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Welcome!

Physics 194 - Lecture 23

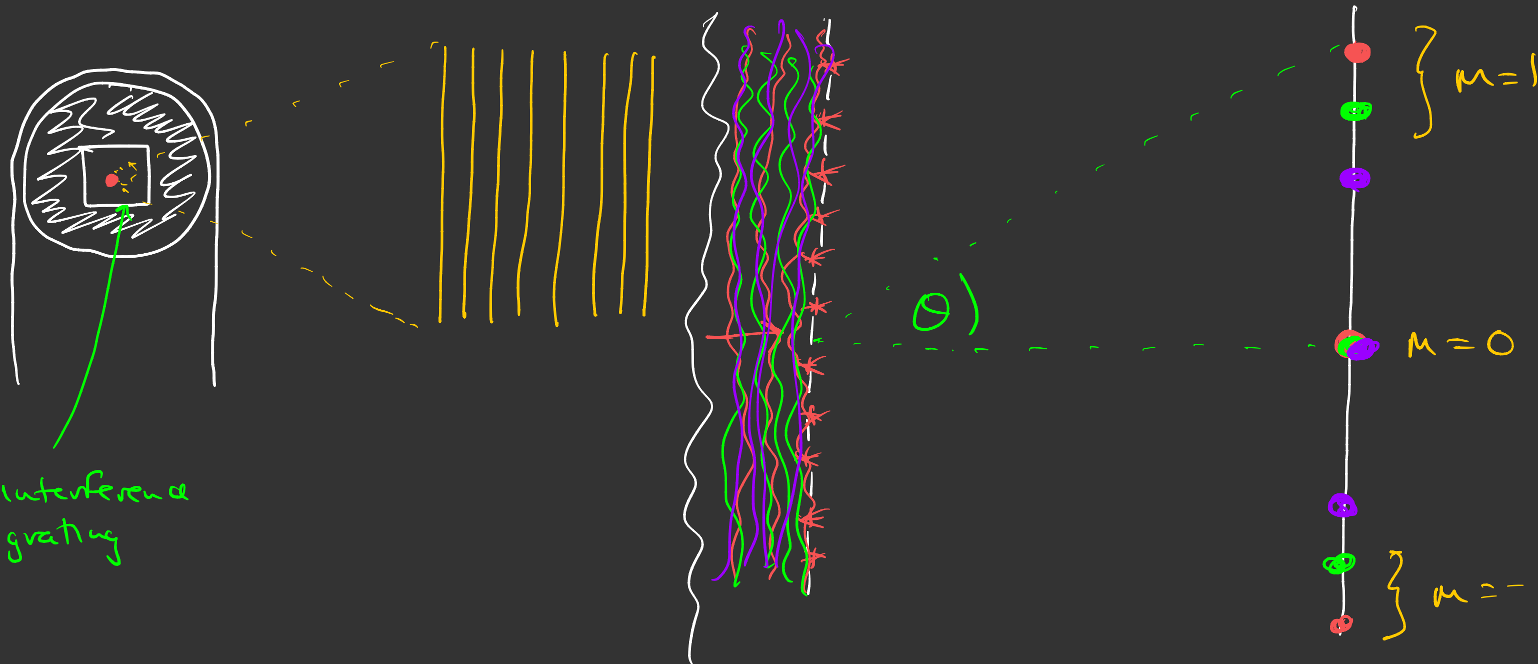
Have a question during class? Please ask it right away, even if it means interrupting in the middle of a thought. I want you to!

Agenda

- The wave model of matter
- the Bohr model of the hydrogen atom
- Emission & absorption processes

Class starts @2:15 pm

Can we use interference to investigate physical phenomena in new ways?



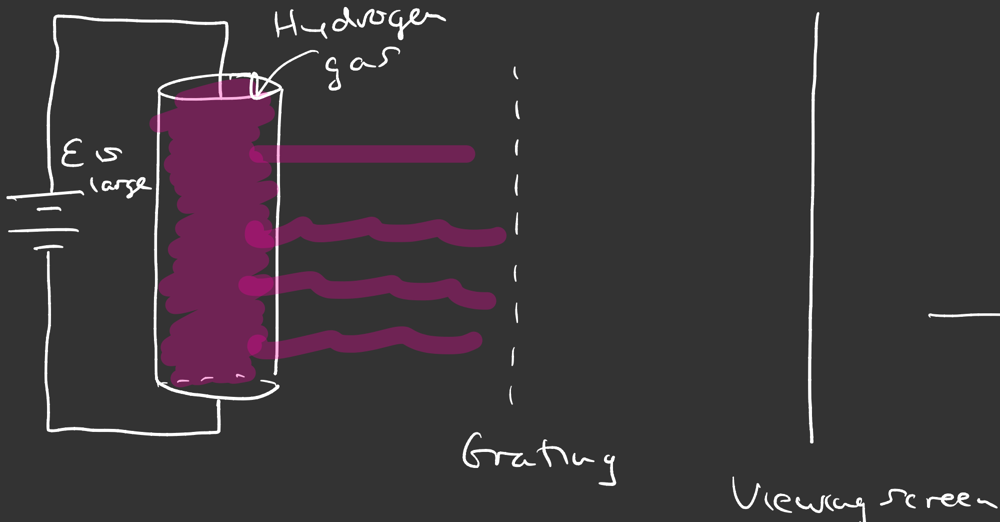
$d \sin\theta = m\lambda$

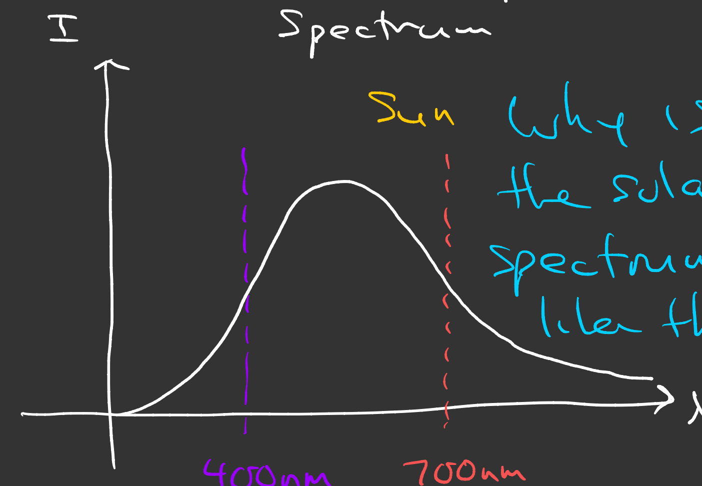
$\lambda = 430\,nm$

$\lambda = 515\,nm$

$\lambda = 650\,nm$

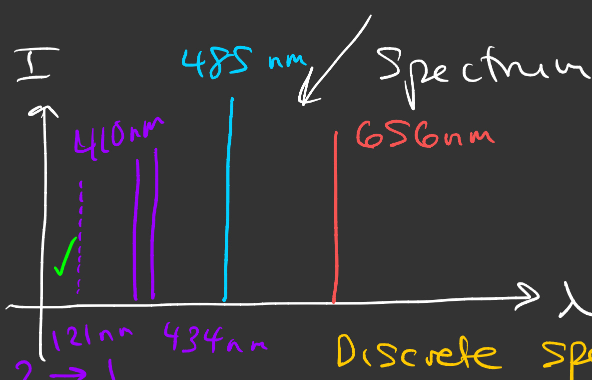
Gases glow when a strong electric field is applied to them...





Continuous spectrum

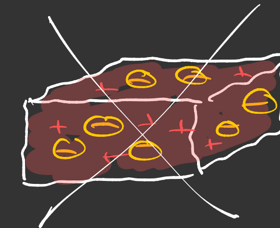
Why is the solar spectrum like this?

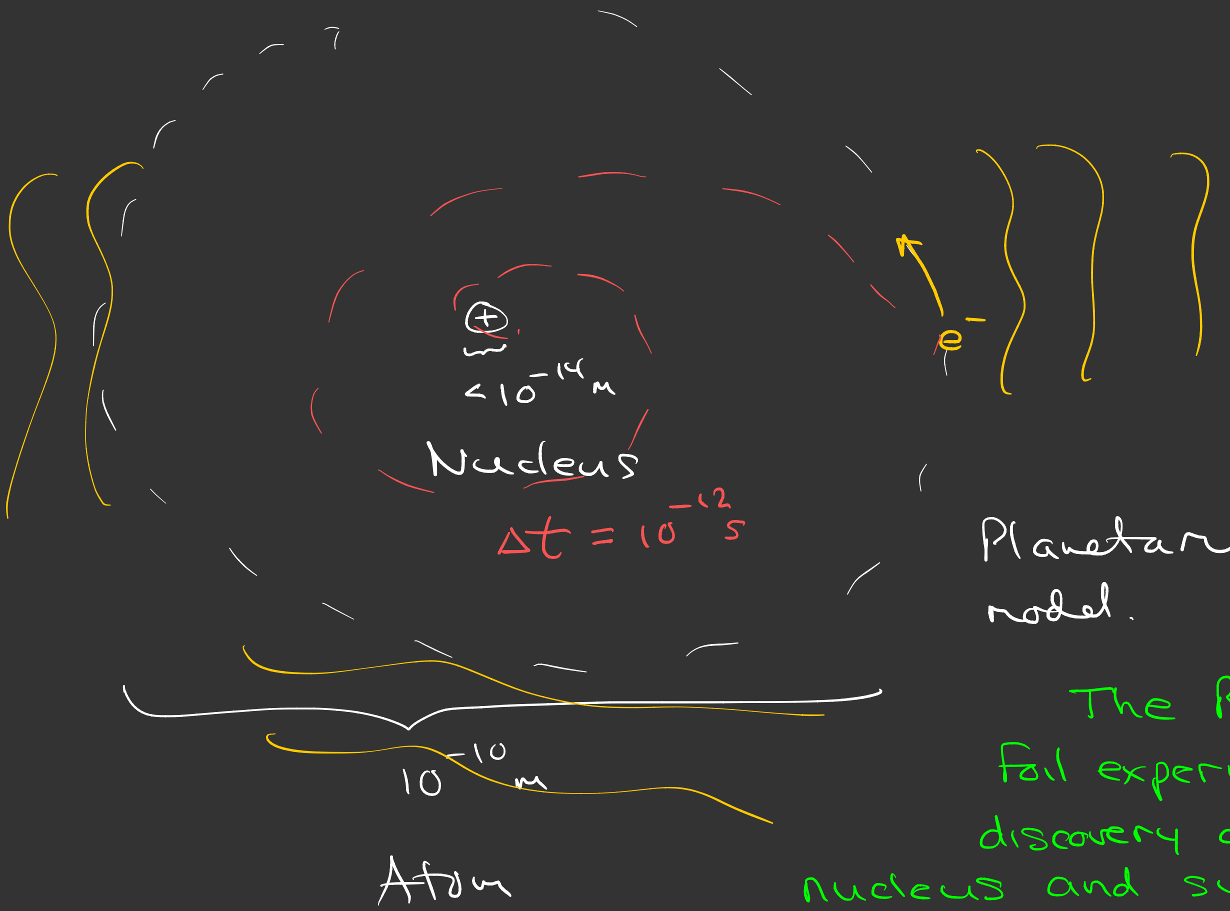


Discrete spectrum.

Mystery to be solved. Why does hydrogen do this??!..

What is the structure of an atom?



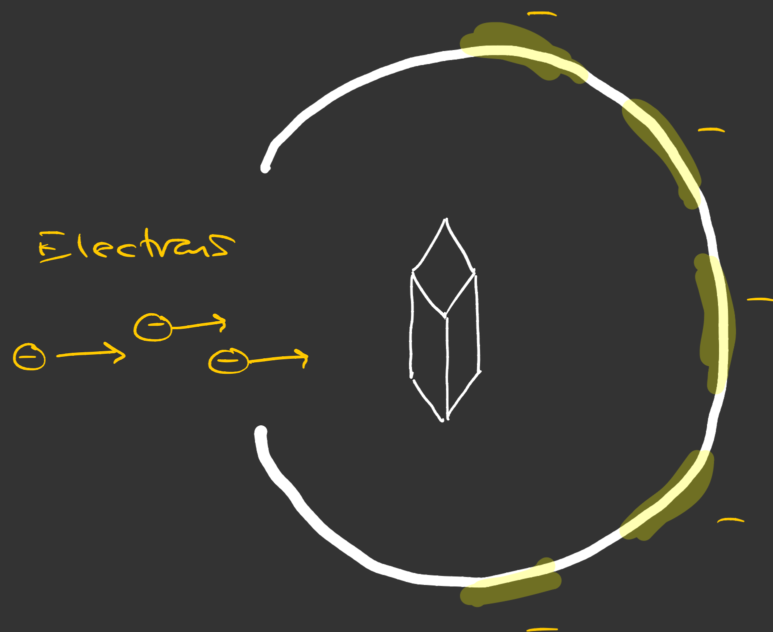


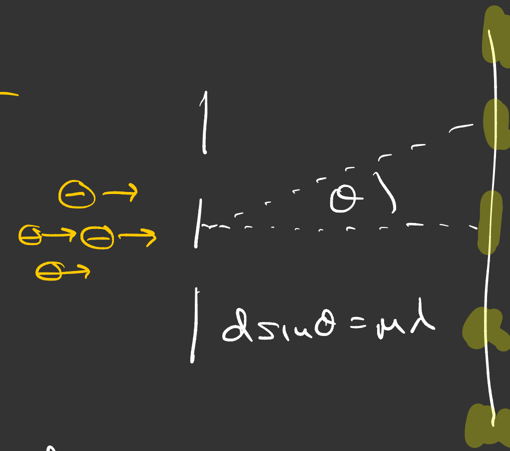
Planetary model.

The Rutherford gold foil experiment led to the discovery of the atomic nucleus and suggested a "planetary model" for the atom.

Davisson-Germer expt.

Electrons are wavelike!





Electrons have a wavelength and it depends on speed.

$$\lambda \overset{?}{\propto} \frac{1}{v} \longrightarrow \lambda = \frac{7.28\times10^{-4}\ m^2/s}{v}$$

$$E_{photon} = hf$$

↑ Planck's constant $= 6.63\times10^{-34}\ J\cdot s$

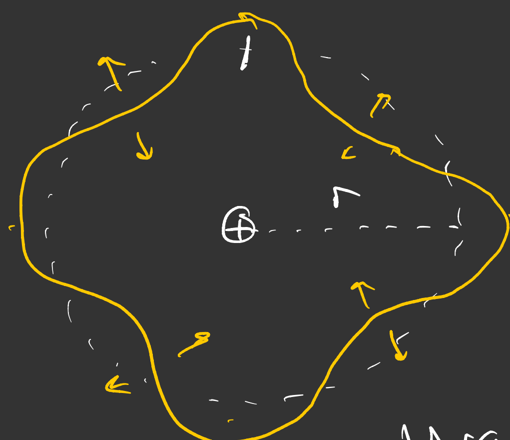
$$\frac{h}{m_e} = \frac{6.63\times10^{-34}\ J\cdot s}{9.11\times10^{-31}\ kg} = 7.28\times10^{-4}\ m^2/s$$

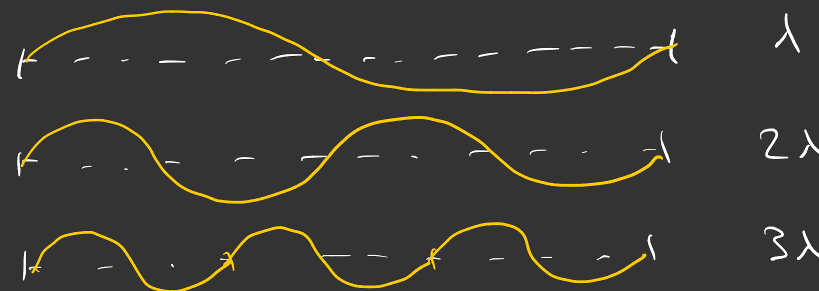
$$\lambda = \frac{h}{m_e v} = \frac{h}{p}$$

$$\lambda = \frac{h}{p}$$

De Broglie wavelength.

The Bohr model of the hydrogen atom...





Wave part

1, 2, 3, ...

$$2\pi r_n = n\lambda = n\left(\frac{h}{m_e v}\right)$$

$$\boxed{2\pi \boxed{r_n} = \frac{nh}{m_e \boxed{v_n}}}$$

Particle part

$$a = \frac{1}{m_e} \sum F_{on\ e}$$

$1.6 \times 10^{-19}\,C$

$$\frac{v_n^2}{r_n} = \frac{1}{m_e}\left(k\frac{|-e||+e|}{r_n^2}\right)$$

$$r_n \cdot \frac{v_n^2}{r_n} = \frac{ke^2}{m_e r_n^2} \cdot r_n \rightarrow \boxed{\boxed{v_n}^2 = \frac{ke^2}{m_e \boxed{r_n}}}$$

Solve the 2 equations as a system:

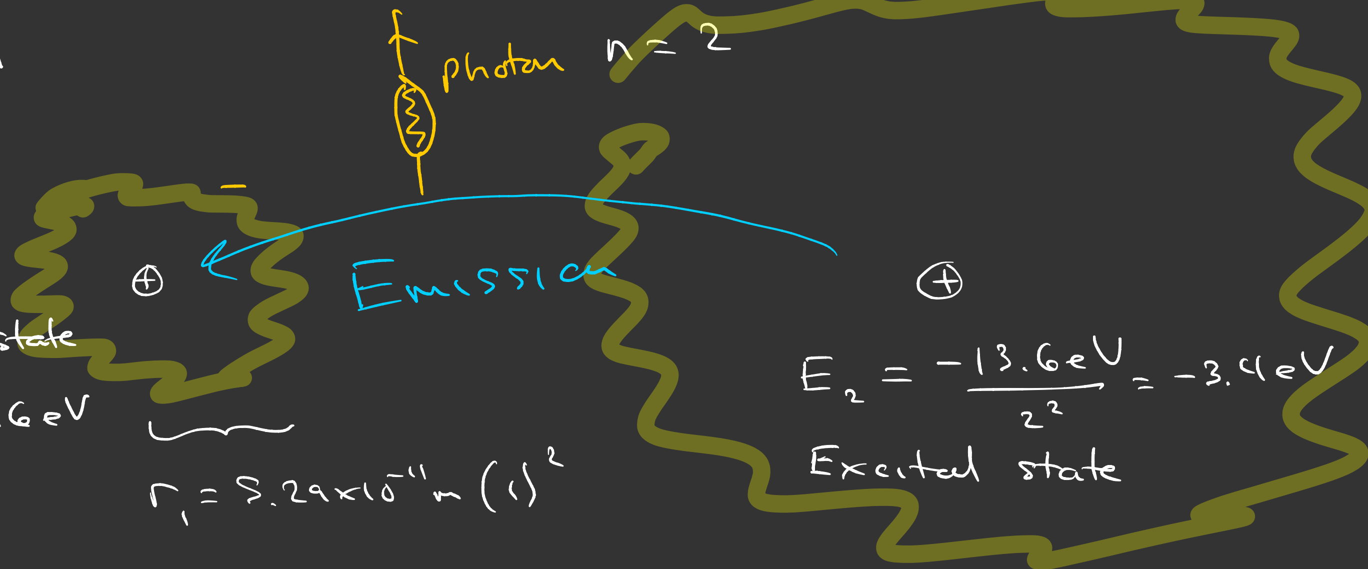
$$r_n = (5.29 \times 10^{-11}\,m)\,n^2$$

1, 2, 3, ...

$$v_n = (2.18 \times 10^6\,m/s)\frac{1}{n}$$

quantum number

$n = 1$



Ground state

$E_1 = -13.6\,eV$

$r_1 = 5.29\times10^{-11}m\,(1)^2$

$E_2 = \frac{-13.6\,eV}{2^2} = -3.4\,eV$

Excited state

$r_2 = 5.29\times10^{-11}m\,(2)^2$

$$E_n = K_n + U_{q,n}$$

$$= \frac{1}{2}m_e v_n^2 + k\frac{(-e)(+e)}{r_n}$$

$$\vdots$$

$$= \frac{-2.18\times10^{-18}\,J}{n^2}$$

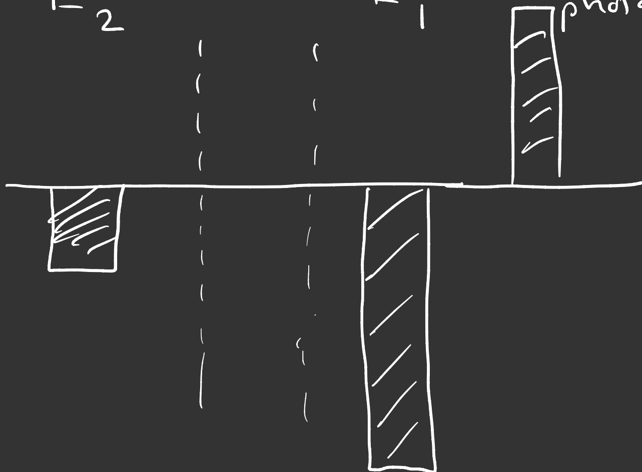
$$\boxed{1\,eV = 1.6\times10^{-19}\,J}$$

electron volt

$$E_n = \frac{-13.6\ eV}{n^2}$$ Bohr model

$$\overset{=-3.4\,eV}{E_2} = \overset{=-13.6\,eV}{E_1} + E_{photon}$$

$$E_{photon} = hf = \frac{h\overset{3\times10^{8}\,m/s}{c}}{\lambda}$$



$6.63\times10^{-34}\ \boxed{J}\cdot s$

$$-3.4\,\boxed{eV} = -13.6\,\boxed{eV} + \frac{hc}{\lambda}$$

$$\Rightarrow \lambda = 121\ nm = 1.21\times10^{-7}\ m$$ Ultraviolet