Range of α-particles

RT 4.1

Although the energy of the α-particles is normally very high, their range in air is only a few centimeters and only a few micrometers in solids. The reason for their small range is their high ionization property. In a distance of about 1 cm in air they ionize about 10^4 molecules and lose about 33 eV of their energy each time they ionize. They thus have a discrete range depending on their initial energy. The relationship between the range in air R and the energy E_α is expressed by the following empirical equation:

$$R_{max} = 0.32\ E_\alpha^{\ 1.5}$$

(R in cm, E_α in MeV, for air under normal pressure)

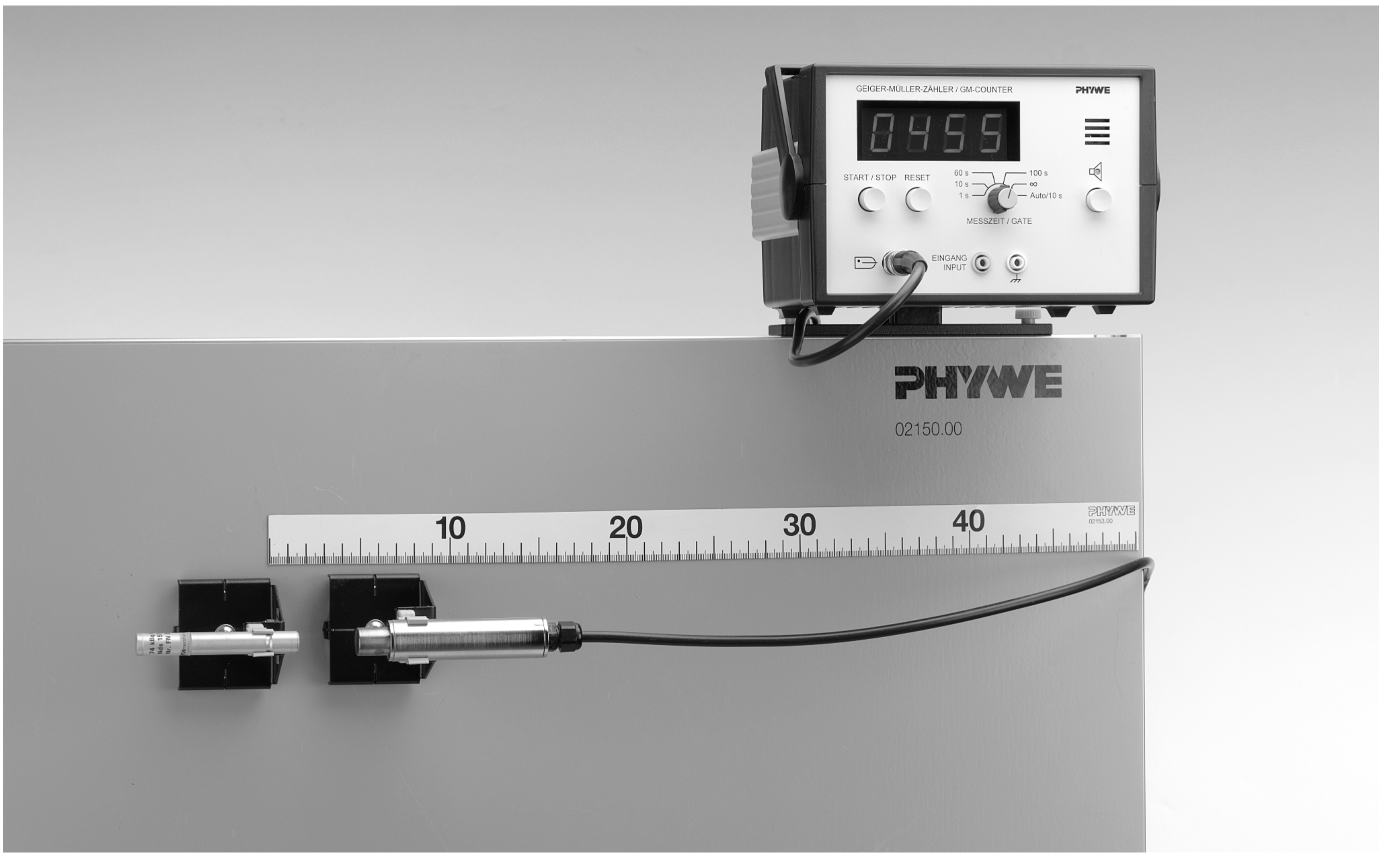
The radiation source Am-241 emits five groups of α-particles during transition to the different excited states of the neptunium nucleus Np-237 with energy values between 5.387 MeV and 5.543 MeV, whereby the energy value of 5.484 appears with the highest frequency of 85.2 %.
The neptunium nucleus emits a small amount of γ-radiation when changing from the excited state to the base state with relatively lower energy. This portion of the radiation is also registered by the counter tube; by taking the difference of the counting rates, which were registered once with and then without a piece of paper as the α-absorber, the actual α-percentage can be deduced.

The range of 4.1 cm expected from the empirical formula cannot be confirmed with this experimental setup, because the radioactive substance was covered with a gold-palladium foil and even the counter tube window causes a shortening of the range. Moreover, an energy loss of the α-particles also takes place within the active substance because of the overlying layers.
Caution! Since the counter tube is at a distance of 1 cm from the radiation source, the risk of a contact and hence a damage to the counter tube window is especially high. Hence, the counter tube holder must be moved very carefully on the demo board.

Equipment

Support clamp for small case	02043.10	1
Clamp on holder	02164.00	1
Support rod, stainless steel	02030.00	1
Counter tube holder on fix. magnet	09201.00	1
Source holder on fixing magnet	09202.00	1
Scale for Demo-board	02153.00	1
Counter tube Type B	09005.00	1
Geiger-Müller-Counter	13606.99	1
Demo-Board for Physics with stand	02150.00	1
Radioactive sources, set	09047.50	1

Fig. 1: Experimental setup



Set-up and procedure

- Fig. 1 shows the experimental set-up
- Fix the counter tube in the holder without the protective cap in such a way, that its window is present exactly above the front edge of the counter tube holder.
- Fix the radiation source Am-241 in the source holder such that the exit opening of the radiation is present exactly above the front edge of the source holder.
- Set the scale on the demo board such that the zero mark of the longitudinal division lies at the front edge of the source holder.
- Move the counter tube holder carefully towards the radiation source upto a distance of a = 1 cm
- Select a measurement time of 100 s and determine the impulse rate Z_1; enter the value in Table 1
- Determine the counting rate Z_2 after covering the opening of the radiation source with a piece of paper.
- Repeat the same measurements for distances a = 1.5 cm, 2 cm, 2.5 cm and 3 cm.
- After concluding the experiment put the radiation source back in the container and replace the protective cap of the counter tube.

Results

Table 1

$\frac{a}{\text{cm}}$	$\frac{Z_1}{\text{Imp/100 s}}$	$\frac{Z_2}{\text{Imp/100 s}}$	$\frac{Z_1 - Z_2}{\text{Imp/100 s}}$
1	1477	1150	327
1.5	842	736	106
2	539	529	10
2.5	411	388	23
3	315	320	-5

Evaluation

The α-radiation is completely absorbed by the paper; as a result the impulses of the counting rate Z_2 are caused by the γ-radiation. The proportion of the α-radiation can be determined from the difference in the counting rates.
The α-radiation is registered only till a distance of 1.5 cm. The difference between the impulse rates at greater distances are only due to the statistical inaccuracy of the measured values.
For determining the maximum range of the α-radiation it must be considered, that the radioactive substance is present at a distance of 0.7 cm behind the exit opening of the source. As a result, the experiment returns only a lower value of R_{max} = 2.2 cm for the range of the α-radiation.