V16 Rutherford scattering experiment

Abstract

In this experiment the scattering of alpha particles by a gold foil is investigated.

References

[1] H. Haken, H.C. Wolf *Atomic and Quantum Physics*, Springer Verlag

[2] G. Pfennig, H. Klewe-Nebenius, W. Seelmann-Eggebert *Karlruher Nuklidkarte* 1998

[3] A.C. Messelinos *Experiments in Modern Physics* Academic Press, New York

[4] W.R. Leo *Techniques for nuclear and particle physics experiments* Springer

Preparation

Working through these questions should prepare you for doing the experiment sucessfull.

- What assumption are made in deriving the Bethe-Bloch eqation and Rutherford scattering formula?
- What is a scattering cross section? How does it differ from the differential scattering cross-section?
- Use the Bethe-Bloch formula to calculate the stopping power of alpha particles in air? At what chamber pressure do energy losses become noticeable?
- What is the term diagram of ^{241}Am? What types of radioactive radiation does americium emit? What must be taken into account in the experiment?
- How does a surface barrier detector and a rotary vane pump work?
- How large does the measured count rate have to be to get a relative statistical uncertainty of maximum 3%?
- Why is gold particularly suitable as a scattering material?

Experimental setup and Alignment

A ^{241}Am serves as the radioactive source. The α-particles are collimated with two 2 mm slit apertures and scattered on a thin gold foil. A surface barrier detector detects the scattered alpha particles as a function of the scattering angle θ. Since the α-radiation emitted by americium has a range of about 1.5 cm in air, the set-up is located in a vacuum apparatus. The negative pulses amplified by the detector are post amplified ba an amplifier. A storage

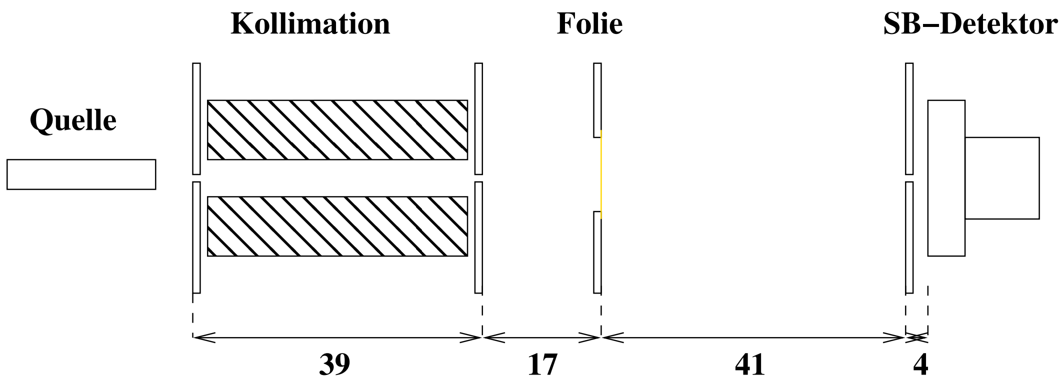

Figure 1: Experimental setup

oscilloscope is available for measuring the energy loss and a counter for determining the scattering cross-section.

Measurements and analysis

Please read the radiation protection instructions before experimenting and observe all safety instructions given!

The radioactive source is installed by the supervisor!

You must place a shutter in front of the radiator each time you change the film!

- A rotary vane pump is available for evacuating the chamber. Make sure that all valves are closed and evacuate the chamber. To change the chamber pressure, you must slowly open the fine dosing valve on the vacuum chamber. Please note that the fine dosing valve only opens after approx. 10 turns!! Please do not slam the fine dosing valve when closing it, otherwise the valve will no longer close.

- Set the reverse voltage of the surface barrier detector to $U_{det} = +12\ V$ and observe the pre-amplified pulses on the oscilloscope. What do the pulses look like and what are their rise times? Document how the pulses change behind each electronic component.

- Determine the film thickness by measuring the energy loss of the alpha particles when passing vertically through the scattering film. Measure the pulse hight of the detector pulses as a function of the chamber pressure one with and one without the film. Extrapolate the range of the α-particles and determine the film thickness from this.
  Note: It is necessary to set the ´overglow´ on the oscilloscope in order to determine the average pulse hight.

- Investigate the differential cross-section for a thin gold foil. To do this, measure the count rate as a function of the scattering angle and plot the differential cross section as a function of the scattering angle. Calculate the solid angle using the geometry shown in Figure 1. Compare the measured values with the theoretically calculated one. Discuss any deviations from small and large angles.

- To investigate the influence of multiple scattering, measure the scattering cross-section for different film thicknesses. select fixed angles for this purpose.
- Measure the Z-dependence on a silver, platinum, aluminium and gold foil and discuss the result. To do this, measure the intensity of the α-particles at a large scattering angle and plot against I/Nx against the nuclear charge number Z. Here N is the number of scattering centres and x is the thickness of the scattering foil. What is the dependence? Compare the measured data with the calculated data.

Appendix

Source: ^{241}Am with A = 330 kBq (October 94)
Detector: active area d = 1 cm^2
Aperture: F = 2 mm × 10 mm