

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*

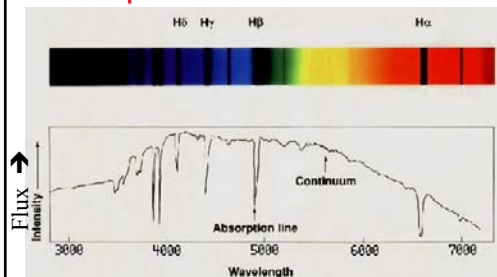
$$\text{Wavelength} \propto \frac{1}{\text{energy}}$$

of each photon

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

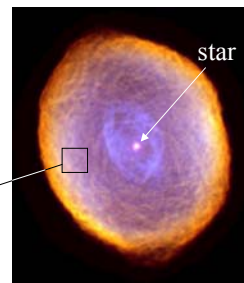
Absorption and Emission Lines

• Absorption Lines

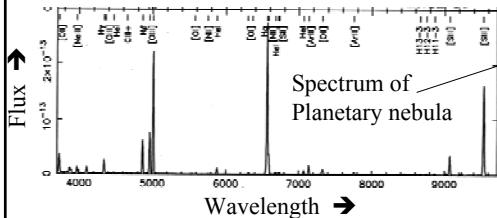


Spectrum of a star

IC 418 – shell of gas blown off central star.



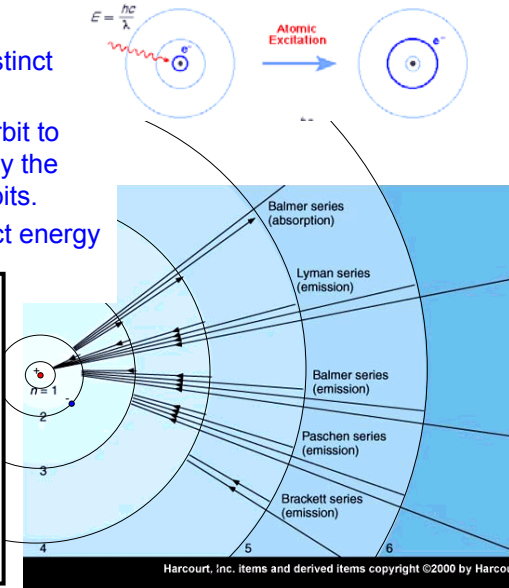
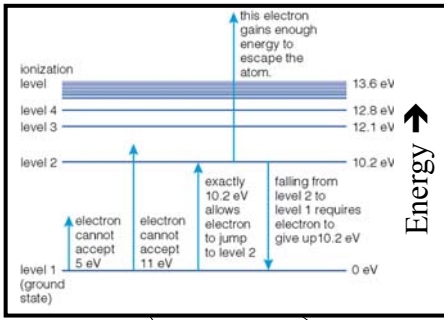
• Emission Lines



Absorption Lines = Atomic Excitation

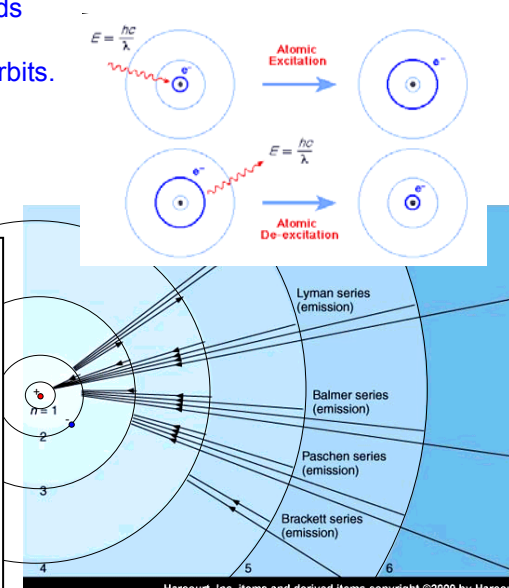
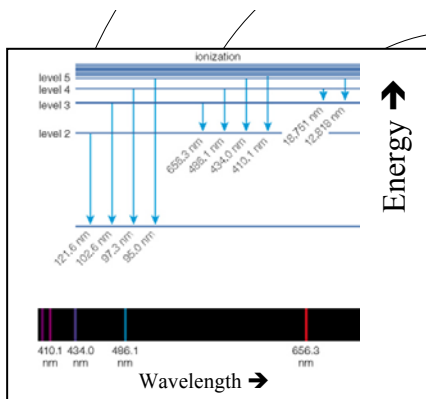
Bohr's Model of the Atom

- 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

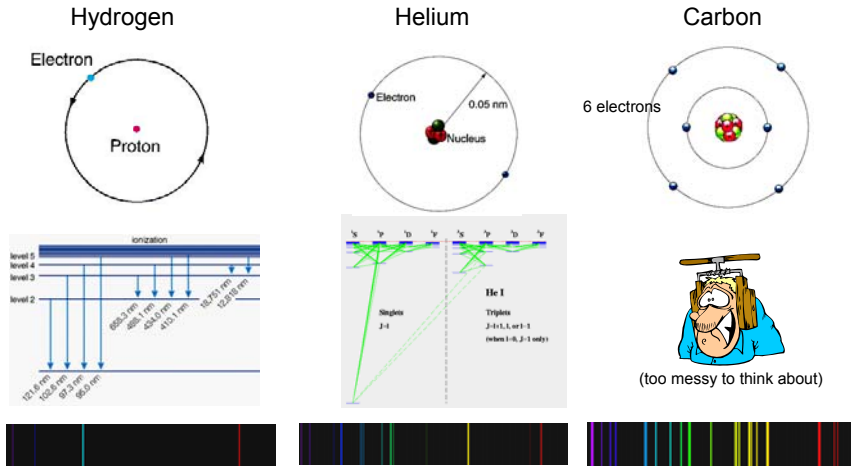


Emission Lines = De-Excitation

- 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

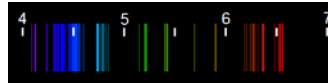
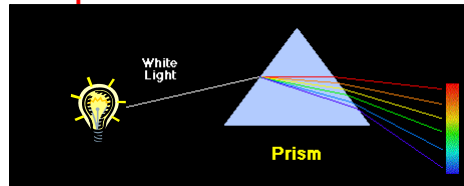


- ➔ different sets of energy levels with different energy spacings
- ➔ different sets of emission lines.

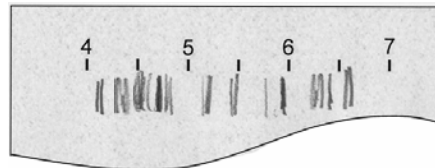
Observing Emission Line Spectra

(today's experiment)

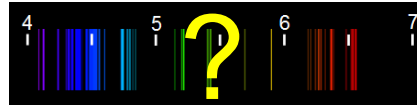
- Look at spectrum of 4 different lamps, each of which produces emission lines from a different element.



- *Quickly* sketch each spectrum

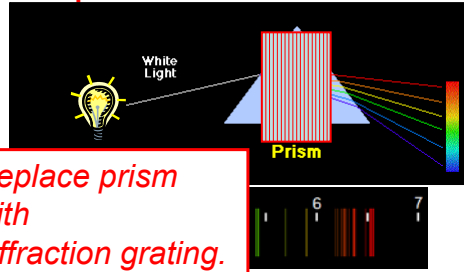


- Come back into Planetarium Theater and take quiz to identify chemical compositions of different gases from their emission-line spectra.

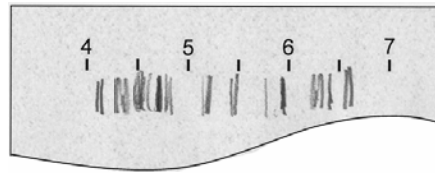


Observing Emission Line Spectra (today's experiment)

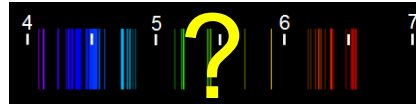
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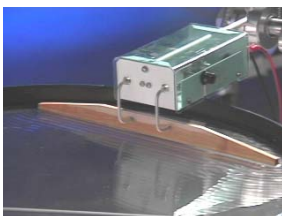
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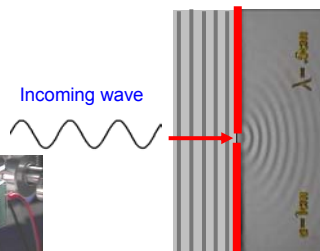
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Waves: Diffraction



Use ripple tank to study water waves.



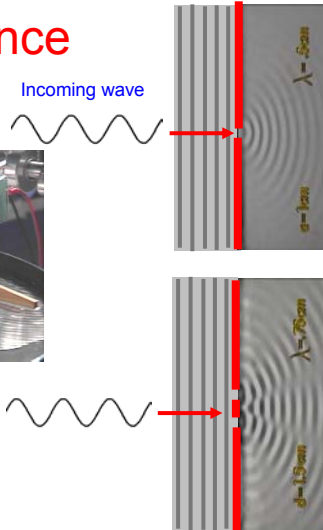
When parallel waves pass through a narrow slit, they spread out into a circular pattern.

Light waves do this same thing.

Waves: Diffraction + Interference



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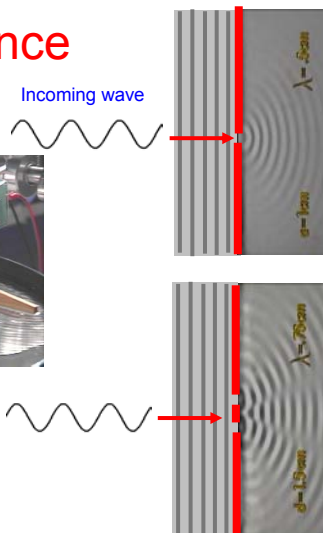
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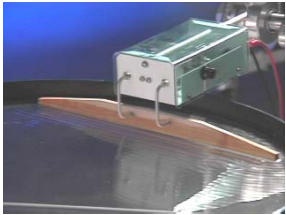


Wave from:
—— top slit
..... bottom slit
...reinforce each other.

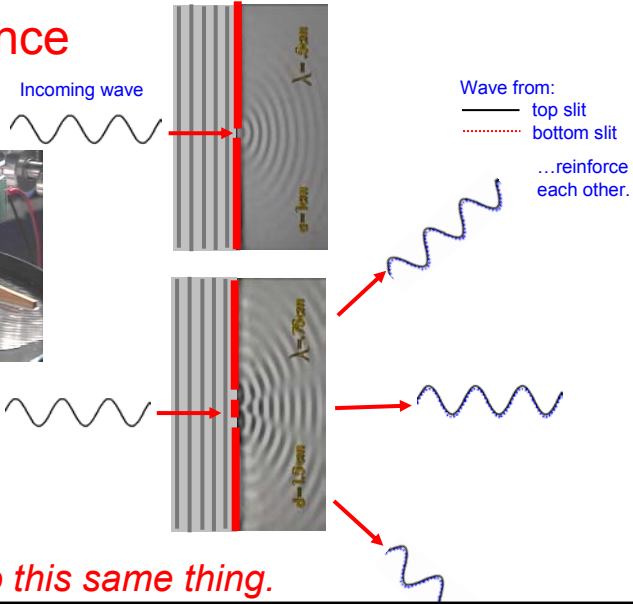
...cancel each other out.

Light waves do this same thing.

Waves: Diffraction + Interference



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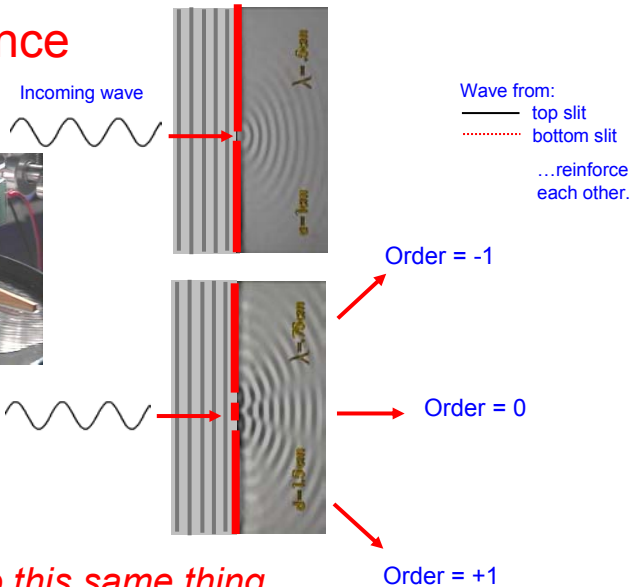


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Waves: Diffraction + Interference

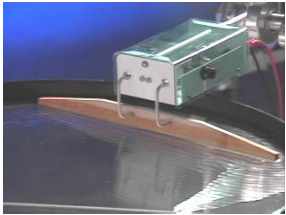


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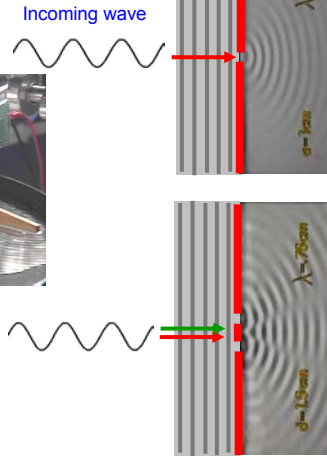


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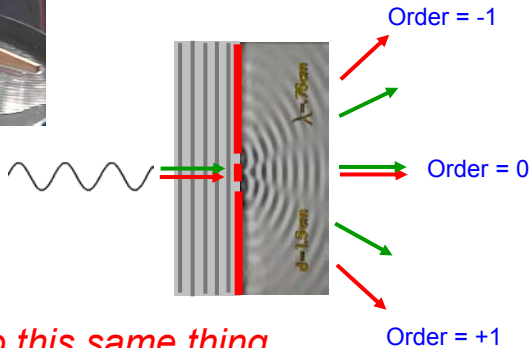


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Waves: Diffraction + Interference

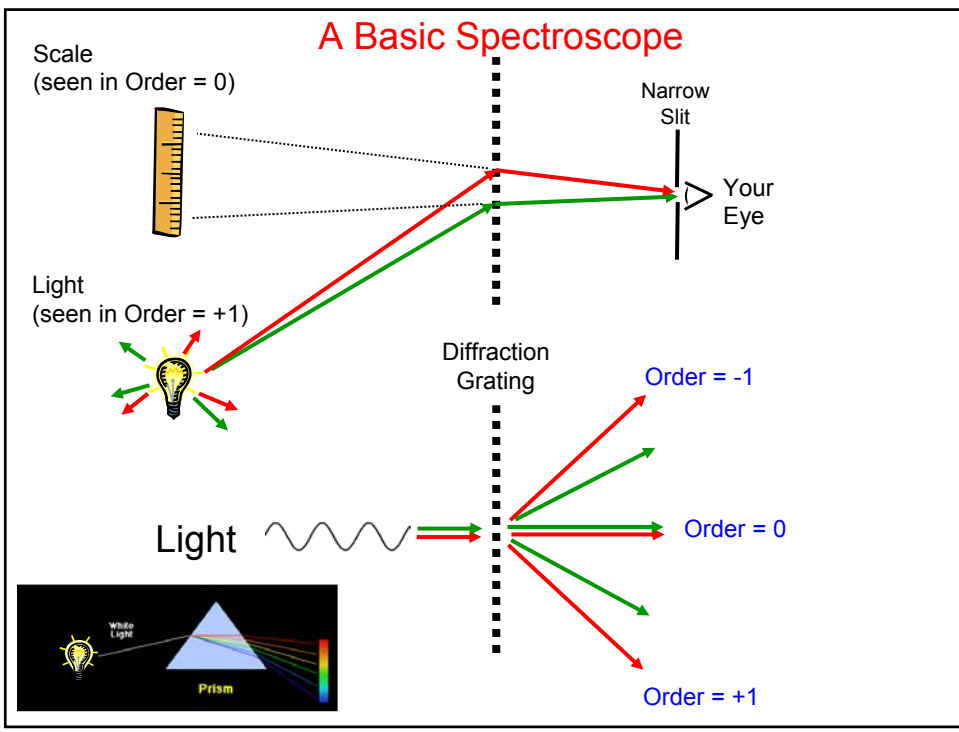
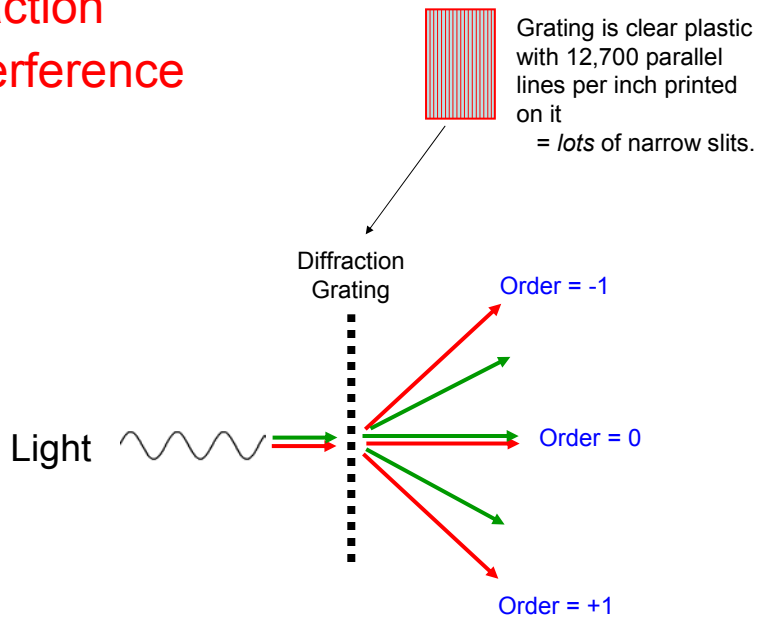


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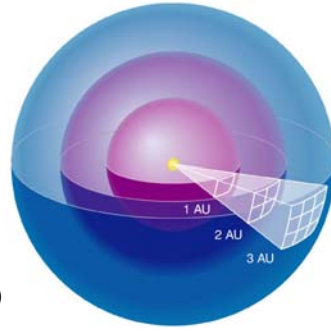


Light waves do this same thing.

Waves: Diffraction + Interference



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

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

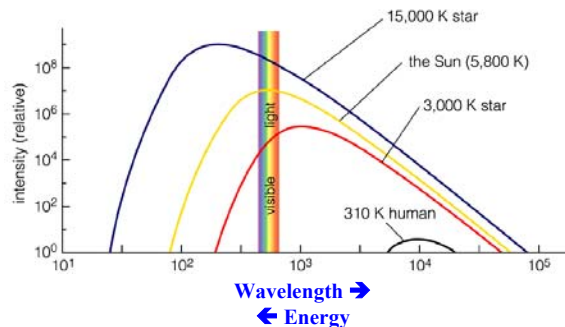
Light bulb looks fainter at greater distances.

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

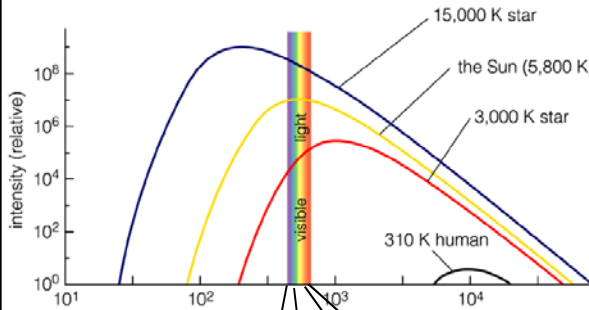
Thermal Radiation

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

	Temperature		Color
	°K	°F	
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



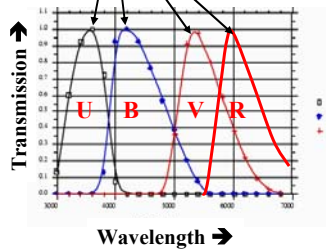
Photometry & Colors = Thermometer # 1



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

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

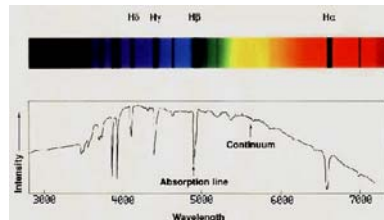
Some filters used to measure temperature.



- 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