Elements of Astrophysics—Class notes 1/23/2015

Diffraction glass experiment—shows each "dot" of laser beam is displaced proportional to its wavelength.

- Furthermore, if temperature is high enough, a hot dilute gas of any element will emit a very specific set of wavelengths. The same gas at low temperature will absorb the same set of wavelengths from any light source behind it.
- By using the dark lines in spectrum, we can deduce what kind of elements are present in the star (at least in the photosphere).
- Absorption lines reveal temperature and chemical composition.

We can make two claims/predictions using **Quantum Mechanics**:

1. Lots of physics observations are quantized
    a. Recall Planck's constant h… energy in electromagnetic radiation is quantized h*f
2. If something isn't quantized, it's uncertain (in position, precision, etc.)
    a. Ex: What is the probability of finding an electron between the range of [x, x+Δx]? The probability of the exact point is ZERO.
    b. This is also true for momentum [p, p+Δp]
    c. The product of the uncertainties is bounded by Heisenberg's uncertainty relationship: $\Delta p\, \Delta x \geq h/2\pi/2 = \hbar/2$

How do we understand these two statements? Picture the behavior of waves. Recall:

$$E_o = \cos(kr - \omega t)$$

(plane wave): precisely known wave length (momentum), position spread out over all space

Conversely: Short pulse of electromagnetic radiation: Position well-defined, but wave length (momentum) very uncertain.

Within the context of an atom:

We cannot predict where an electron may exactly be.

Lowest possible energy E(of atom) = - Ry [Where R = -13.6 eV of a Hydrogen atom in ground state… this is its *exact* lowest energy] But it can go higher…

$$E_n = -Ry * 1/(n^2)$$

Where n is some integer corresponding to the orbital levels.
Ex. E_2 of a Hydrogen atom would equal -3.4 eV (etc)

****Any number between these levels are NOT possible… no intermediate energies!****

Ex. E_n for a Hydrogen atom could never equal -8.5 eV (or another number between -13.6 and -3.4) because it is in between orbital levels 1 and 2

Since energy can neither be created or destroyed, for E_n to go from -13.6 eV to -3.4 eV that photon has an *exact* energy of hf = Ry [(1/n^2) – (1/m^2)] and thus can only emit/absorb the exact difference of energy between levels.

This is true for atoms as well as everyday objects ☺