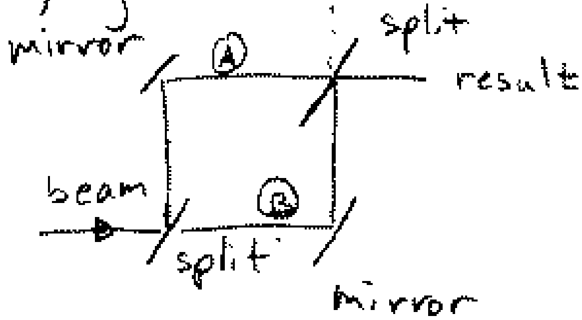
We're going to have a speaker this afternoon that will discuss neutron interferometry. So far, you've studied interferometry with the double slit,

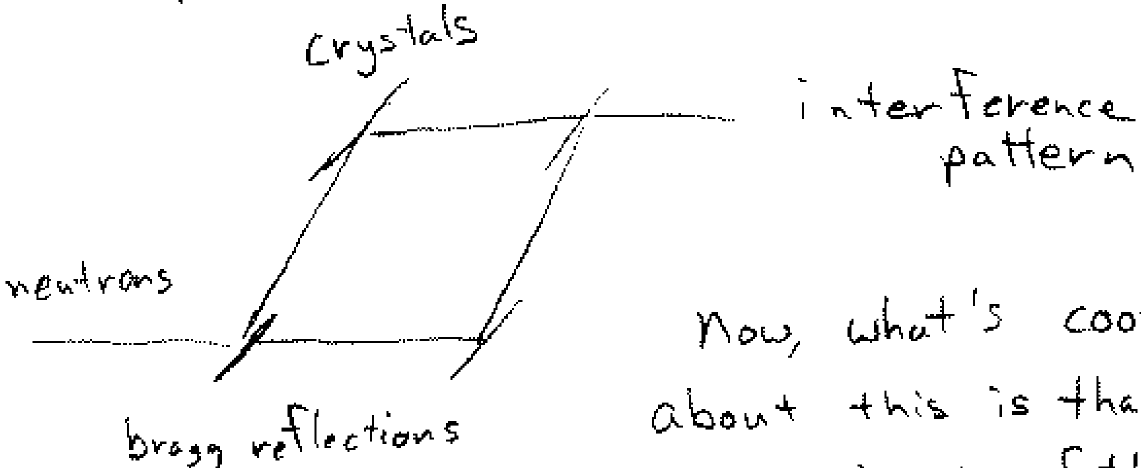
Well, you can do other things too:



- We think of the light going along both paths simultaneously
- The path length difference gives us the interference pattern
- works for low intensity & high intensity

Now, consider what happens if we use neutrons!

Neutrons come from nuclear reactors & you can velocity select the one's you're interested in



Now, what's cool about this is that the wavelength of the neutrons changes depending on it's orientation!

We've been using the Laser a lot in class room demonstrations. How does it work?

What do we know

1) we get one wavelength out
2) It is a very good beam
3) probably coherent (shaking the same way)

How do we get this, fairly efficient (about 0.1%) way to get a nice beam of light.

It's a several step process. (Ex HeNe laser)

1st step

We excite He to a higher energy stable state

hmmm, what's that mean?

Consider the hydrogen atom

> electron around a proton

$KE = \frac{1}{2}mv^2$

$PE = -\frac{1}{4\pi\varepsilon_0}\frac{q_e q_p}{r}$

Recall for Bohr, we treat this like a circular orbit except $[mvr = nh/2\pi]$

total $E = KE + PE$

$= -k\frac{q^2}{2r}$ electron bound in orbit

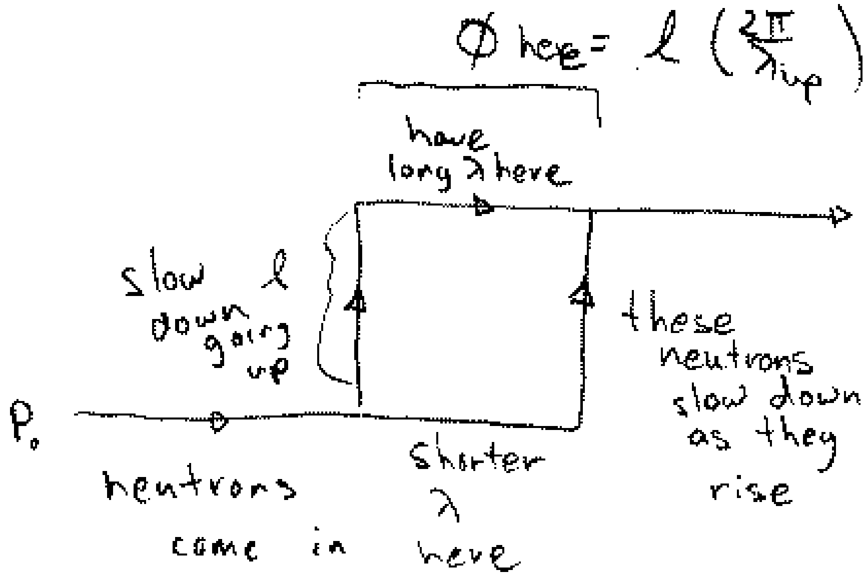
& Forces balance $\frac{kq^2}{r^2} = \frac{mv^2}{r}$

$\frac{mv^2}{2} = \frac{kq^2}{2r}$

$(mvr)^2 = n^2h^2/(2\pi)^2$

& $\frac{(mvr)^2}{mr^2} = \frac{kq^2}{r}$

or $\frac{n^2h^2}{m_e(2\pi)^2 kq^2} = r$



$$\phi_{here} = l\left(\frac{2\pi}{\lambda_{down}}\right)$$

$$\lambda_0 \sim 2\,\text{Å}$$

$$l \sim 2\,\text{cm}$$

$$p_0 = \frac{1240\,\text{eV nm}}{.2\,\text{nm}(c)}$$

$$\sim 6000\,\text{eV}/c$$

$$\lambda_{down} = \frac{h}{p_0}$$

When the neutron goes up, it loses energy

$$E = \tfrac{1}{2}mv^2 - mgh = \text{constant}$$

$$= \frac{p_{new}^2}{2m} - mgl = \frac{p_0^2}{2m}$$

$$p_{new}^2 - 2m^2gl = p_0^2$$

$$p_{new}^2 = p_0^2 + 2m^2gl$$

$$= p_0^2\left(1 + \frac{2m^2gl}{p_0^2}\right)$$

$$p_{new} = p_0\sqrt{1 + \frac{2m^2gl}{p_0^2}}$$

If this is small

$$p_{new} \sim p_0\left(1 + \frac{m^2gl}{p_0^2}\right)$$

For $n=1$ $r_0 = 0.0529\,nm$

& $E_1 = \frac{-kq^2}{2r_0} = -13.6\,eV$

$$E_n = \frac{-13.6\,eV}{n^2} \text{ in Bohr theory}$$

& $L = nh/2\pi$

works not too bad.

⇒ A way to get an excited state is to go to higher n by absorbing a photon

⇒ can't go lower than $n=1$

(consequence of electron being a wave, doesn't spiral into the nucleus.)

⇒ Know the nucleus is concentrated in the center from scattering experiments (And other things)

early Experiment by Rutherford > α radiation ↳ most passed through (empty space)

many deflected at huge angles

()

nasty units problem

$$\Delta\phi = \frac{l\,(mc^2)\,\overset{\text{an energy}}{(mgl)}\,\lambda_0\,2\pi}{(hc)^2}\quad \frac{1}{1.6\times10^{-19}\,J/eV}$$

multiply by $\frac{1}{1.6\times10^{-19}\,J/eV}$

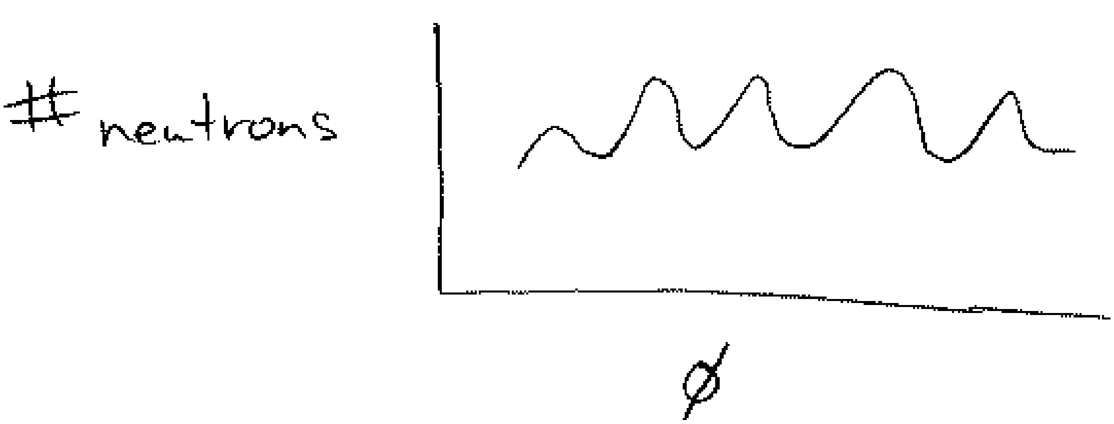
$$= \frac{(0.02\overset{\times10^9}{m})\,(935\times10^6\,eV)\,\underbrace{(1.67\times10^{-27}\,kg\ 9.8\,\tfrac{m}{s^2}\,0.02\,m)}_{(2.04\times10^{-9}\,eV)}\,2\times10^{-1}\,nm\,(2\pi)}{(1240\,eV\,nm)^2}$$

$= 31.1$ radians, wow!

more than enough to get several interferences.

what they did was to tilt the apparatus to get less Δp.

& the saw



Is this enough?

Well, we excite a bunch of atoms and get them to release photons when they return to the ground state.

(we reinvented the neon sign, but little more)

Need something else besides just excited atoms.

What are the different ways atoms lose and gain energy?

Elastic scattering	$E_\gamma < E_2 - E_1$ (photon)	photon just scatters off
Inelastic scattering	$E_\gamma > E_2 - E_1$	get excited state and lower energy photon
Resonance Absorbtion	$E_\gamma = E_2 - E_1$	atom goes to excited state, after a bit, decays back to ground state
Flnorescence	$E_\gamma >> E_2 - E_1$	get back lots of photons from lots of states (Flaorescence)

metastable state {Some states take a long time to return to the ground state} (Phosphorescent material)

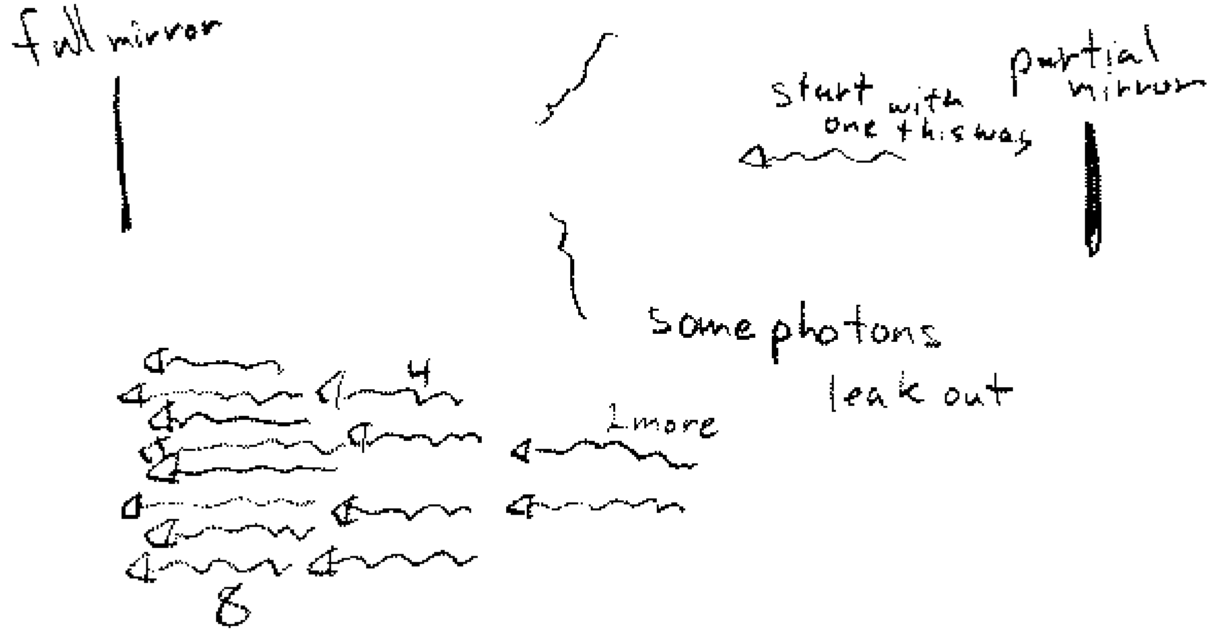
photo electric effect & Compton effect

Stimulated (or resonance) emission: If atom is in excited state we can send in $E_\gamma = E_2 - E_1$ light and stimulate an emission of an $E_\gamma = E_2 - E_1$ photon in same direction & phase

Ah ha, I see a plan forming.

If we can store enough energy in a metastable state (like a battery), then, begin stimulated emission somehow maybe we can get the laser to work.

So we need a way to control the directionality of the stimulated emission, how bout mirrors



8 reflect 16, 32, 64 ...

and if each one of these occurs in $\sim 10^{-8}$ or so seconds, we can get a lot of photons via stimulated emission quickly and continuously as long as we can pump energy into the metastable state. And the state we're jumping down to is not filled up

The condition where we have lots of atoms in an excited state is called population inversion