Deflection of β^+- particles (positrons) in a magnetic field

RT 4.4

Positron radiation (β^+-particles) arises during the spontaneous nuclear decomposition of artificial nuclides with a relative excess of protons. The energy distribution of the protons emitted shows a continuous spectrum, same as in the case of β^--radiation.

The radio isotope Sodium-22 is used here as the positron emitter, which also emits γ-quanta along with the β^+-radiation when it changes to the more stable Neon-22. These produce a radiation background independent of the direction of observation when one studies the deflection of the positrons in a magnetic field, in addition to the zero rate.

Equipment

Support clamp for small case	02043.00	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
Plate holder on fixing magnet	09203.00	1
Deflection magnet for plate holder, 2 pcs	09203.02	1
Optical disc, magnet held	08270.09	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

Set-up

Fig.1

Instruction: To avoid the disturbing of the positions of the radiation source and the plate holder during the execution of the experiment, it is recommended to conduct the experiment first with and then without the deflection magnet. Further, the position of the counter tube in the counter tube holder should be marked either with the help of an adhesive strip or a color marker and should not be disturbed during the experiment.

If a comparison of the behavior of the β^-- and β^+-particles is desired, then the distance and the position of the deflection magnets, as well as the geometric arrangement of the two experiments should conform to each other.

— Place the optical disc on the demo board.

— Place the deflection magnet with a pole distance of 1.5 cm on the inner surface of the plate holder and position it such on the optical disc, that the center of the magnetic poles is present over the center of the angular scale.

Fig. 1: Experimental setup

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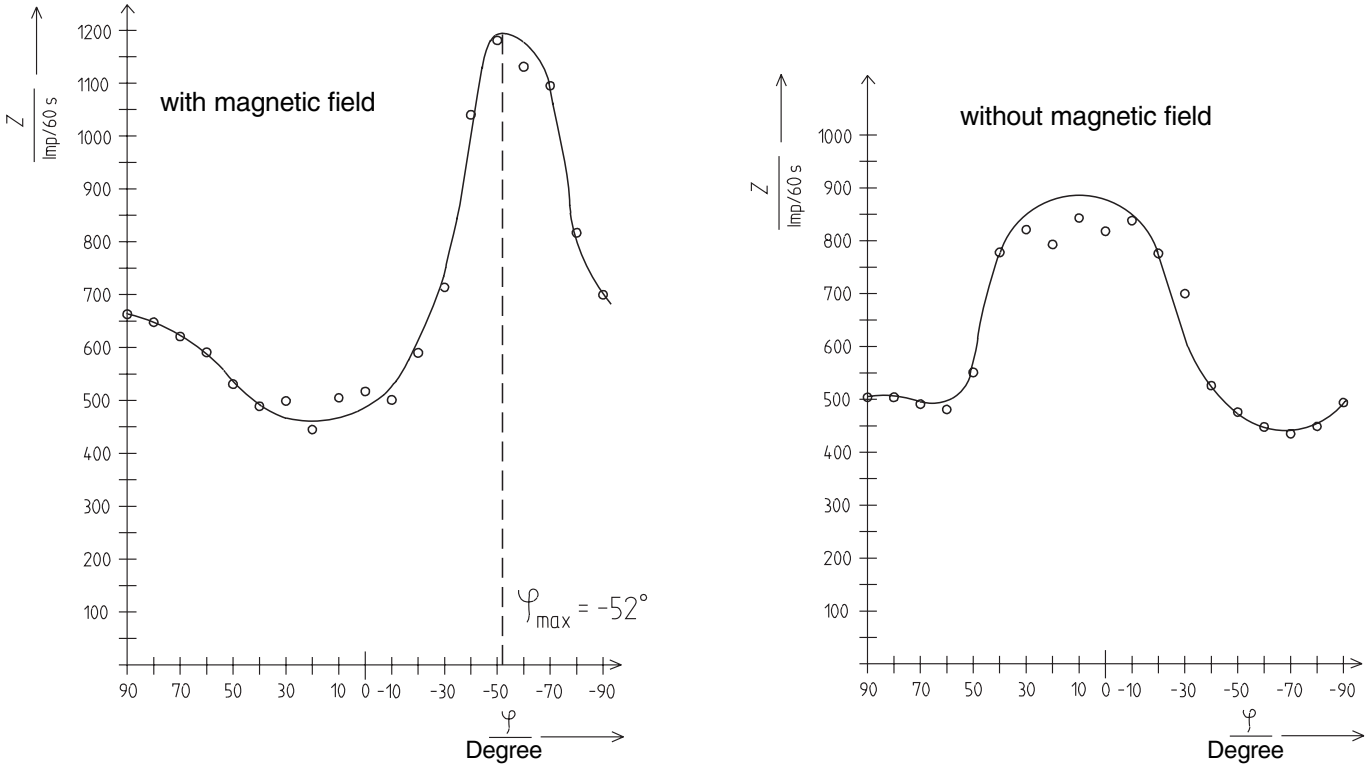
— Set the counter tube along with holder without the protective cap on the 0°-line of the optical disc such that the rear pointed end of the holder lies exactly on the outer circumference of the optical disc; the counter tube window should be at a distance of about 5 cm from the deflection magnet; Align the longitudinal axis of the counter tube with the center of the angular scale.
— Place the source holder with the β^+-radiation source Na-22 on the demo board such that the exit opening for the radiation is positioned directly in front of the deflection magnet.
— Select the measurement time of 60 s, determine the count rate and note the value in Table 1.
— Push the counter tube to the 10°-angle mark, such that the distance of the tube to the radiation source does not change.
— Determine the count rates for this and for all other deflection angles in steps of 10°-in the range of +90° and -90° and enter the values in Table 1.
— Remove the plate holder with the deflection magnet from the demo board; the position of the radiation source should not be disturbed; repeat the complete series of measurements in the same way without the deflection magnet.
— After concluding the measurements replace the radiation source in the protective container and place the protective cap again on the counter tube.

Result

Table 1

φ/Degree	with magnetic field $\frac{Z}{\text{Imp/60 s}}$	without magnetic field $\frac{Z}{\text{Imp/60 s}}$
0	518	819
10	506	844
20	446	794
30	500	822
40	490	779
50	532	552
60	592	482
70	622	492
80	649	505
90	664	505
10	502	839
-20	591	777
-30	715	701
-40	1041	527
-50	1182	477
-60	1132	449
-70	1096	436
-80	818	450
-90	701	495

Fig. 2



Evaluation

The count rates Z are graphically displayed as a function of the deflection angle φ in a Cartesian coordinate system or in a polar diagram. The angular position of the maximum count rate must be marked.
(see Fig. 2 and Fig. 3)

A comparison of both the intensity distribution shows, that the positrons carry an electrical charge, because they are deflected in a magnetic field.

Upon the application of the three-finger rule, the direction of the magnetic field and the deflection show, that the β-radiation from Na-22-carry a positive charge.

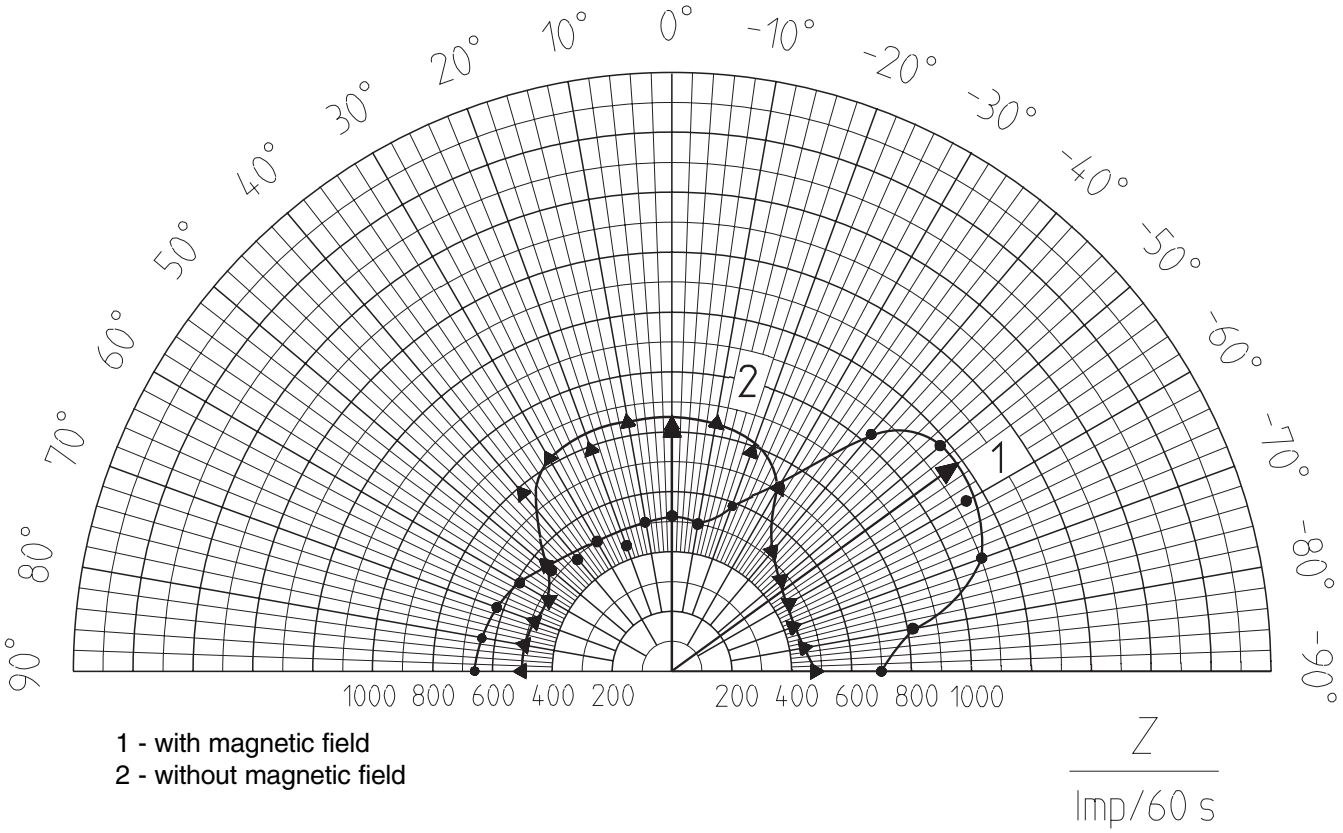
A comparison with the deflection of the β^--particles from the source Sr-90 shows:

1. The β^+-particles of the Na-22 source experience a stronger deflection in a magnetic field of the same strength. One can deduce from this, that the positrons emitted from the Na-22 source possess a lower energy than the β^--particles of the Sr-90-source.
2. In addition to the β^+-particles, Na-22 source also emits another radiation that is not affected by the magnetic field. Along with the positron radiation, the Na-22 also emits some γ-radiation.

Instruction

1. An interchange of the magnetic poles causes a reversal of direction of the magnetic field and hence a change in the direction of the deflection of the β^+-particles.
2. Reducing the distance of the magnets increases the strength of the magnetic field and the β^+-particles get deflected more strongly.

Fig. 3



1 - with magnetic field
2 - without magnetic field

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Room for notes