Physics Lab

ETH zürich

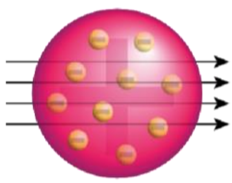
D PHYS

Rutherford Scattering

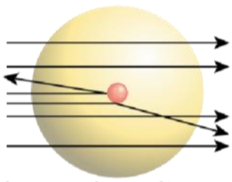
Abstract

At the end of the 19th century the scientifc community agreed on the existence of atoms but their structure was yet to be understood. A model by J.J. Thomson suggested that atoms were lumps of positive matter with the negatively charged electrons embedded in them ("Plum Pudding Model"). This model was shown to be incorrect by the scattering experiment performed by H. Geiger and E. Marsden under the direction of E. Rutherford in 1909. The intriguing results showed that around 1 in 8000 alpha particles shot on a thin gold foil were deflected by very large angles (over 90°), while the rest passed straight through with little or no deflection. From this, Rutherford concluded that the majority of the mass was concentrated in a minute, positively charged region (the nucleus) surrounded by electrons.

The gold foil experiment (1909)



expected result based on the "plum pudding model"

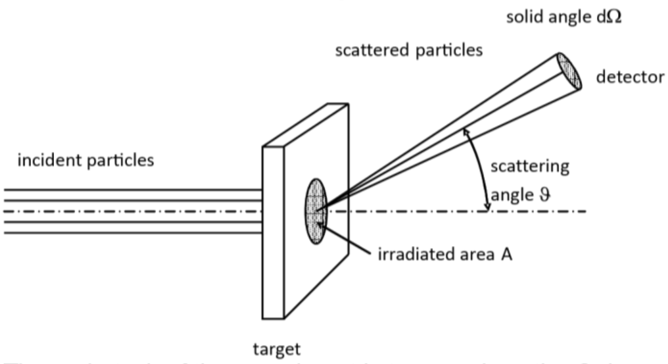


observed result: "Rutherford Scattering"

When a (positive) alpha particle approachs sufficiently close to the nucleus, it is repelled strongly enough to rebound at high angles. The formula to describe the scattering of charged particles at a Coulomb potential is the famous **Rutherford formula**:

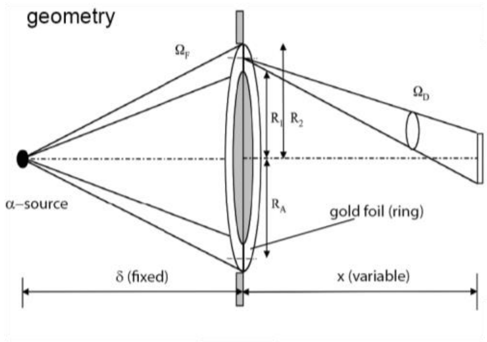
$$\sigma(\vartheta) = \frac{d\sigma(\vartheta)}{d\Omega} = \left(\frac{Z_1 Z_2 \in^2}{4E}\right)^2 \frac{1}{\sin^4(\vartheta/2)}$$

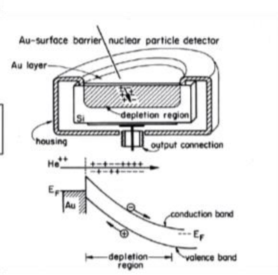
Main task of the VP experiment



The main task of the experiment is to reproduce the Geiger and Mardsen experiment including its theoretical background and to re-assess the angular dependency of the Rutherford scattering formula.

Experimental setup

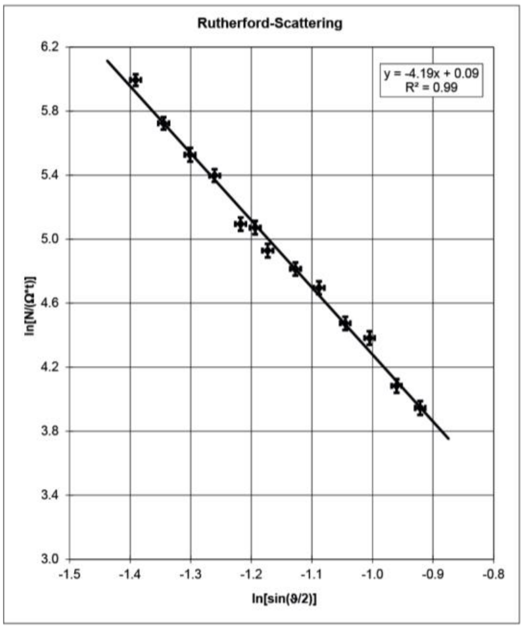




The scattering angle is varied by changing the distandce "x" between the gold foil (ring) and the detector. For a given scattering angle the number of atoms reaching the detector is given by :

$$N_a = \frac{N_{AK}}{A}\frac{N_e}{t}\int_{\Omega_D}\frac{d\sigma}{d\Omega}d\Omega \cong n_{AK}\, d\, t\, \frac{N_e}{t}\Omega_D \overline{\frac{d\sigma}{d\Omega}} \cong n_{AK}\, d\, t\, I_S \frac{\Omega_F}{4\pi}\Omega_D \left(\frac{Z_1 Z_2 \epsilon^2}{4E}\right)^2 \frac{1}{\sin^4\left(\frac{\vartheta}{2}\right)}$$

Results



Expected: linear trend in a log - log plot

$$\ln\left(\frac{N_a}{\Omega_D t}\right) = \ln C - 4\ln\left(\sin\frac{\vartheta}{2}\right)$$

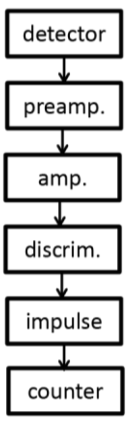
Linear regression:

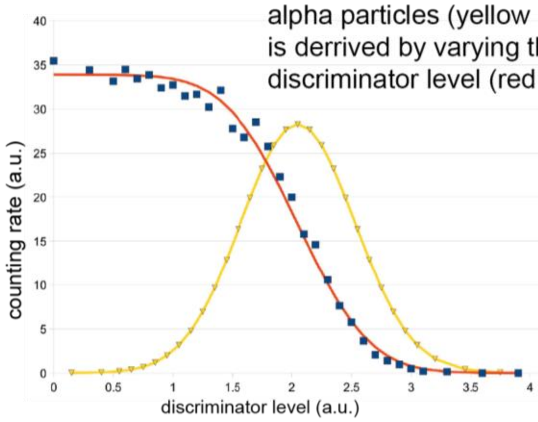
- include errors in x and y
- slope = -4.19±0.15

Statistical analysis:

- Chi-squared test (95% conf.)
- agreement with theory
- no unaccounted errors

Electronics





The energy distribution of the alpha particles (yellow curve) is derrived by varying the discriminator level (red curve).

Poster made by: M. Christl, P. Gautschi 13.05.2019