

Experiment: Rutherford scattering

Aim: Measuring the angle dependency of Rutherford scattering using semiconductor detector.

Apparatus required:

- Scattering chamber equipped with alpha particle source, scatterer with collimator slit, semiconductor detector
- Discriminator preamplifier
- Counter
- Vacuum pump

Theoretical Background:

The fact that an atom is “mostly empty space” was confirmed by Rutherford, Geiger and Marsden in one of the most significant experiments in the history of physics. They caused a parallel beam of α -particles to fall on an extremely thin sheet of gold leaf. They discovered that most of the α -particles passed through the gold leaf virtually without deflection, and that only a few were deflected to a greater degree. From this they concluded that atoms consist of a virtually massless extended shell, and a practically point-shaped massive nucleus.

This experiment reproduces these observations using an Am-241 preparation in a vacuum chamber. A beam of monoenergetic α -rays is directed onto a thin metal foil (silver). Besides those α -particles which penetrate the foil virtually without changing their direction, there are such α -particles which are scattered by the also positively charged nuclei of the foil material. These are deflected by different angles θ . The α -particles are recorded via a semiconductor detector with counter. Measurement of the scattering rate $N(\theta)$ as a function of the scattering angle θ allows to draw conclusions with respect to nuclear diameter of foil material. The relationship of scattering rate with scattering angle θ is,

$$N(\theta) \propto \frac{1}{\sin^4 \frac{\theta}{2}}$$



Fig. 1: Experimental set up and inside of the scattering chamber.

Procedure:

- Scattering chamber, discriminator preamplifier and counter are connected as shown in Fig. 1.
- The chamber is set up so that the rotational axis runs precisely through the foil and the rays fall vertically on to the slit plane.
- Close the lid and evacuate the chamber for 5 to 10 min.
- The discriminator is set to its threshold value.
- Note the no. of counts for 60 sec at $\theta = 0^\circ, \pm 5^\circ, \pm 10^\circ, \pm 15^\circ, \pm 20^\circ, \pm 25^\circ$ and $\pm 30^\circ \dots$
- Slowly release the knob of the vacuum pump.
- Plot $\log N$ vs deflection angle.

Sources of errors:

- Counting errors may occur if serious sources of interference are present during the measurement (spark gaps etc.). To minimize this error, one has to take care of sources of interference by checking the zero effect of the detector (if the detector is operating correctly then it should not substantially exceed 0.1/min).
- Inaccuracy of the collimator adjustment or non-central distribution of radiation of the Am-241 preparation in the holder may cause a shifting of curve along the abscissa.
- For low angles, α -particles scattered by electrons are present which one can see by the strong rise of incidents in that range that was not predicted by the Rutherford formula at all.