PH 315 Monday 6 March

Have Hg/Incandescents set up for students

Displayed Questions:

1. What color does each lamp appear?
2. What colors can you see through the diffraction grating?
3. Sketch a graph of I_λ vs. λ for the Hg ~~[illegible]~~ lamp.
4. What can you say about the energy of the ~~light~~ photons emitted from each lamp?

Follow-up from me: Why aren't there any photons with in-between energies?

↕

Where is the energy coming from?

What properties of photons/light lead to the effects we have seen in lab and now today?

Could we get similar behavior if we used something other than light? Something like an electron?

→ Possible analogy: Throwing Tennis balls through a hole.

→ Electron demonstration (possibly with Laser demonstration)

Don't forget to change power and note changing ring size

This behavior suggests that a "classical" model, where we treat electrons as pointlike particles (like tiny tennis balls) is insufficient to describe reality.

We have done a lot of model-building in this class, which is a good thing because we're all scientists. If our ~~model~~ basic model doesn't work, we don't get upset – we get excited. We don't give up – we change our model.

What might be a good change to our model for electrons that would account for the results of this experiment?

→ We already know that waves will give us interference behavior, so let's try treating electrons as waves as well as particles! (We can't give up everything about particles, since we still see them get detected, just like we couldn't treat light/photons as only one or the other – we have to think of them as both.)

So I'm going to describe an electron as a wave, what are some properties of that wave I might be interested in?

→ Wavelength (λ)
Amplitude / Intensity → Probability / # detected
Frequency (ω)

[See chapter 4 of "Modern Physics"]

It turns out that we can relate the wavelength of the electron to its momentum (p), just like we can with light.

$$\lambda = \frac{h}{p}$$ (known as the de Brogie relation)

And we can relate energy to frequency (again just like light!)

$$E = hf = \hbar\omega$$

So this is all cool, but how can we use this information about electrons as waves to make predictions about the real world to test our new model?

→ Atoms are made of electrons, so let's see if this will describe the colors we saw at the start of class?

Is there a property or a system at waves that will give us a <u>discrete</u> set of frequencies/energies instead of the <u>continuous</u> spectrum we got for incandescence?

→ Standing waves demo

If we want standing waves from our electron, we need two things just like the demonstration:

① A wave equation to give us waves : Example — $$-\frac{\hbar^2}{2m}\frac{\partial^2 \Psi(x,t)}{\partial x^2} + V(x)\Psi(x,t) = i\hbar\frac{\partial \Psi(x,t)}{\partial t}$$

② Boundary conditions to get standing waves

↳ This only happens if we trap our electron somehow, by putting it in a box or on a spring or in an atom