sound, etc.

[1] H. Suhl, J. Phys. Chem. Sol. 1, 209 (1957).

CONCERNING THE ANISOTROPY OF THE PROBABILITY OF THE MOSSBAUER EFFECT ON Sn^{119} NUCLEI IN THE LATTICE OF WHITE TIN

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We have already reported [1] results of an investigation of the anisotropy of the Mossbauer effect as determined by the anisotropy of the resonant absorption of γ quanta by Sn^{119} nuclei in thin single-crystal absorbers made of white tin.

In the present paper we report the results of measurements of the amplitude of the absorption for so-called "black" resonant absorbers ($C_a \simeq 100$) combined with a thick single-crystal source ($C_s \geq 10$), using the previously described setup [1]. The absorption amplitude is proportional in this case to the probability of γ-quantum emission in the given direction of the crystal, and the proportionality coefficient itself is practically independent of either the thickness of the absorber and source, or of the hyperfine structure of the emission and absorption lines. This makes it possible to measure directly the anisotropy of the emission probability, and its temperature and angular dependences.

In the measurements we used as the "black" absorbers plates made of tin enriched to 88.1% of Sn^{119}. The effective thickness of resonant absorption C_a was in this case 53 at 290°K for an absorber 0.25 mm thick, and 330 at 4.2°K for an absorber 0.10 mm thick.

One of the single-crystal sources, in the form of a plate 70 μ thick, was grown from active tin with the aid of a single-crystal primer, using the method described by P. L. Kapitza for the growing of single crystals of bismuth [2]. The primer was a plate cut by the electric spark method from a single-crystal block in such a way that the normal to the plate made an angle of 45° with the crystal axes [001] and [100]. The surface layer deformed by the spark processing was removed electrolytically. The direction of the normal to the plane of the obtained single-crystal source relative to the crystal axis was monitored with an x-ray setup. The content of the Sn^{119} was 1.4% in the active tin material and 1.7% in the primer material. A second single-crystal source had the form of a cylinder of 1 mm diameter and 10 mm long. It was grown by the same method,

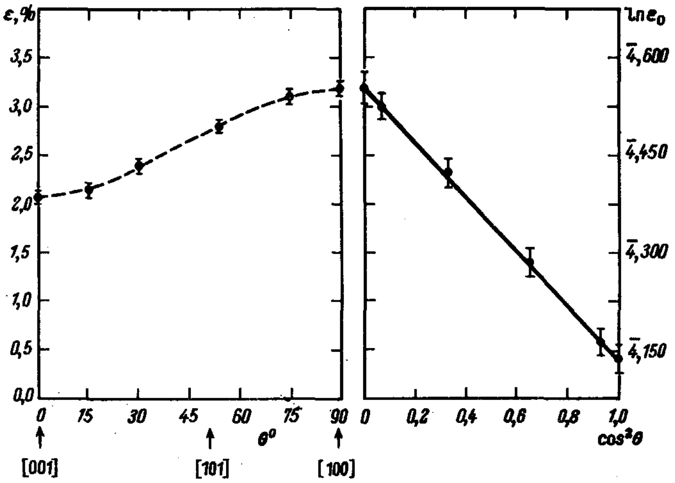

Fig. 1. Angular dependence of the emission probability of β-Sn(010), T = 290°K.

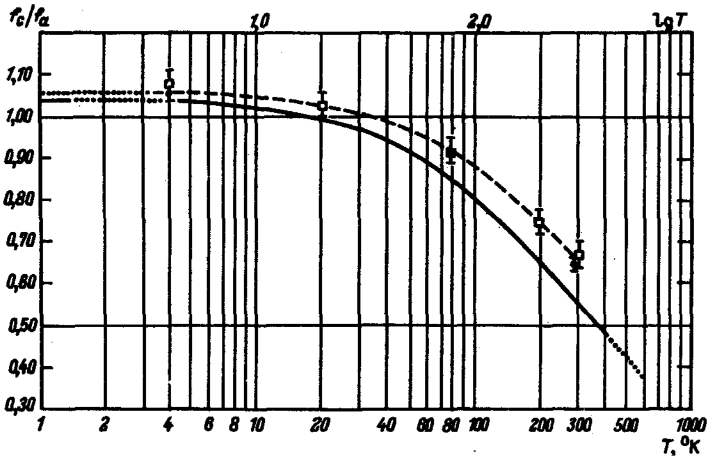

Fig. 2. Temperature dependence of the anisotropy of the emission probability f_c/f_a: ● - present data, □ - data of [1], —— - theoretical curve [4].

the primer being a crystal of natural tin, the axis of which coincided with the [010] direction within 2°.

We measured the angular dependence of the absorption amplitude ϵ_0 on the γ-quantum emission direction θ relative to the [001] axis in the (010) plane at 290°K (see Fig. 1), and the temperature dependence of the anisotropy of the emission probability (Fig. 2). Figure 1 shows also the dependence of $\ln \epsilon_0$ on $\cos^2\theta$, making it possible to determine directly, from the slope of the line, the difference of the squares for the mean-square displacements $(2\pi/\lambda)^2[\langle u_c^2\rangle - \langle u_a^2\rangle]$ for the β-Sn lattice at 290°K. It is easy to see that this difference equals (0.42 ± 0.03). Comparison with the absorption amplitude of a polycrystalline source makes it possible to obtain the absolute values for the emission probability f and the mean-square displacement $\sigma = \langle u^2\rangle^{1/2}$ in the corresponding directions, if we use the data of [3] for the factor f in the polycrystalline tin.

In particular, we have $f_c/f_a = (0.655 \pm 0.015)$, $f_c = (0.034 \pm 0.002)$, and $\sigma_c = (0.152 \pm 0.004)$ Å at 290°K, $f_c/f_a = (0.915 \pm 0.015)$, $f_c = (0.43 \pm 0.01)$, and $\sigma_c = (0.076 \pm 0.002)$ Å at 77°K, and $f_c/f_a = (1.055 \pm 0.015)$, $f_c = (0.74 \pm 0.01)$, and $\sigma_c = (0.046 \pm 0.002)$ Å at 4.2°K. It should be noted that the statistical error of the measurements of the absorption amplitude was 0.03% at 290°K and 0.2% at low temperatures, and was the cumulative result of many measurements [1].

Figure 2 shows also, for comparison, the data of [1] (squares) and the results of the theoretical calculations of Brovman and Kagan [4] (continuous curve). The agreement between the present measurment results and our earlier data [1] and also with the theoretical calculations [4] is quite satisfactory and serves as additional confirmation that the temperature dependence of the anisotropy of the Mossbauer-effect probability in single crystals of white tin is apparently due, according to [4], to the overlap of the optical branch of the oscillations with the acoustic branch, and to the larger weight of this branch in the phonon spectrum of tin.

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[1] We note that the influence of the non-parallelism of the γ-quantum beam on the measurement result was taken into account by a correction to the absorption amplitude $\Delta\epsilon_0 = 2\epsilon_0[(f_a - f_c/f_a]P_2(\cos\theta)(1/4)(\rho_1^2 + \rho_2^2)$, where $P_2(\cos\theta)$ is a Legendre polynomial, and ρ_1 and ρ_2 are the radii r_1 and r_2 for the absorber and source in units of z_0 - the distance between them along the axis of the apparatus. In particular, at r_1 = 10 mm, r_2 = 5 mm, z_0 = 10 cm, and $\Delta f/f = 0.05$, this correction amounts to only 0.06% of ϵ_0 at $\theta = 0°$.

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[1] N. E. Alekseevskii, A. P. Kir'yanov, V. I. Nizhankovskii, and Yu. A. Samarskii, ZhETF Pis. Red. 2, 269 (1965) [JETP Lett. 2, 171 (1965)].
[2] P. L. Kapitza, Proc. Roy. Soc. A119, 358 (1928).
[3] C. Hohenemser, Phys. Rev. 135A, 170 (1965).
[4] E. G. Brovman and Yu. M. Kagan, Fiz. Tverd. Tela 8, 1402 (1966) [Sov. Phys.-Solid State 8, 1120 (1966)].

ANOMALOUS HALL COEFFICIENT IN THE REGION OF THE PARA-PROCESS

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It is known that most experimental data on the Hall effect in magnetic materials are described essentially by the two-term equation

$$E_x = R_0H + R_II. \tag{1}$$

Here E_x - Hall emf, R_0 and R_I - classical and anomalous Hall coefficients. The quantity R_I is defined as the ratio E_{xs}/I_s, where E_{xs} and I_s - spontaneous Hall emf and magnetization, obtained by extrapolating the $E_x(H)$ and $I(H)$ curves from the region of magnetic fields H larger than the technical-saturation field H_s. Near the Curie temperature, the values of E_{xs} and I_s are calculated by the method of thermodynamic coefficients [1,2], but in many cases it is necessary to take into account here the classical Hall field R_0H (see, e.g., [3]). The coefficient R_I defined in this manner is equal to the slope of the $E_x(I)$ line in the technical part of the magnetization curve at small H.

According to existing theoretical concepts, the temperature dependence of the anomalous Hall coefficient R_I is determined essentially by the change of the magnetic part of the electric resistance ρ_m, i.e., the resistance corresponding to the scattering of the carriers by the spin homogeneities (see, e.g., [4]). Indeed, a number of experiments have shown that when the temperature is varied the coefficient R_I depends linearly on ρ_m [5-8].

We present in this paper new experimental data on the Hall effect in certain magnetic materials with a large para-process. These results make it necessary to refine the existing theoretical concepts concerning the nature of the anomalous Hall coefficient.

Figures 1a and b show plots of the Hall emf E_x against the magnetization I for different temperatures in the case of gadolinium and an alloy of the invar type. We see that in the region of the para-process the slope of the $E_x(I)$ lines is independent of the temperature, whereas in the technical part of the magnetization curve this angle increases on approaching the Curie point.

It follows from Figs. 2a and b that the numerical values of the Hall coefficients corresponding to the technical and para-process parts of the magnetization, are essentially different.

K. P. Belov and one of us proposed in [9,10] to describe the Hall emf in the para-