Experiment 8

Radiation Intensity and Distance

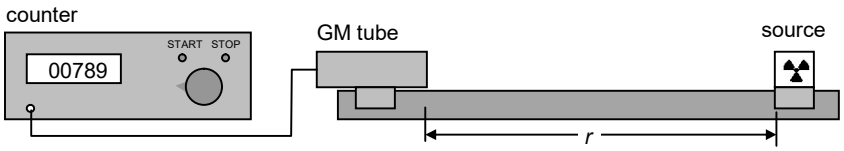
First read the introduction at experiment 8 in the booklet *ISP Experiments* about the relation between radiation intensity and distance.

Aim

To determine the relation between the radiation intensity and the distance to a radioactive point source.

Set-up

The set-up consists of a Geiger-Müller tube, a pulse counter and a source of strontium-90 (^{90}Sr). 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.
The distance between the GM tube and the source is adjustable between 20 and 80 cm, and can be read on a scale. At distances smaller than 20 cm, deviant measurement results will occur. First of all, the radiation intensity then is too high for the GM tube to cope with: the tube will not succeed in detecting all incoming β particles. Secondly, the source emits β particles with different energies. The low-energetic β particles do not move any further than about 20 cm in air. So, only at distances larger than 20 cm the (divergent) beam of radiation is made up of a roughly constant number of high-energetic β particles.



With the equipment set-up, the radiation intensity *I* (in pulses per unit of time) can be measured as a function of the distance *r* between the source and the GM tube.

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 radiation intensity *I* and the distance *r* to the source.
- Give this hypothesis also in the form of a sketch of the relation between these quantities in an *I*,*r*-graph.

Plan of Work

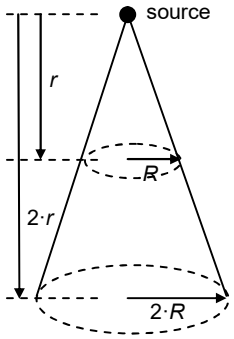
- Draw up a plan of work for the investigation with the given equipment set-up.
- In this plan of work, indicate how you will vary which quantities in order to be able to check your hypothesis.
- Indicate how you will correct your measurements for the background radiation.
- Prepare an (empty) table for recording your measurements.
- Indicate 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, determine the relation between radiation intensity *I* and distance *r*.

- From the *I*,*r*-graph of your measurements it appears that the relation between radiation intensity *I* and distance *r* probably is *inversely squared*. In a formula:

$$I = \frac{c}{r^2} = c \cdot \frac{1}{r^2}$$

In this formula *c* is a proportionality constant.

> Explain how this follows from the *I*,*r*-graph.

> Check whether there is indeed an inversely squared relation by plotting the radiation intensity *I* versus $1/r^2$.

- The relation between radiation intensity and distance is called the *inverse square law*: the radiation intensity *I* decreases with the square of the distance *r* between source and GM tube.

> Explain this relationship with the help of the drawing (left).

Extra question

According the nuclear energy law a sealed radioactive source for transportation may have a maximum activity of 4 Bq/cm^2 for the outside of the package. How large does the packaging need to be when you want to transport a source with an activity of 100 kBq? (Consider the source as point source, and assume that the packing itself doesn't interfere with the radiation).

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.