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BAND-STRUCTURE EFFECT ON THE ANGULAR CORRELATION OF ANNIHILATION RADIATION IN YTTRIUM

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Submitted to JETP editor September 4, 1963

J. Exptl. Theoret. Phys. (U.S.S.R.) **45**, 2070-2071 (December, 1963)

A study of the angular correlation of the γ-quanta pairs which appear on annihilation of positrons in a solid gives information on the distribution function of the valence-group electrons in momentum space. However, because of the considerable experimental difficulties only the most general features of this effect have been studied so far. In the present work measurements carried out on yttrium showed certain details in the angular distribution of the annihilation quanta which have not been detected earlier in similar experimental studies.

The measurements were carried out on a sample of polycrystalline yttrium at room temperature. The measurement technique was essentially the same as that described by Green and Stewart.[1,2] The angular half-width of the resolution curve was 0.5×10^{-3} rad.

The direct results of measurements are given in Fig. 1. The ordinate gives the number of γ-quanta pairs recorded per unit time (in arbitrary units), and the abscissa represents the angle θ (which gives the projection of the momentum of a pair of quanta on a given axis z: $p_z = mc\theta$). The dashed curve in Fig. 1 was calculated for the photon angular distribution in the case when the valence electrons in the sample form an ideal degenerate Fermi gas. This curve corresponds to two electrons per yttrium atom and is plotted with allowance for the finite width of the resolution function. Both curves in Fig. 1 are normalized to the same area. The considerable difference between these curves is explained by the annihilation of positrons and electrons in the 4d band. This effect was observed earlier in transition metals of the iron, platinum and palladium groups and in the noble metals.[2-5]

Figure 2 gives on an enlarged scale parts of the experimental curve in Fig. 1. The circles and crosses denote the left-hand and right-hand parts of this curve respectively. Figure 2 shows the local changes in the slope of the $N(\theta)$ curve. Berko[6] detected anisotropy of the annihilation radiation in a single crystal of beryllium at values of the angle θ corresponding to $p_z = \pi/c$ (c is the parameter of the hexagonal close-packed lattice along the sixfold axis). It is evident from Fig. 2 that, in the present case, there is a clear local singularity of the $N(\theta)$ curve at a similar value of θ. It is also possible that the other similar singularities of the $N(\theta)$ curve are related to the influence of the periodic potential of the lattice on the electron spectrum.[5] Clarification of this problem could be obtained from measurements at a smaller angular resolution.

In conclusion the author thanks Professor E. I. Kondorskiĭ for his help in the present work, and V. I. Chechernikov for supplying the samples.

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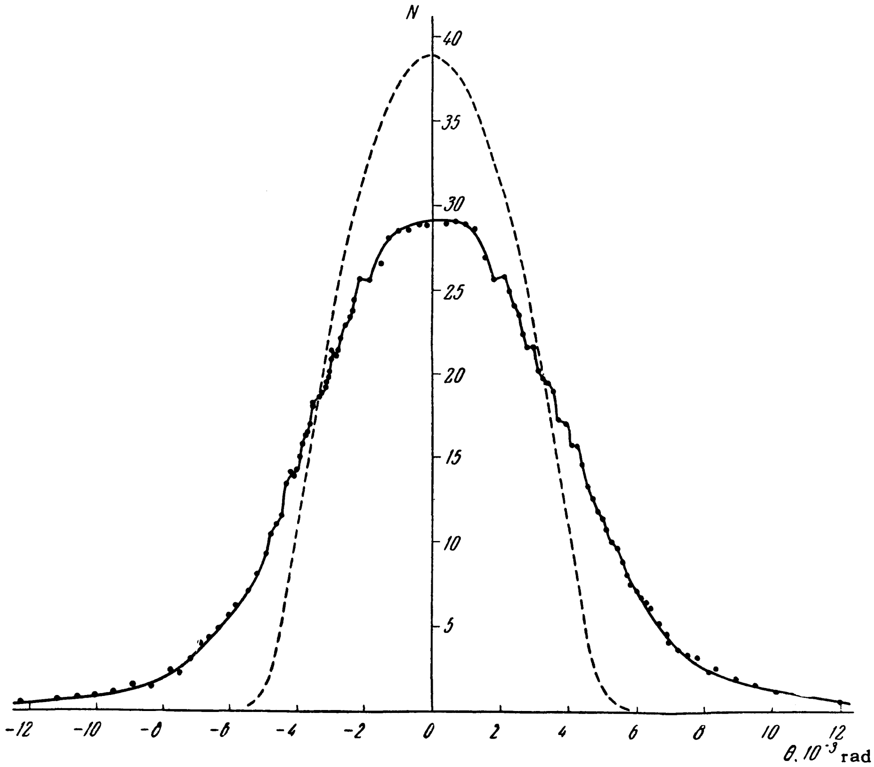

FIG. 1

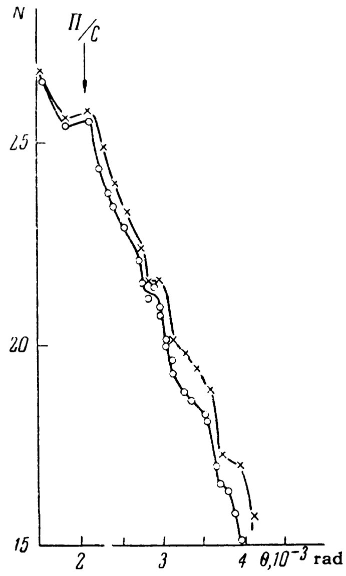

FIG. 2

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Translated by A. Tybulewicz
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FORMATION OF FAST RESIDUAL NUCLEI

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Submitted to JETP editor September 11, 1963

J. Exptl. Theoret. Phys. (U.S.S.R.) **45**, 2072-2073 (December, 1963)

IT was indicated in [1,2] that in any analysis of the formation of fast fragments upon interaction between nuclei and high-energy particles, it is necessary to take account of the possibility of intranuclear reactions in the diffuse region of the nucleus, that is, inelastic interactions between fast nucleons and nucleon clusters in the nucleus.

In this case the fragment emitted in the disintegration is a unique residual nucleus due to the destruction of nuclear substructure, and when a fragment unstable against decay is produced this can be the cause of some of the lighter products of the nuclear disintegration. (In the disintegration of light nuclei, in particular, this can be the high-energy components of the alpha particles, which cannot be explained within the framework of the cascade-evaporation mechanism [3]).

It is sensible to assume that the intranuclear reactions should be accompanied by production of a small number of nucleons, since excessive fractionalization of the energy of the cascade or incident nucleon among a large number of nucleons of a given group is hindered in the nucleus, in accordance with the Pauli principle. In this connection, great interest is attached to the question of the momentum distribution of the residual nuclei in the case of few-nucleon simple reactions of the