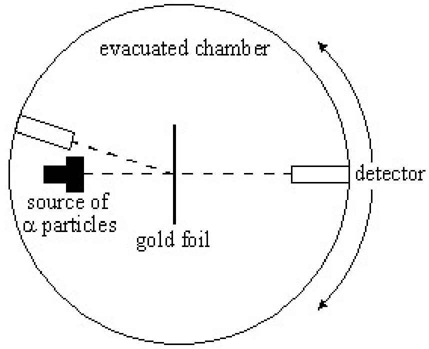
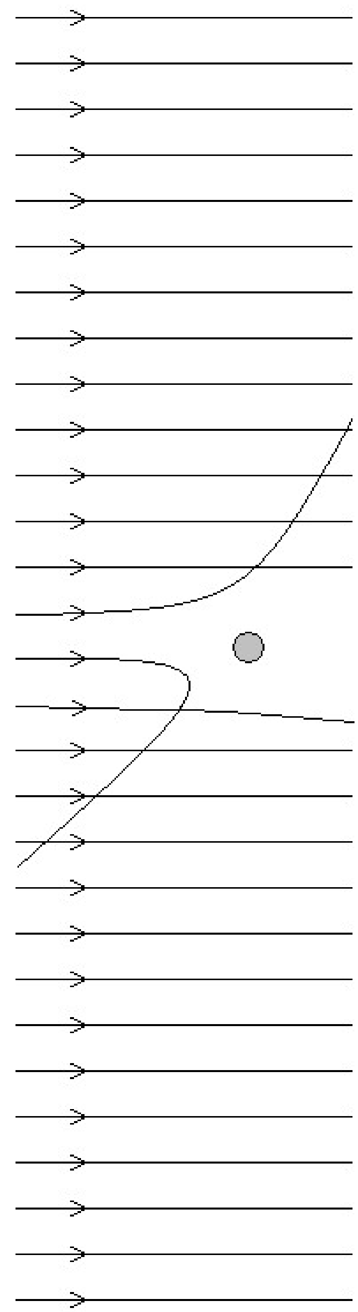
Rutherford Scattering

Rutherford's Scattering Experiment



Hans Geiger and Ernest Marsden worked with Ernest Rutherford in his Manchester laboratories in 1909. They fired alpha particles (which they knew to have a positive charge) of a few MeV into a thin piece of gold foil. This was done in an evacuated chamber connected to a vacuum pump. When the alpha particles passed through the gold foil they hit a zinc sulphide screen which emits light whenever an alpha particle strikes it. This screen was observed using a moving microscope in a dark room.
At the time the accepted structure of the atom was like a plum pudding: positive dough spread evenly with negative electrons scattered through it like plums in a pudding.

Results



Geiger and Marsden found that almost all of the alpha particles passed through with little or no deflection. Rutherford suggested moving the microscope in front of the foil, when they did they found that about 1 in every 8000 was 'reflected' back or scattered through an angle of more that 90°.
If the plum pudding model was the structure of the atom this would be like firing a bullet at a piece of toilet paper and it bouncing back!

The Nuclear Model

Rutherford used these results to make the following conclusions:

- Most of the mass must be gathered in one small volume – the nucleus.
  They can repel a fast moving alpha particle
- The nucleus must be positively charged.
  They repel positive alpha particles
- Most of the atom is empty space.
  Only 1 in 8000 alpha particles are deflected
- Negative electrons orbit the nucleus at a large distance from it.
  Negative charges are needed to keep the atom neutral

Which Particle to Use?

There are two things to consider when using scattering to find the structure of things: the particle and the energy.
Alpha Scattering: Rutherford used alpha particles with energies around 4MeV, any higher and it would be close enough to the nucleus to experience the strong nuclear force.
Electron Scattering: Electrons are accelerated to high energies of around 6GeV. They have enough energy to be scattered within protons and neutrons; discovering quarks. Electrons travelling at this speed have a de Broglie wavelength 1000 times smaller than visible light meaning we can see more detail.
X-ray Scattering: X-ray photons have short wavelengths and can be scattered or completely absorbed by atomic electrons. If the electron is tightly bound or the photon has very little energy the electron remains in the atom and the photon loses no energy. This is known as elastic or coherent scattering. If the photon has enough energy it knocks the electron out of orbit (ionisation) and does lose energy.
Neutron Scattering: Very useful because they are not charged but this limits the energies they can be accelerated to. Neutrons interact weakly with other nuclei and do not interact with electrons at all, because of this they can penetrate further. Their wavelengths are similar to that of atomic spacing, meaning that diffraction will occur.