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I. Khubeis, H. Schopper

GESELLSCHAFT FUR KERNFORSCHUNG M.B.H.

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THE CIRCULAR POLARIZATION OF EXTERNAL BREMSSTRAHLUNG PRODUCED BY β-RAYS IN A MAGNETIZED IRON TARGET

I. KHUBEIS and H. SCHOPPER

Institut für Experimentelle Kernphysik der Technischen Hochschule und des Kernforschungszentrums Karlsruhe

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Abstract: The degree of the circular polarization of external bremsstrahlung produced by β-rays from a $Sr^{90}+Y^{90}$ source in an iron target was investigated with the target magnetization perpendicular to the momentum of the electrons. No variation of the circular polarization as a function of the magnetization was found in disagreement with the results of Bisi *et al.*

1. Introduction

The production of circularly polarized bremsstrahlung by longitudinally polarized electrons has been extensively investigated [1-4]), and the experimental results are in perfect agreement with the theoretical expectations. Surprisingly Bisi and Zappa [5]) found that the circular polarization is affected by the magnetization of the target if the bremsstrahlung is produced in iron. In particular they found that the polarization is decreased by about 10% for a completely magnetized iron target compared to unmagnetized iron.

Later [6]) the dependence on the magnetization was investigated more extensively and a maximum of the polarization was found for the magnetization $B = 1300$ G. Furthermore the effect for an unmagnetized target was smaller than for a completely magnetized one in contradiction to the first paper. In a subsequent paper [7]) the same group of authors studied also the effect of a longitudinal external magnetic field and found large effects (30 to 50%) for iron and silver targets.

As it seems to be very difficult to explain these effects an experimental re-investigation seemed interesting. The influence of a transverse magnetization of an iron target on the circular polarization of the bremsstrahlung was measured and within the experimental error of about 1.5% no effect was observed, in disagreement with the effects of up to about 27% found by Bisi *et al.*

2. Experimental Arrangement

The circular polarization of the bremsstrahlung was measured by using the Compton forward scattering from magnetized iron in a standard arrangement [2]) which is shown in fig. 1.

The output of the photomultiplier was fed into a single-channel pulse-height discriminator permitting the selection of different photon energies. In order to reduce the influence of the magnetic stray fields on the multiplier two μmetal shields and three iron cylinders were used. The change in the counting rate due to reversing the magnetic field was smaller than $(1.5 \pm 2) \times 10^{-4}$.

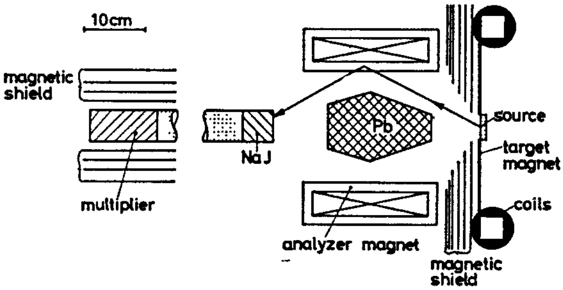

Fig. 1. Experimental arrangement.

The β-source (23 mCur $Sr^{90}+Y^{90}$) was deposited on a disc of plexiglas 1 cm thick and was covered with a thin foil of Hostaphan 0.02 mm thick.

A slab of Armco iron 1.5 mm thick was used as a target. It was attached to the two poles of a horseshoe electromagnet. Between the target magnet and the analysing magnet a set of 6 iron plates was introduced in order to minimize the magnetic stray field of the analysing magnet at the target position.

In order to detect the circular polarization of the bremsstrahlung the magnetization of the analysing magnet was reserved every ten minutes. In addition the magnetization of the target was reversed every twenty minutes. In this way counting rates for four different target-analyser combinations were obtained: N_+^+, N_-^+, N_+^- and N_-^- where the subscript indicates the analyser magnetization and the superscript the target magnetization, respectively.

From these four counting rates the following four polarization effects can be computed:

$$E_1 = \frac{N_-^+ - N_+^+}{\frac{1}{2}(N_-^+ + N_+^+)}, \quad E_2 = \frac{N_-^- - N_+^-}{\frac{1}{2}(N_-^- + N_+^-)}, \quad E_3 = \frac{N_-^+ - N_+^-}{\frac{1}{2}(N_-^+ + N_+^-)}, \quad E_4 = \frac{N_-^- - N_+^+}{\frac{1}{2}(N_-^- + N_+^+)}.$$

As the polarization should not depend on the direction of the target magnetization an average polarization effect can be calculated:

$$E = \frac{(N_-^+ + N_-^-) - (N_+^+ + N_+^-)}{\frac{1}{2}(N_-^+ + N_-^- + N_+^+ + N_+^-)}.$$

Measurements were performed for two different pulse-heights corresponding to mono-energetic photons of 660 keV and 470 keV, respectively, with a window width of 50 keV. The relation between the output of the single-channel analyser and the incident photon energy is rather complicated for a continuous spectrum[3]). However, these relations are of no importance here as we are interested only in relative measurements and an absolute determination of the polarization is of no interest.

3. Experimental Results

The polarization effect was measured for various transverse magnetizations for two different effective photon energies. Between runs for different target magnetizations the target was always demagnetized.

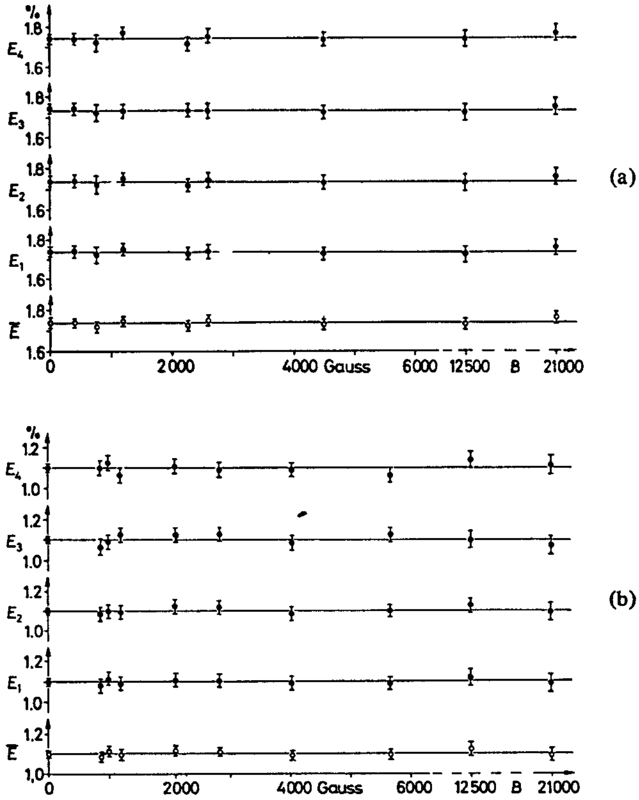

Fig. 2. The polarization effect E as a function of the target magnetization B.E_1 to E_4 belong to different combinations of the directions of the target and analyser magnet magnetization, respectively. (a) pulse heights corresponding to a primary γ-energy of 660 keV. (b) a γ-energy of 470 keV. $\bar{E}$ is the average polarization effect.

The results for the individual target-analyser combinations and the average polarization effects are shown in fig. 2(a) and (b). Within the statistical errors of about 1.5% the effects show no dependence on the magnetization. The fact that the four effects E_1, E_2, E_3 and E_4 agree within the statistical errors of about 2% also proofs that there is no detectable effect of the magnetic stray fields.

In fig. 3 the results of this work are compared with those of Bisi *et al.*[6]). All effects are normalized to the value for $B = 21000$ G. There is an obvious disagreement between the two kinds of measurements.

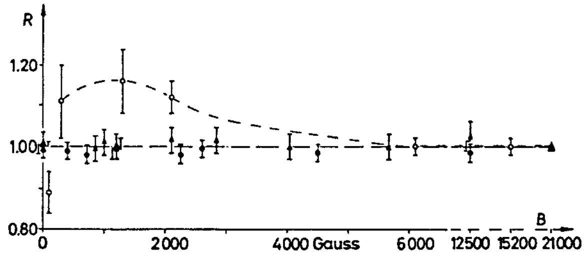

Fig. 3. The normalized average polarization effect $R = \bar{E}(B)/\bar{E}(21 \text{ K Gauss})$ as function of the target magnetization B. ●-this work (for pulse-heights corresponding to 660 keV), ▲-this work (for pulse-heights corresponding to 470 keV), o-results by Bisi *et al.*[6]) (broad range of pulse-heights).

4. Discussion

The results of the work presented here clearly indicate that there is no direct influence of the target magnetization on the circular polarization of the bremsstrahlung.

With respect to the results obtained by Bisi *et al.* we think that our experimental arrangement is superior in several respects:

(1) Our source was deposited on plexiglas and covered by a thin foil whereas Bisi *et al.* used a source deposited on a thick silver disc and covered with a silver foil. Hence backscattering and bremsstrahlung production in the target foil is negligible in our case.

(2) The target magnetization was reversed in this work in addition to the analyser magnetization. In this way it was easier to recognize the influence of stray fields on the photomultiplier.

(3) A narrow range of pulse-heights was selected instead of performing an integral measurement. Hence a small change in the photomultiplier amplifications can easily be detected as the bremsstrahlung spectrum is a steeply decreasing function.

(4) The target was magnetically well shielded from the analysing magnet and the target was demagnetized between different runs.

As was shown by Galster[3]) the backscattering of electrons can influence the circular polarization of the bremsstrahlung. One might imagine therefore, that the magnetic field changes the backscattering and hence in an indirect way also the bremsstrahlung polarization. In order to check this possibility plexiglas was used as target and an iron backing for the source. In such a combination the contribution of backscattered electrons to bremsstrahlung production is greatly enhanced. However, no effect of the magnetization of the source backing was found.

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