TOPIC 7 - Atomic + Nuclear Physics

§7.1 The Atom

Early models

- Greeks → tiny indivisible particles "atomos"
- Brownian motion → jiggling of dust/pollen particles.
- Explained by Einstein → due to collisions with surrounding particles that were invisibly small (atoms or molecules in the air)

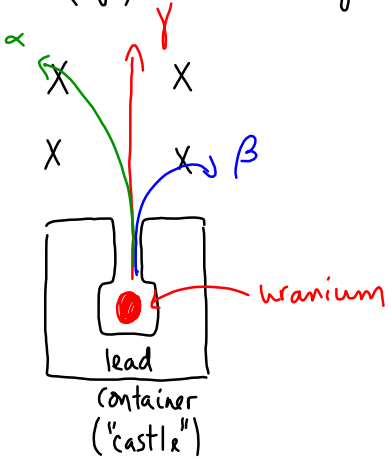
Discovery of Radioactivity

- Becquerel (1896) discovered that when a photographic plate became darkened when placed over top of uranium.
- proposed that radiation was coming from the uranium ⇒ radioactivity.
- Rutherford (1898) → conducted experiements to see what happens to the radiation in a magnetic field.
- He found that the radiation was composed of 3 types of particles:

alpha (α) → positive

beta (β) → negative

gamma (γ) → uncharged.



Alpha particles → found to be doubly ionized Helium atoms
→ basically it is a helium nucleus. (He^{2+})
(but alpha particles were discovered before anything was known about the nucleus)
→ energy ~ 5 MeV ($v \sim 10^7 ms^{-1}$)

Beta Particles → found to be electrons (e^-)
→ energy ~ 1-5 MeV ($v \sim$ speed of light $3 \times 10^8 ms^{-1}$)

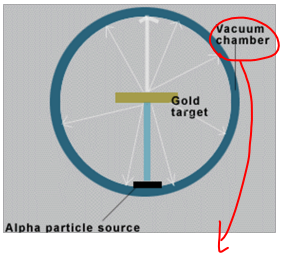
Gamma Rays → found to be short wavelength, high frequency / energy radiation ($\lambda \sim 1 10^{-13} m$)

Thomson model

JJ Thomson discovered the electron + his experiments in the early 1900's → Raisin Bun or Plum Pudding Model.
→ mass of atom due mainly to positive part of atom and electrons distributed throughout to balance the positive charge.

Discovery of the nucleus (the Geiger Marsden Experiment)

- In 1909, two of Rutherford's students (G + M) fired α particles at thin gold foil to investigate the structure of the atom.
- Alpha particles were able to penetrate the gold foil (travelling @ about 10^7 m/s)



to minimize scattering of the alpha particles

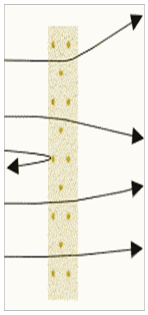
most α particles passed straight through, but some were deflected and a very few deflected straight back.

The Thomson model explained why the alpha particles went straight through There was no internal structure in that model to stop the high energy alpha particle. => would suggest no scattering

Most particles were not scattered, but a few were.

about 1 in 10,000 were deflected by more than 90°.

Rutherford's analogy →
"I like cannon balls being reflected by tissue paper"



Rutherford's Explanation of the results of the Geiger-Marsden experiment

Rutherford explained the results by proposing the existance of a "nucleus".

The "nucleus" must have the following properties:

→ All the positive charge is contained in the nucleus of the atom.

(The scattering of the α particle is due to the Coulomb repulsion force between the positive α-particles and the positive nucleus => $F \propto \frac{1}{r^2}$ obeys an inverse square law)

→ The nucleus must contain most of the mass of the atom

(The mass of the negative electrons is much less than the whole atom)

→ The nucleus must be very small compared to the whole atom ($\sim 10^{-14}$m diameter)

(Only a very few alpha particles were significantly deflected)