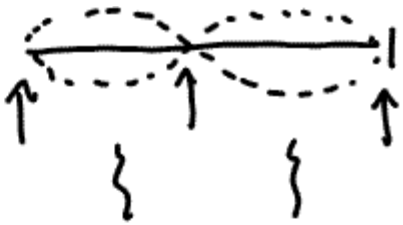
Physics 114 - April 25, 2006

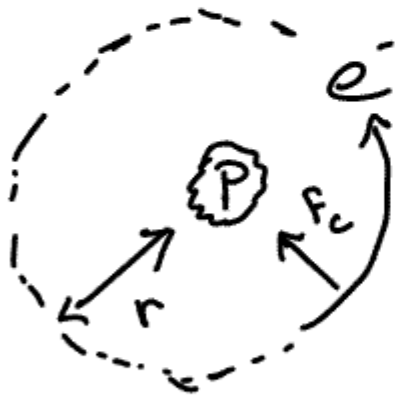


Important pre-quantum mechanics model of Atom

Bohr Atom 1913

→ impt for giving us intuition about Atoms

Assume e^- orbits proton in a circular orbit



$$F_{cent} = \frac{m_e v^2}{r}$$

$k\frac{Ze^2}{r^2}$ if single e^- Atom w/ Atomic # Z

Equation 1

$$\frac{k|e|^2}{r^2} = \frac{m_e v^2}{r}$$

Coulomb attraction between p and e^-

Centripetal force

Since e^- is a wave

imagine e^- as a Circular STANDing Wave

only works for certain λ that satisfy

$$2\pi r = n\lambda \qquad n = 1, 2, 3 \cdots$$

↓ From DeBroglie

$$2\pi r = n\frac{h}{p}$$

This is where Things become discrete or quantized

$$\hbar \equiv \frac{h}{2\pi} \equiv \text{called } h\text{-bar}$$

So, $pr = n\hbar$

Angular Momentum

$mvr = n\hbar$ same as $L = n\hbar$

So can also say Bohr quantized Angular Momentum

Eqn 2

$$v = \frac{n\hbar}{mr}$$

Substitute into Equation 1 Above

$$\frac{k|e|^2}{r^2} = \frac{mv^2}{r} \longrightarrow \frac{ke^2}{r^2} = \frac{mn^2\hbar^2}{r\,m^2r^2}$$ solve for r

$$r_n = \frac{n^2\hbar^2}{ke^2m} \qquad n = 1, 2, 3 \cdots$$

says that electron only exists at discrete radii

If done for single e^- atom of atomic # Z in initial eqns

$$\frac{ke^2}{r^2} \longrightarrow \frac{kZee}{r^2}$$

$$\boxed{r_n = \frac{n^2\hbar^2}{kZe^2m}}$$ good for single e^- atom w/ at. # Z

r_1 = Ground state orbital radius

$$\boxed{r_n = \frac{n^2}{Z} r_1}$$

$$KE. = \frac{1}{2}mv^2 = \frac{1}{2}m\left(\frac{n\hbar}{mr}\right)^2 = \frac{n^2\hbar^2}{2mr^2}$$

from Eqn 2

Substitute in for r

$$KE. = \frac{n^2\hbar^2}{2m}\frac{k^2z^2e^4m^2}{n^4\hbar^4} = \frac{mk^2z^2e^4}{2n^2\hbar^2}$$

$$E_{TOTAL} = KE + PE$$

What is P.E.? Recall Potential $= \frac{\text{work}}{\text{chg}}$

$$P.E. = -k\frac{ze^2}{r}$$

"−" because ATTRACTIVE

Sub in for r

$$P.E. = -\frac{kze^2}{n^2\hbar^2}kze^2m = -\frac{k^2z^2e^4m}{n^2\hbar^2}$$

$$E_{TOTAL} = KE + PE = \frac{1}{2}\frac{mk^2z^2e^4}{n^2\hbar^2} - \frac{mk^2z^2e^4}{n^2\hbar^2}$$

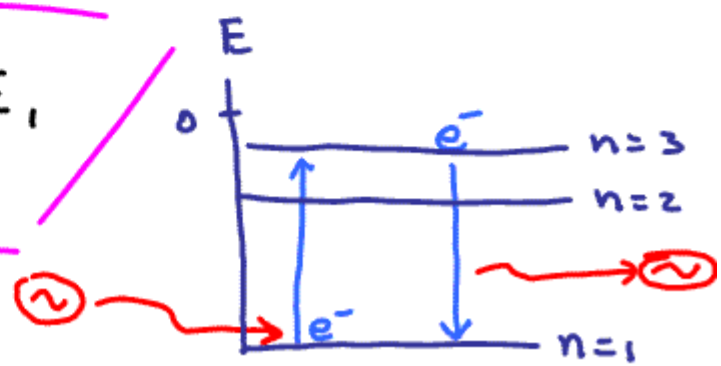
$$E_{n\,(TOTAL)} = -\frac{mk^2z^2e^4}{2n^2\hbar^2}$$

What is meant by the negative sign here?

for $Z = 1$, $n = 1$ ⟶ Most tightly bound Energy level for H

$$E_1 = -13.6\ eV$$

$$E_n = -\frac{Z^2}{n^2}E_1$$



photons emitted or Absorbed as e^- shifts levels $E_\gamma = h\nu$

Discrete Atom Emission + Absorption lines come from e^- transitions between discrete Energy levels

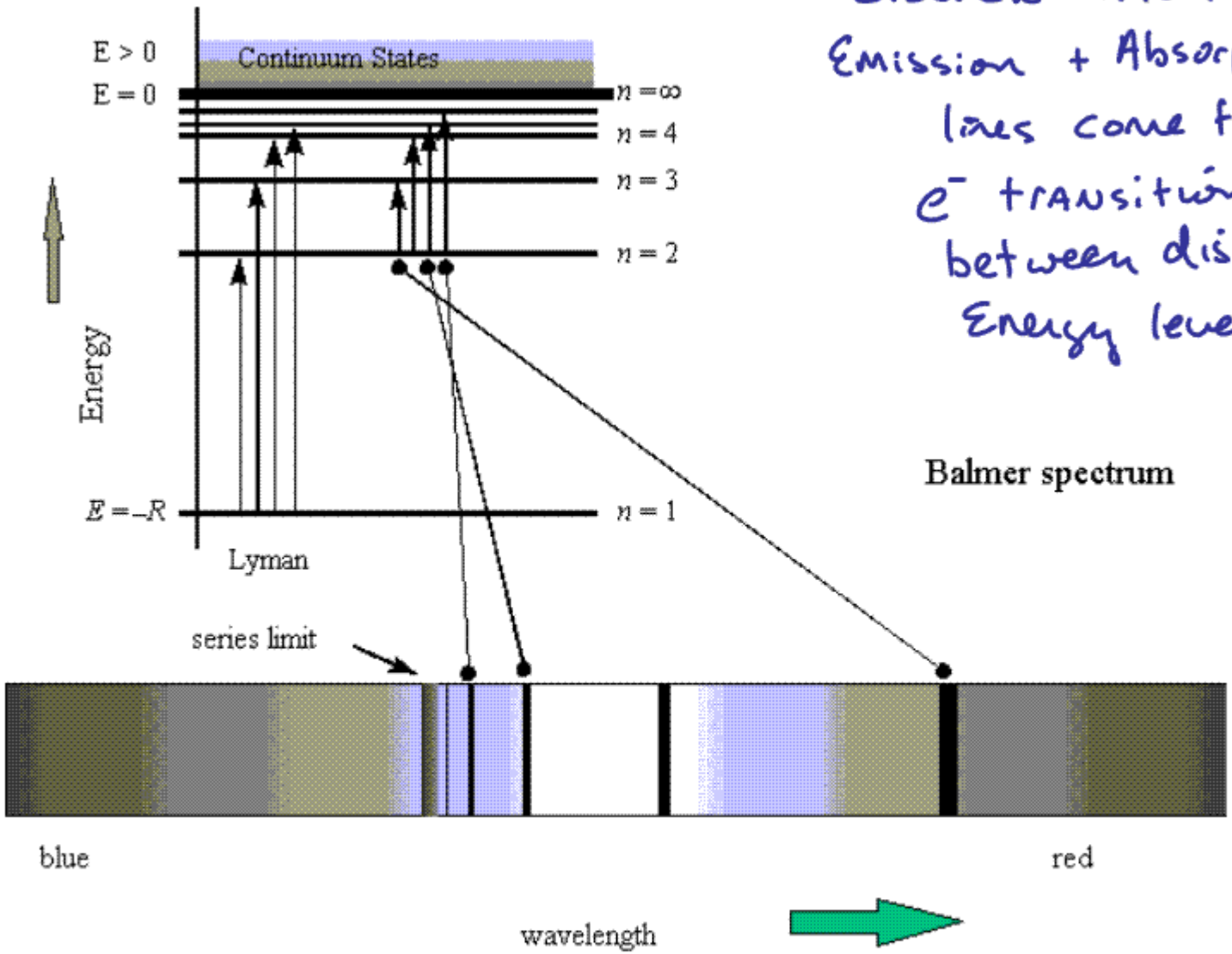
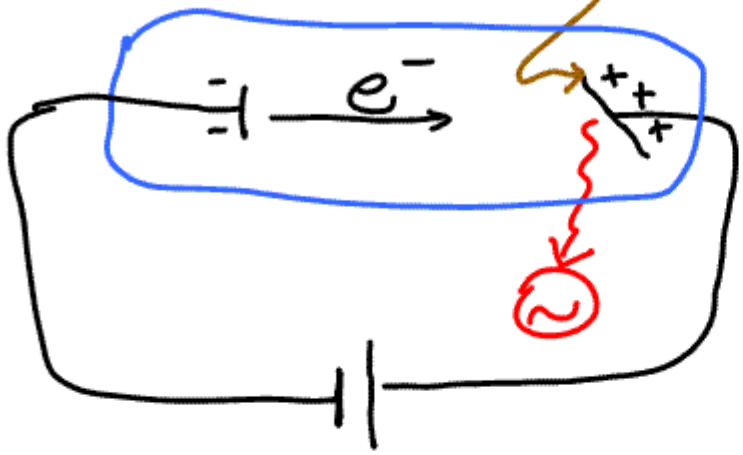
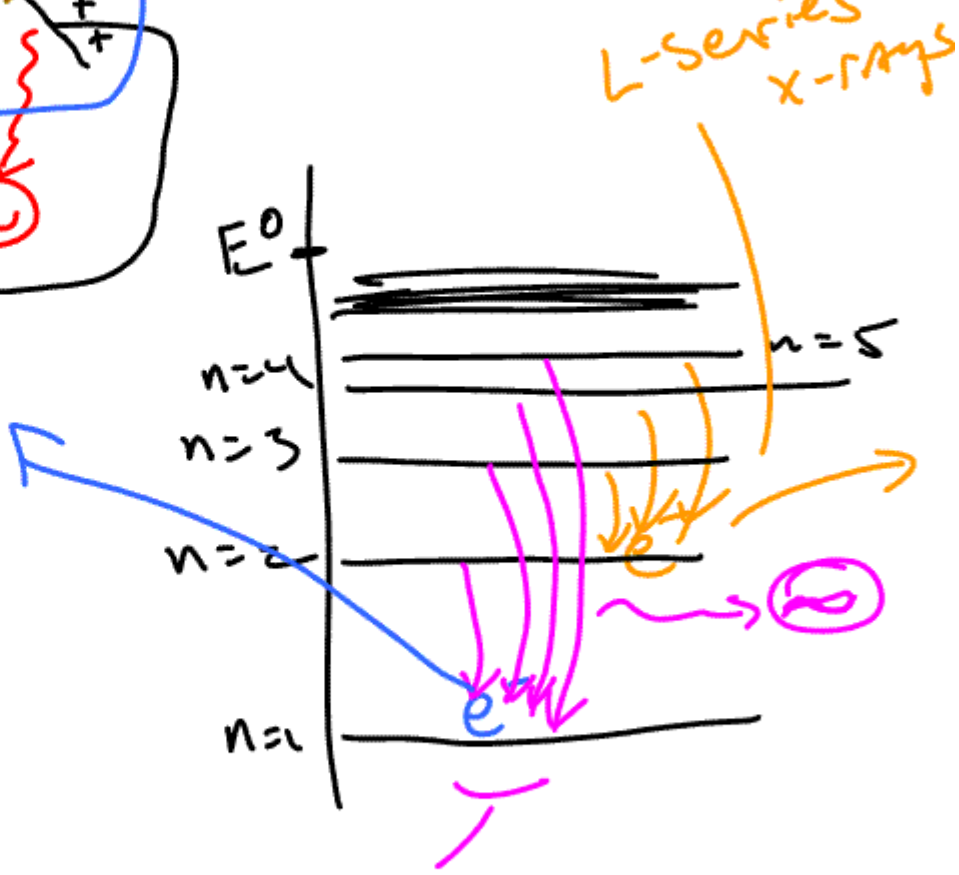


Figure from

http://www.uclan.ac.uk/facs/science/physastr/x99/PAM98/UCert/Ch06/6_6ato~1.htm

X-rays





X-rays

100 ~100,000 eV

Remove inner electron. When e^- from higher n cascades down to fill open place in inner shell, high energy γ is emitted

Another way to generate beams of x-rays
synchrotron light source

undulate high energy beam of electrons
by passing it thru series of closely
spaced magnets — undulating charge
emits light (x-rays)

high intensity source of x-rays