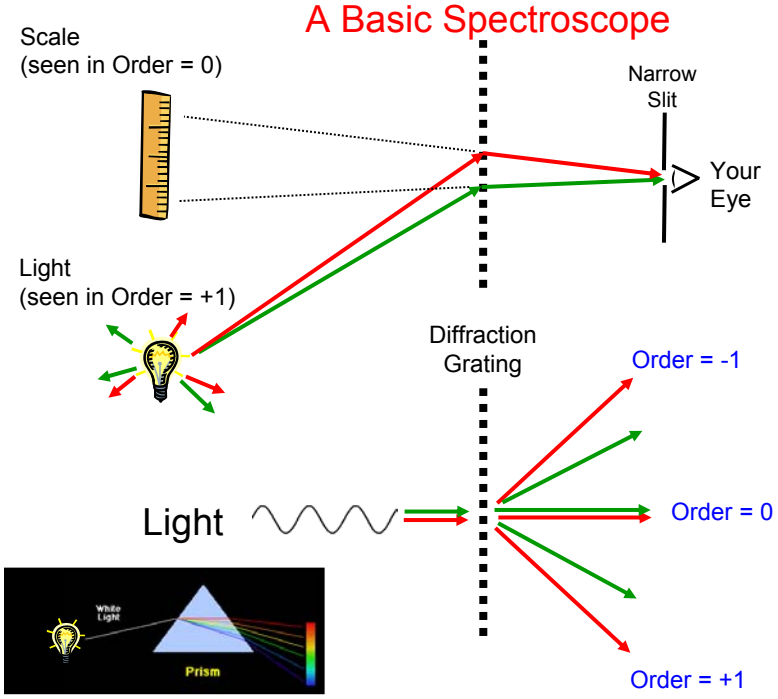


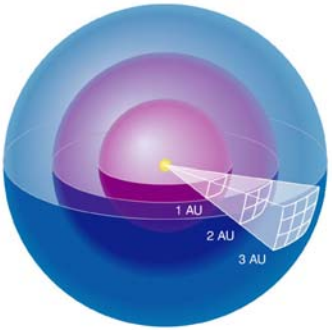
Grating is clear plastic with 12,700 parallel lines per inch printed on it
= *lots* of narrow slits.



A Basic Spectroscope



Review (continued): Absolute vs. Apparent Brightness



- *Luminosity* (L)
  - intrinsic brightness of light source
  - energy per unit time (for example, *Watts*)
- *Flux* (F)
  - apparent brightness of object as it appears from distance r.
  - energy per unit time per unit area

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

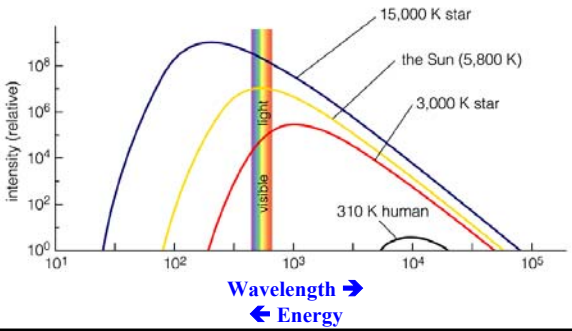
Light bulb looks fainter at greater distances.

- Outgoing light wave spreads out over more and more surface area.

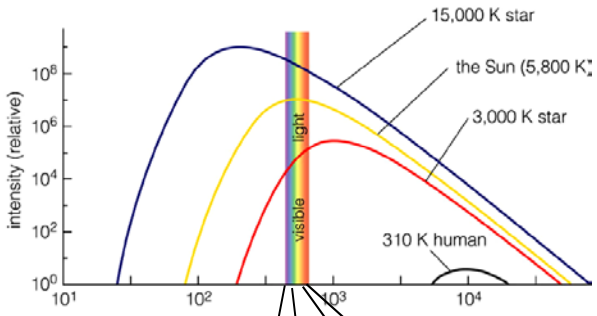
Thermal Radiation

- Heat up light bulb filament
  - It glows more brightly as it gets hotter
  - It changes color as it gets hotter

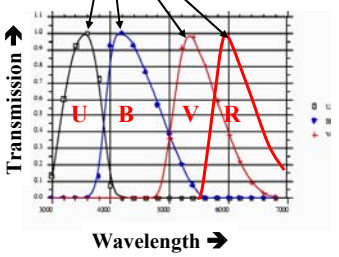
	Temperature		
	°K	°F	Color
Completely cold	0	-459	Does not emit light
Body temperature	310	99	Infrared
Blowtorch	3000	5000	Red-hot
Blast furnace	6000	10,300	White-hot
Hotter still	15,000	26,500	Blue-hot



Photometry & Colors = Thermometer # 1



Some filters used to measure temperature.



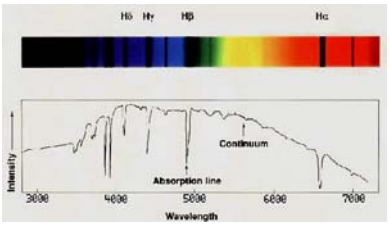
- Measure flux from black body in 2 colors
  - blue
  - red
- Use colored glass filters in front of a photocell.

Temperature	F_{blue}/F_{red}
15,000	> 1
5,800	~ 1
3,000	< 1

- So *ratio* of fluxes measures the temperature.

Absorption Lines = Thermometer # 2

- Temperature determines
  - Ionization state
  - Excitation state
- Spectral Classes determined by which absorption lines present.



This week's homework

Type	Temperature	Absorption Lines
O	>30,000 °K	Ionized helium, some hydrogen
B	10000-30000	Neutral helium, moderate hydrogen
A	7500-10000	Very strong hydrogen
F	6000-7500	Moderate hydrogen, ionized calcium
G	5000-6000	Weak hydrogen, strong ionized Ca.
K	3500-5000	Neutral & singly ionized metals, some molecules
M	<3500	Strong molecular lines