ANGULAR DISTRIBUTION OF PHOTOELECTRONS KNOCKED OUT BY Cs^{137} *PHOTONS FROM TARGETS WITH DIFFERENT Z*

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The angular distribution of photoelectrons from Nd and U targets is measured. The results, together with data from an earlier paper[3], make it possible to determine the Z dependence of the photoelectron flux at $\theta = 0$.

SAUTER'S known formula[1] describes the angular distribution of relativistic photoelectrons knocked out of the K shell of substances having low atomic numbers. In later theoretical papers[2-4] it was shown that the angular distribution picture should actually be quite different from that given by Sauter.

For small angles θ the theory predicts[3,4] a nonzero intensity when $\theta = 0°$. In the photoeffect problem, the final-state wave function used in the calculation of the matrix element is customarily expanded in the parameter αZ, where $\alpha = 1/137$.

Sauter's solution[1] takes into account terms up to $(\alpha Z)^2$ only, which do not contribute to the intensity at $\theta = 0°$. The contribution to the intensity at $\theta = 0°$ should thus be due to the term proportional to $(\alpha Z)^3$ or to an even higher power.

The difficulty in the experimental investigation of angular distributions of photoelectrons lies in the strong smearing of the original angular distribution, due to multiple scattering of the electrons in the target substance itself.[4-7] Only by introducing a rather complicated correction for the experimental geometry and for multiple scattering was Hultberg[7] able to obtain approximate data on the true picture of the angular distribution in the elementary act.

The purpose of the present investigation was to investigate experimentally the angular distribution of the photoelectrons from the K shell, knocked out by Cs^{137} γ rays from targets with different Z. The investigation was carried out with the aid of a magnetic spectrometer. The measurement procedure and the analysis of the experimental material were described earlier.[8] The use of very thin targets and the good angular resolution of the instrument enabled us to obtain a picture of the angular distribution in the elementary photoeffect act.

Since the most interesting deviation from Sauter's angular distribution is the emission of electrons at an angle $\theta = 0°$, we have investigated the variation of I_0/I_{max} (the ratio of the intensity at $\theta = 0°$ to the maximum intensity which corresponds to an angle $\theta = 15°$ $h\nu = 662$ keV) with increasing Z of the target. The measured angular distributions of the K photoelectrons knocked out of neodymium and uranium targets are shown in Fig. 1.

The Z dependence of I_0/I_{max}, based on data of the previous investigation and the present work, is shown in Fig. 2.

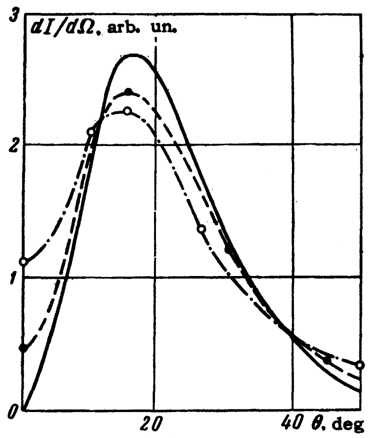

FIG. 1. Angular distribution of photoelectrons knocked out by Cs^{137} γ radiation ($h\nu = 662$ keV) from neodymium (•) and uranium (o) targets with surface density 0.05 and 0.04 mg/cm², respectively. The continuous curve is that of Sauter.[1]

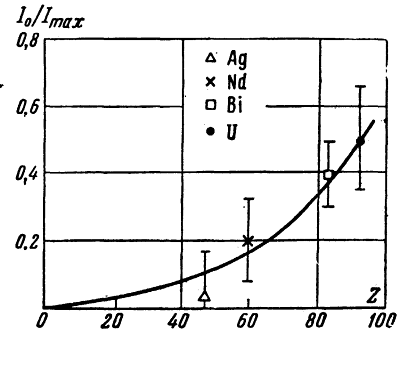

FIG. 2. Relative probability I_0/I_{max} of emission of K photoelectrons at an angle $\theta = 0°$. The continuous curve corresponds to an approximate $Z^{2.7}$ variation.

We see that the "anomalous" probability of emission of electrons in the direction of the γ-ray beam increases rapidly with increasing Z. The course of the variation of I_0/I_{max} with the Z of the target can in accordance with our measurement be represented by the empirical formula

$$I_0/I_{max} = 2.59 \cdot 10^{-6} Z^{2.7}.$$

We can therefore readily assume that the intensity at $\theta = 0°$ is due actually to the expansion term proportional to $(\alpha Z)^3$.

This type of intensity variation at $\theta = 0°$ is quite interesting from the point of view of the theory of the photoeffect, and needs a quantitative explanation.

In conclusion, the authors are grateful to Professor K. K. Aglintsev for continuous interest in the work and to M. N. Chubarov for help with the measurements.

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