Rutherford Scattering

Fluxion Example Description

1 Physical Background

Rutherford scattering studies the scattering of charged particles from a charged nucleus. Originally, the scattering of alpha particles ^4_2He on gold atomic nuclei $^{118}_{79}Au$ was investigated.

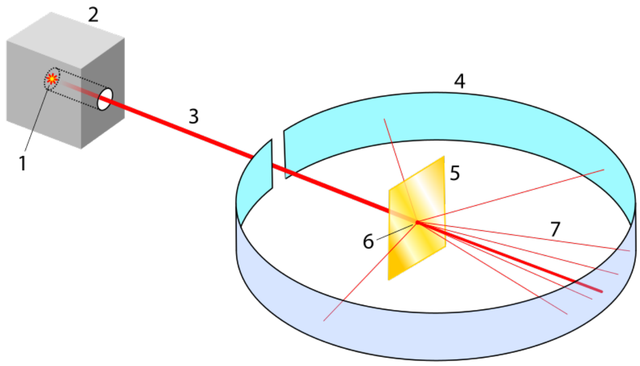

Abb. 1: Experimental Setup.
Source: Sundance RaphaelThe original uploading user was Sundance Ra- phael on Wikibooks related to German narrative Fujnkyderivative work: Oldracoon - This file is derived from this work: Rutherford Scattering.svg :, Public domain, https://commons.wikimedia.org/w/index.php?curid=76546189)

The number labels correspond as follows:

1. Radioactive Radium
2. Lead coat for shielding
3. Alpha particles
4. Fluorescent screen
5. Gold foil
6. Collision point between alpha particles and foil
7. Particle beam hits the screen directly behind detector, a few particles are deflected.

The pattern that emerged on the fluorescent screen (most alpha particles passed straight through, undeflected, but others were deflected at large angles) allowed conclusions to be drawn about the atomic structure. Rutherford hypothesized that the positive charge of an atom is concentrated in a small nucleus.

2 Simulation

First of all, some physical constants are introduced (one could also refer back to the program-internal constants - these are available with a right-click in the definition window). The gold atom carries a nuclear charge of Q = 79q and the mass of the helium nucleus is m = 4u.

Then some fundamental position - force relations are set up: velocity is the derivative of position, $F = m \cdot a$, ...
In the simulation, we focus on the interaction between a single gold nucleus and a helium nucleus (alpha particle) (whose trajectory is shown on the graph). If we put the gold nucleus at the origin of the coordinate system, then the distance between the helium nucleus and the gold nucleus is given by:

$$r = \sqrt{x^2 + y^2} \tag{1}$$

The force between the two particles is described by the Coulomb force - the gold nucleus, of course, experiences the same force as the helium nucleus, but is also much heavier and is located in a solid, therefore we consider the movement of the gold nucleus to be negligible. Now, we obtain the following force component functions:

$$F_x = \frac{1}{4 \cdot \pi \cdot \epsilon_0} \cdot \frac{2q \cdot Q}{r^2} \cdot \frac{x}{r} \tag{2}$$

$$F_y = \frac{1}{4 \cdot \pi \cdot \epsilon_0} \cdot \frac{2q \cdot Q}{r^2} \cdot \frac{y}{r} \tag{3}$$

The factor of 2 in the numerator simply means that the charge of the helium nucleus is 2q.
Now, by varying the initial conditions (x0, y0 and vx0), different trajectories of the helium nucleus can be observed.