INFLUENCE OF HYDROSTATIC COMPRESSION ON THE TURNING EFFECT IN ANTIMONY

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The gist of the turning effect is that the diagonal components of the thermoelectric power $\alpha_{ii}(H)$ are not even functions of the magnetic field H. This effect can occur in crystals having a complicated carrier energy spectrum. In crystals of the Bi type, in particular, the odd character of $\alpha_{ii}(H)$ is connected with the inclination of the axes of the constant-energy ellipsoids relative to the twofold axis [6, 7]. The odd character of the thermoelectric power becomes most strongly pronounced in intermediate magnetic fields, $\mu H/C \approx 1$ (μ is the carrier mobility). The turning effect was observed experimentally in Bi and Sb [1 - 4, 13]. The theory of the effect was considered in [1, 2, 6, 7].

The purpose of our investigation was to determine the influence of hydrostatic compression on the turning effect in antimony. According to [5], the Fermi surface of antimony consists of three triaxial deformed electron ellipsoids located near the L point of the Brillouin zone and inclined 83° to the threefold axes in the trigonal-bisector plane. The hole Fermi surface consists of six deformed triaxial ellipsoids located near the T point of the Brillouin zone, having major axes inclined 52.6° to the threefold axes.

The experimental data [9, 10] and the theory [8, 112] indicate that the pressure changes the ratio of the crystal axes and the rhombohedral angle of the Sb unit cell in such a way that its structure comes closer to cubic upon compression. This should result in significant changes in the carrier spectrum, namely, according to an analysis of galvanomagnetic-effect measurements [11], the inclination of the ellipsoids to the twofold axis decreases with increasing compression. If this is indeed so, then the turning effect should decrease with increasing pressure [2]. Thus, measurements of the dependence of the turning effect on the hydrostatic compression should yield direct information on the deformation of the carrier energy spectrum.

The thermoelectric power was measured in Sb single crystals grown by the Bridgman method from brand-SU000 antimony, in magnetic fields up to 3×10^3 Oe, at $T_{av} \approx 97$°K. The pressure ranged from 0 to 12 kbar. The samples were cut from the ingot by the electric-spark method. The sample dimensions were 1 x 0.8 x 10 mm. The samples were oriented by the Laue method with accuracy 2 - 3°. A pressure up to 15 kbar was produced in a nonmagnetic high-pressure chamber placed between the poles of an electromagnet. The chamber was lowered as a unit in a Dewar. The setup was cooled, at a fixed pressure in the chamber, at a rate ensuring hydrostatic compression of the samples.

A turning effect for the diagonal components of the thermoelectric power $\chi_{22}(H)$ and $\chi_{33}(H)$ was observed in a magnetic field H directed along the binary (C_1) and bisector (C_2) axes. There was no turning effect for $\chi_{22}(H)$ when the magnetic field was parallel to the trigonal axis (C_3). Figures 1 and 2 show plots of the thermoelectric power against the magnetic field for two opposite field directions, +H and -H, at different orientations of H relative to the crystallographic axes and the temperature gradient. The ordinates represent the relative changes of the magnetothermal emf in the field

Fig. 1. Magnetothermal emf $(\Delta\alpha/\alpha_0)^{\pm}_{33}$ vs. magnitude and direction of magnetic field H: $H \parallel C_1$, $\nabla T \parallel C$, $T_{av} \approx 97°$

Fig. 2. Magnetothermal emf vs.H at 97°K: I $-\left(\frac{\Delta a}{a_0}\right)^{\pm}_{22}$, $H \parallel C_1$ $\nabla T \parallel C_2$, II $-\left(\frac{\Delta a}{a_0}\right)^{\pm}_{33}$ $H \parallel C_2$, $\nabla T \parallel C_3$

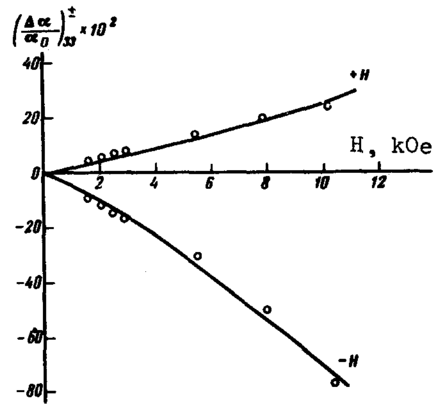

Fig. 1

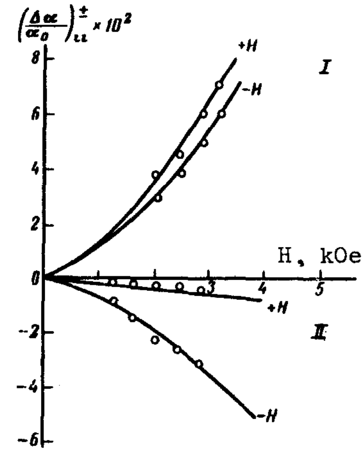

Fig. 2

$$\left(\frac{\Delta a}{a_0}\right)^{\pm}_{ii} = \frac{a_{ii}(\pm H) - a_{ii}(0)}{a_{ii}(0)}.$$

It is convenient to describe the turning effect by means of the quantity

$$\left(\frac{\Delta a}{a_0}\right)_{ii} = \left(\frac{\Delta a}{a_0}\right)^{+}_{ii} - \left(\frac{\Delta a}{a_0}\right)^{-}_{ii} = \frac{a_{ii}(+H) - a_{ii}(-H)}{a_{ii}(0)}.$$

With increasing hydrostatic compression, the quantity $(\Delta\alpha/\alpha_0)_{ii}$ decreases, as can be seen from Fig. 3. This decrease of the turning effect is direct proof that the angle of inclination of the ellipsoids to the principal axes of the Brillouin zone decrease with increasing pressure.

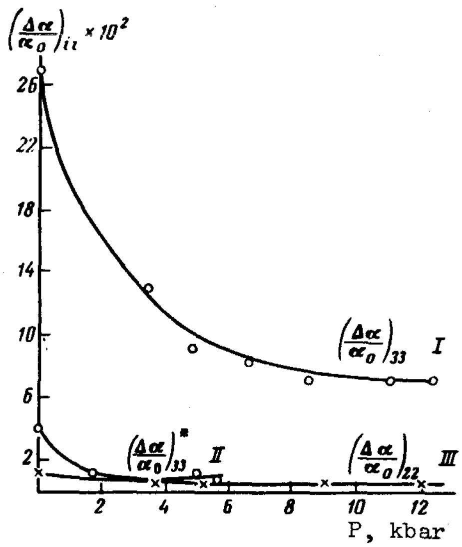

Fig. 3. Plot of $(\Delta\alpha/\alpha_0)_{ii}$ for different orientations of the magnetic field and of the temperature gradient T relative to the crystallographic axes C_1, C_2, and C_3, $T_{av} \approx 97°K$:

I $\left(\frac{\Delta a}{a_0}\right)_{33}$ $- H \parallel C_1$, $\nabla T \parallel C_3$,

II $\left(\frac{\Delta a}{a_0}\right)^{*}_{33}$ $- H \parallel C_2$, $\nabla T \parallel C_3$,

III $\left(\frac{\Delta a}{a_0}\right)_{22}$ $- H \parallel C_1$, $\nabla T \parallel C_2$.

(All $\left(\frac{\Delta a}{a_0}\right)_{ii}$ taken at $H = 3000$ Oe)

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DEPENDENCE OF THE ORIENTATIONAL MAGNETOOPTIC EFFECT ON THE MAGNETIZATION

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A new magnetooptic effect observed in ferromagnetic metals was reported in [1]. It consists of a change in the intensity of the reflected light and is comparable in magnitude with the usual equatorial Kerr effect. Unlike the latter, however, it is even in the magnetization and is strongly anisotropic. It is assumed that this effect is due to the influence of the orientation of the magnetization vector (we shall henceforth call it the orientational magnetooptic effect) on the electronic structure of the ferromagnet, owing to the presence of spin-orbit interaction. We show here that this effect depends on the magnetization.

The measurements were performed on thin permalloy strip films (for details and references see [2]). The choice of the samples was dictated by the fact that the domain structure of these films is very simple (see Fig. 1) and the film is magnetized by simultaneously increasing the angle ϕ in all the domains. In addition, owing to the smallness of the magnetizing field ($\vec{H}_s \approx 100$ Oe) and the small volume of the sample, all type of noise has been reduced to practically zero. A sensitive magnetooptic setup [1] was used to record the changes in the intensity of the reflected light for arbitrary variation of the angle ϕ in the intervals $\phi_0 < \phi < \pi/2$ and $-\phi_0 < \phi < -\pi/2$, i.e., in the region where $\vec{I}_x$ depends linearly on $\vec{H}$. It was possible to apply to the sample simultaneously a constant field $\vec{H}_=$ and an alternating field $\vec{H}_\sim$. The field $\vec{H}_\sim$ ensures periodic variation of the magnetization relative to any $\vec{I}$, determined by the magnitude and sign of $\vec{H}_=$. We measured directly the relative change of the reflected-light intensity $\delta = [J(\vec{I}_1) - J(\vec{I}_2)]/J(\vec{I})$, corresponding to a magnetization change from $\vec{I}_1$ to $\vec{I}_2$. Reversal of the sign of $\vec{H}_=$ has made it possible, using the geometry of the equatorial Kerr effect ($\vec{H} \parallel x$, light incident in the yz plane), to obtain two values of the effect, δ_a and δ_b, corresponding to changes of I_x from I_1 to I_2 and from $-I_2$ to $-I_1$, respectively. With this, the usual equatorial Kerr effect is $\delta_{eq} = \delta_{odd} = (\delta_a + \delta_b)/2$, and the orientational magnetooptic effect observed in [1] is $\delta_{or} = (\delta_a - \delta_b)/2$. The first series of measurements (I) was performed at the geometry of the equatorial Kerr effect.

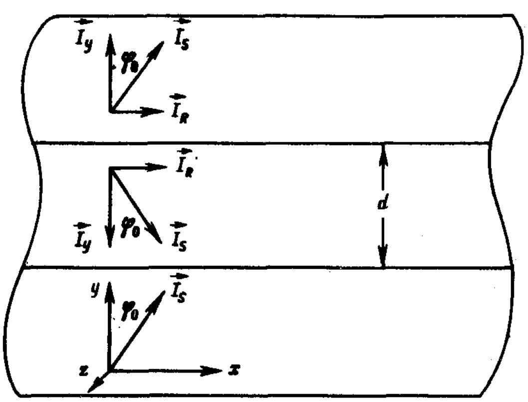

Fig. 1

$\vec{H}_=$ was set equal to the saturation field $\vec{H}_s$, and δ_a and δ_b were then measured at different