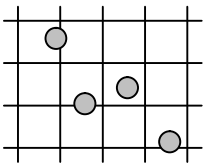
Experiment 4

Back Scattering of Beta Particles



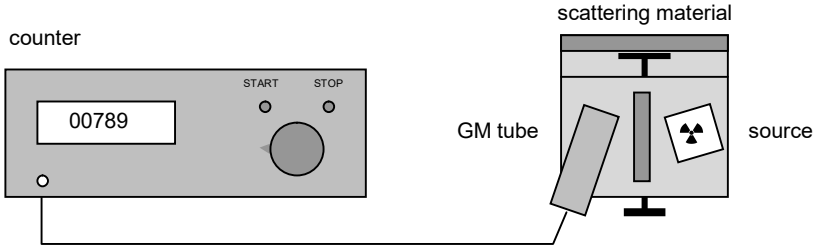
First read the introduction at experiment 4 in the booklet *ISP Experiments* about scattering and back scattering of β radiation.
If you have difficulty in understanding what back scattering is, image throwing tennis balls towards a rough wire mesh (see the diagram on the left). Part of the balls will go through the mesh, other balls will be deflected to the left or to the right, and some balls will be reflected in your direction. Those are the balls that are being back scattered.

Aim

- To determine the relation between the number of back-scattered β particles and the atomic number of the scattering material.
- To identify an unknown material from the measured back scattering.

Set-up

The set-up consists of a Geiger-Müller tube, a pulse counter and a source with the β emitter strontium-90 (^{90}Sr). A metal partition wall is positioned between the source and the GM tube. Sheets of different scattering materials can be inserted in the equipment set-up. The counter can be set to an automatic measuring time of 10 s or to 'continuous'. In the latter case, after starting the counter will continue counting until the stop button is pressed. For measuring time, then use a stopwatch.



With the equipment set-up, the intensity *I* (in pulses per unit of time) of the back-scattered β radiation can be measured for different scattering materials: carbon, iron, aluminium, copper, tin and lead – and an unknown material.

Research Question

- Draw up a research question fitting the aim and equipment set-up of this experiment.

Hypothesis

- Draw up an argued hypothesis about the relation between the intensity *I* of the back-scattered radiation and the atomic number *Z* of the scattering material.
- Give this hypothesis also in the form of a sketch of the relation between these quantities in an *I*,*Z*-graph.

Plan of Work

- Draw up a plan of work for the investigation with the given equipment set-up.
- In this plan of work, indicate how you will vary which quantities in order to be able to check your hypothesis.
- Indicate how you will correct your measurements for the background radiation.
- Prepare an (empty) table for recording your measurements.
- Indicate how you will identify the unknown scattering material from your measurements.
- Indicate whether the experiment will contribute to the radiation dose you receive during the laboratory session. And, if so: how you can take care that this radiation dose stays as low as possible.
- Discuss your research question, hypothesis and corresponding plan of work with your teacher or the school's laboratory technician.
- If necessary, review your research question, hypothesis and/or plan of work.

Investigation

- Carry out the investigation according to your plan of work. During the laboratory session, take care of an adequate radiation protection.

Data Processing

● Process your measurements in order to check your hypothesis, and to answer your research question. The box below gives some instructions for such data processing.

Instructions

● Plot your measurements in a graph.

> From this graph, identify the unknown scattering material.

● The β particles have different ways of interacting with the material. The scattering can be a result of one or more collisions with the atomic nuclei or the electrons around these nuclei of the scattering material. The most important interaction is the collision with the atomic nuclei. Over a century ago the English physicist Ernest Rutherford discovered that scattering will occur as a result of electrical forces between the negatively charged β particles and the positively charged atomic nuclei. This interaction involves no loss of energy, and thus the speed of the particle does not change. However, as the mass of the β particle is very small, the particle's direction of motion will change considerably.

> Explain the relation between the intensity *I* of the back-scattered β radiation and the atomic number *Z* of the scattering material.

● In identifying the unknown scattering material, you probably found a material that differs from the material used in the equipment set-up: molybdenum.

> Explain this difference.

Extra question

Sir Ernest Rutherford initially used alpha-particles instead of beta-particles to show that the atomic nucleus actually exists. Name two important differences that would be present because of this and explain how they would influence the experiment.

Report

● Write a report about this investigation. This report presents your *research question*, *hypothesis*, (processed) *measurements* and *conclusion* about the hypothesis being confirmed or not.