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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.

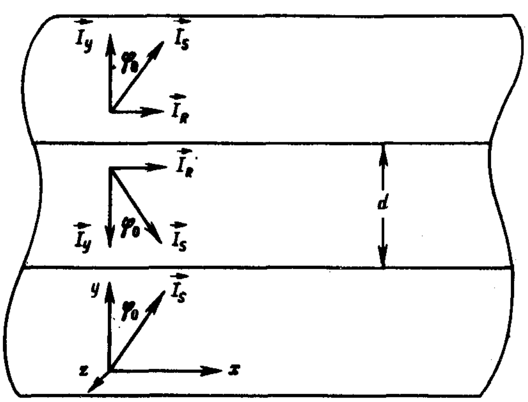

Fig. 1

$\vec{H}_=$ was set equal to the saturation field $\vec{H}_s$, and δ_a and δ_b were then measured at different amplitudes of $\vec{H}_{=}$. Figure 2 shows plots of δ_a, δ_b, and $\delta_{or}(I)$ against λ with $\vec{I}$ ranging from $\vec{I}_R$ to $\vec{I}_s$ for one of the permalloy films ($t = 6\ \mu$, $d = 22\ \mu$, $\vec{H}_s = 95$ Oe, and $\vec{I}_R = \vec{I}_s = 0.45$). The $\delta_{or}(\lambda)$ curve for permalloy has the same form as the corresponding $\delta_b - \delta_a$ curve for nickel [1]. Figure 3 shows plots of $\delta_{eq}/\delta^s_{eq}$ and $\delta_{or}/\delta^s_{or}$ against $\vec{I}_x/\vec{I}_s$, obtained by the same method at a fixed value of λ and at variable $\vec{H}_\sim$. The value of δ^s_{or} required to plot $\delta_{or}/\delta^s_{or}(I)$ was obtained from the relation

$$\delta_{or}^{I=I_R} = \left(\frac{I_R}{I_s}\right)^2 \delta^s_{or} = 0{,}2\,\delta^s_{or}.$$

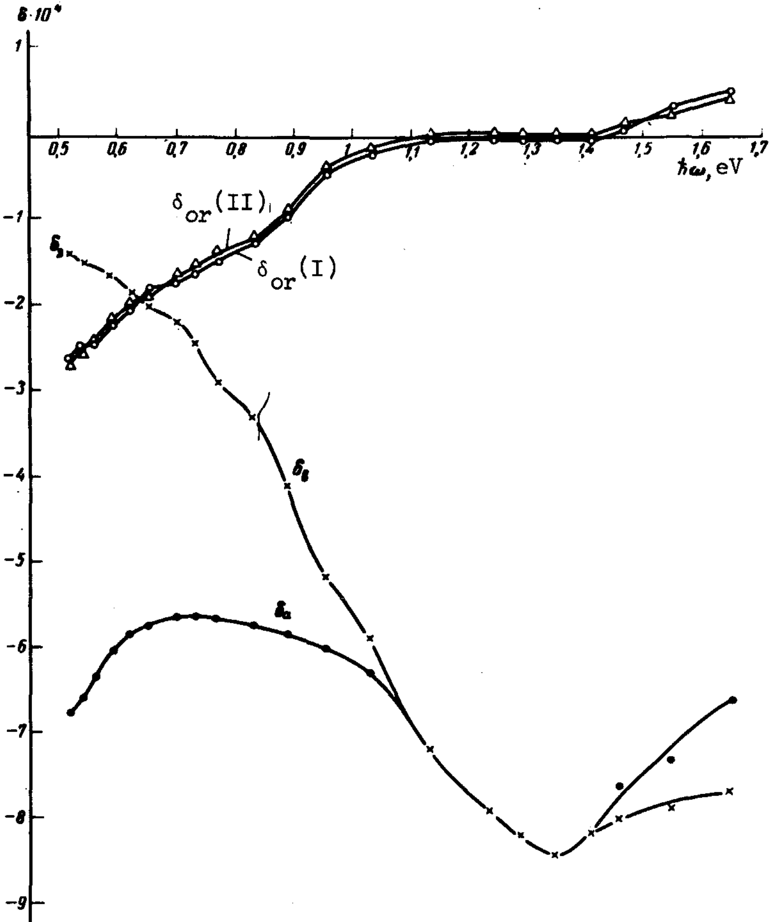

Fig. 2

The second series of measurements was performed at the geometry of the meridional Kerr effect (H x, light incident in the xz plane). In this case the values of δ_{eq} and δ_{or} should be determined by the component $\vec{I}_y$. Since the mean value of $\vec{I}_y$ is zero, we get $\delta_{eq} = 0$ for any $\vec{H}$. However, the even effect δ_{or} is not equal to zero, since it is determined by the absolute value of $\vec{I}_y$ in each domain. As a characteristic of the situation, we note the following "paradox": at a given geometry, the effect δ_{or} should reach a maximum value at $\phi = 0$, i.e., in a completely demagnetized sample, and at $\vec{I} = \vec{I}_s$ we have $\delta_{or} = 0$. Figure 3 shows a plot of $\delta_{or}/\delta^s_{or}(II)$ against the value of $|\vec{I}_y|/\vec{I}_s$, using likewise the normalization $\delta_{or}(I = I_R) = 0.2\delta^s_{or}$. It is seen from the figure that the experimental

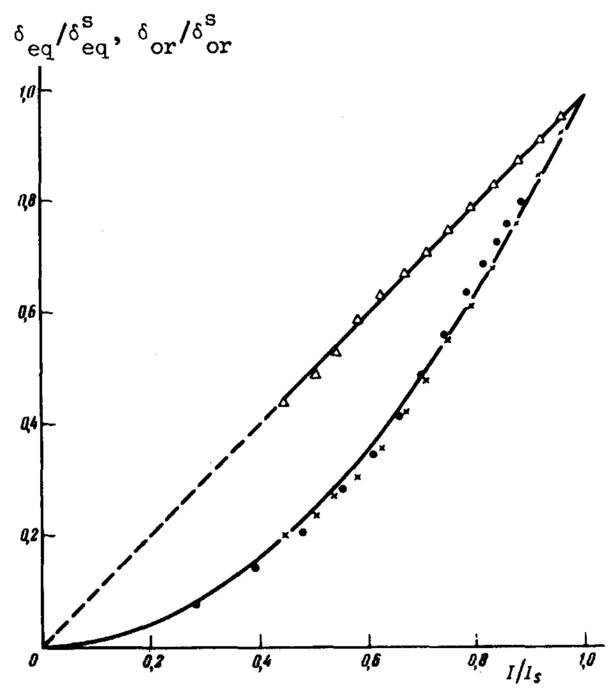

Fig. 3. Triangles – $\delta_{eq}/\delta^s_{eq}$; crosses – $\delta_{or}/\delta^s_{or}(I)$; circles – $\delta_{or}/\delta^s_{or}(II)$.

points obtained by both methods fit the same parabola.

$H_\sim$, Oe	$-\delta_{or}(I)\cdot 10^4$	$-\delta_{or}(II)\cdot 10^4$	$H_\sim$, Oe	$-\delta_{or}(I)\cdot 10^4$	$-\delta_{or}(II)\cdot 10^4$
8	0,2	0,19	50	1,58	1,54
14	0,4	0,38	56	1,76	1,75
20	0,63	0,63	62	1,87	1,91
26	0,85	0,82	68	1,97	2,03
32	1,03	1	72	2,08	2,09
38	1,2	1,2	78	2,2	2,2
44	1,47	1,42			

However, a direct proof of the quadratic dependence of δ_{or} on the magnetization component perpendicular to the plane of incidence and a justification for the normalization used for δ^s_{or} is the following result: Let the angle ϕ change from ϕ_1 to ϕ_2 in the region of rotation of $\vec{I}_s$. The $\vec{I}_x/\vec{I}_s$ component changes in this case from sin ϕ_1 to sin ϕ_2, and the $\vec{I}_y/\vec{I}_s$ component from cos ϕ_1 to cos ϕ_2. If the effect δ_{or} is proportional to the square of the magnetization, then $\delta_{or}/\delta^s_{or} = \sin^2\phi_1 - \cos^2\phi_2$ in the case of equatorial magnetization (I), and $\delta_{or}/\delta^s_{or} = \cos^2\phi_2 - \cos^2\phi_1 = \sin^2\phi_1 - \sin^2\phi_2$ in the case of meridional magnetization (II), i.e., the effects corresponding to identical values of H should coincide in cases (I) and (II). Understandably, this coincidence occurs only if the effect depends quadratically on the magnetization. In addition, this verification method cannot be affected by errors connected with the measurements of $\vec{I}_R/\vec{I}_s$ and $\vec{H}_s$ or of the amplitudes of $\vec{H}_=$ and $\vec{H}_\sim$. The table shows a comparison of the measured values of δ_{or} in cases (I) and (II) at $\hbar\omega$ = 0.59 eV and at different values of $\vec{H}_\sim$ ($\vec{H}_= = \vec{H}_s$), while Fig. 2 shows the corresponding comparison of the effects δ_{or}(I) and δ_{or}(II) when the magnetization changes from $\vec{I}_R$ to $\vec{I}_s$ for different λ. The good agreement between the numerical values of δ_{or} in cases (I) and (II) proves that the effect δ_{or} is proportional to the square of the magnetization component perpendicular to the plane of incidence of the light.

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STIMULATED ENTROPY (TEMPERATURE) SCATTERING OF LIGHT IN LIQUIDS

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The existence of stimulated (entropy) scattering of light (STS) was first proved with full assurance in our earlier paper [1].

Subsequent experimental [2 - 5] and theoretical [6 - 8] investigations have shown that STS can be due to two different causes. It follows from a general analysis [7] of the STS phenomenon that the STS line due to the electrocaloric effect should be shifted to the Stokes side relative to the frequency of the exciting radiation (STS-I), and the STS line