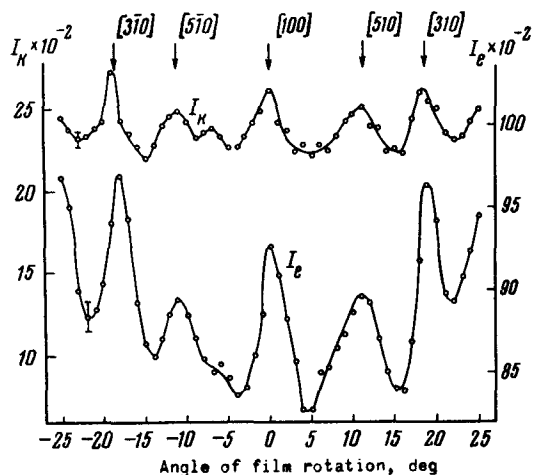


in yield is  $\sim 50\%$  [2]. The difference can be attributed, in our opinion, to the stronger scattering of the electrons in the substance, and in part also to the mosaic structure of the



film. Since in our case the peak amplitudes decreased with decreasing primary-electron energy, we can expect a slight growth with increasing energy.

It can be assumed that the difference between the electron and proton motions is caused also by the fact that as the protons move through the channel they execute a certain number of oscillations during their travel. In the case of the electrons, ordered motion takes place probably only during the first quarter of the oscillation, i.e., until the electron crosses the axis of the atom chain, after which the electron, coming close to the next nucleus, is scattered through a large angle. From this point of

view, a change in the number of electrons scattered into the rear hemisphere should lead to a change in the yield of the secondary electron, i.e., the coefficient of secondary emission from the side on which the beam enters should increase when the electron-motion direction coincides with a crystallographic axis. It is possible that this circumstance plays a certain role in the nonmonotonic angular dependence of the yield of secondary electrons from MgO and Ti single crystals, as observed in [3,4] and elsewhere. It must apparently be assumed that since the electron approaching the atom chain during the course of focusing transfers to the chain nuclei a momentum that increases continuously in magnitude, the focusing effect is accompanied by excitation of phonons. This distinguishes focusing from diffraction, in which the electron, interacting with the crystal as a whole, does not excite phonons.

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#### INFLUENCE OF MAGNETIC FIELD ON SPIN-ORBIT INTERACTION EFFECTS IN FERROMAGNETIC d-METALS

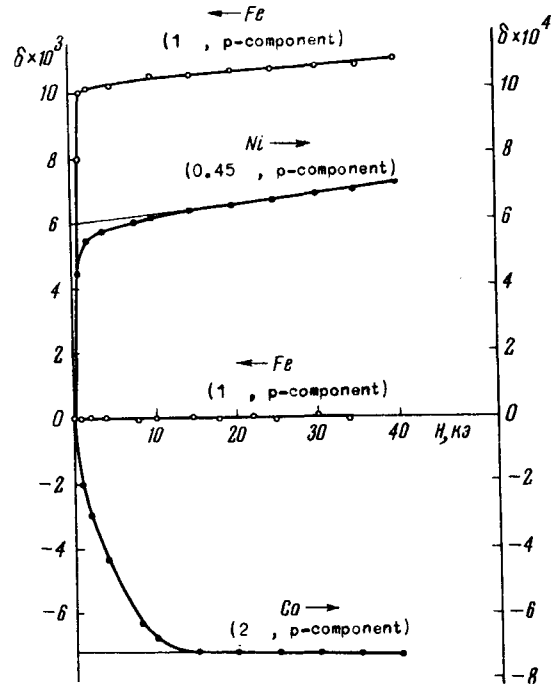
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Investigations of galvanomagnetic effects yield, as is well known, valuable information on the electronic structure of ferromagnetic metals. However, no measurements have been made as yet on magneto-optical effects in strong magnetic fields, which have a similar physical

nature. We present below results of measurements of the equatorial Kerr effect  $\delta$  [1] in Fe, Ni, and Co at an incident-light angle  $\varphi = 75^\circ$ , made in magnetic fields up to 40 kOe. The measurements have shown that the increase of the effect in the saturation region is anomalously large.

The experimental setup was assembled in accordance with the scheme described earlier [1]. The degree of monochromatization of the beam, indicated in the table, was determined by the employed optical filters and light receivers. For example, some of the obtained experimental curves are shown in the figure. To illustrate the measurement error, which did not exceed 0.5%, we present also measurements made at the s-component, when  $\delta = 0$ . The table lists values of  $\delta_s$  obtained by extrapolating the linear section of the  $\delta(H)$  curves to a field  $H = 0$ , as well as the values of  $(1/\delta_s)(\partial\delta/\partial H)$  and the coefficients  $k_\delta$  determined from the relation  $(1/\delta_s)(\partial\delta/\partial H) = k_\delta(1/I_s)(\partial I/\partial H)$  ( $\partial I/\partial H = 1.3 \times 10^{-4}$  (Fe),  $1.1 \times 10^{-4}$  (Ni) [2]).

	$\lambda$ [ $\mu$ ]	$\delta_s \times 10^3$	$\frac{1}{\delta_s} \frac{\partial\delta}{\partial H}$ [% kOe $^{-1}$ ]	$k_\delta$
Fe	$0.45 \pm 0.15$	6.9	0.20	26
	1 $\pm 0.1$	10.2	0.16	21
	2 $\pm 0.1$	-6.7	0.23	30
	4 $\pm 1.5$	-1.95	0.37	48
Ni	$0.45 \pm 0.15$	0.6	0.58	26
	1 $\pm 0.1$	-3.5	0.16	7
	2 $\pm 0.1$	-3.6	0.14	6
	4 $\pm 1.5$	-0.7	0.30	13
Co	$0.45 \pm 0.15$	0.4	0.17	
	1 $\pm 0.1$	1.8	0.10	
	2 $\pm 0.1$	-0.72	0.10	
	4 $\pm 1.5$	-1.8	0.15	



The data obtained show that the increase of  $\delta$  under the influence of the magnetic field greatly exceeds the corresponding increase of  $I_s$  ( $k_\delta \gg 1$ ). The increase of  $k_\delta$  in the short-wave region excludes the possibility of attributing the observed effect to additional magnetization of the surface layer of the sample to saturation, or to the influence of the magnetic field on the carrier motion. As regards magneto optic effects due to interband transitions, their magnitude, according to [3], is determined by the magnetization of the sample, by the details of the band structure, and by the value of the spin-orbit interaction. It is necessary to bear in mind here that the equatorial Kerr effect  $\delta$  is a linear function of the real and imaginary parts of the off-diagonal component  $\epsilon_{12}$  of the dielectric tensor.

The influence of the magnetic field on the behavior of ferromagnetic d-metals in the

saturation region is usually related, directly or indirectly, to a decrease in the number of spin waves, i.e., to the main cause of the dependence of the magnetization on the field. In this case such an explanation is incorrect, since the direct influence of H on I is too small, and the indirect-influence mechanisms proposed for other effects (crystallographic anisotropy, ferromagnetic Hall effect) are likewise inoperative. It can be assumed that we deal in this case with the effect of the direct influence of the magnetic field on the energy band structure of the d-metal, which in turn leads to a change in the value of the spin-orbit interaction. A special role may be played here by states disposed along the symmetry lines of the Brillouin zone or near the Fermi surface, the degeneracy of which is lifted by the spin-orbit interaction.

In connection with the foregoing, attention must be called to other possible manifestations of the influence of the magnetic field on spin-orbit interaction effects in ferromagnetic d-metals. The available experimental data on the influence of H on the anisotropy constant  $K_1$  show that the value of  $(1/K_1)(\partial K_1/\partial H)$  amounts to 0.5%  $\text{kOe}^{-1}$  for Ni [4] and 0.2%  $\text{kOe}^{-1}$  for Fe [5], i.e., it is comparable with the value of  $(1/\delta_s)(\partial \delta/\partial H)$ . Attempts to attribute the corresponding changes of  $K_1$  to the influence of the field on the number of spin waves lead to a qualitative disagreement with experiment by a factor 2 - 3, and the influence of pressure on  $K_1$  cannot be explained at all [4,5].

The discussed influence of the magnetic field can lead also to a dependence of the ferromagnetic Hall constant  $R_s$  on H, although this dependence is masked by the presence of the ordinary Hall effect and by the influence of the magnetic field on  $R_s$ , due to suppression of the spin waves [6]. Nonetheless, if we assume that an essential part of the "ordinary" Hall constant is due to the indicated  $R_s(H)$  dependence, then we can explain in natural fashion the following experimental facts: 1) when copper, iron, and cobalt is added to nickel, the growth of  $R_s$  is accompanied by an increase in the "ordinary" Hall constant [7,8], 2) in Fe-Ni alloys containing 32 - 40% Ni, when it can be assumed, in view of the exceptional growth of  $R_s$ , that the change in the Hall emf  $E_s$  in the saturation region is due essentially to the  $R_s(H)$  dependence, we have

$$\frac{1}{E_s} \frac{\partial E_s}{\partial H} \cong 0.4\% \text{ kOe}^{-1} \quad [8].$$

It is of great interest to investigate experimentally the physical effects connected with the spin-orbit interaction in d-metals in stronger magnetic fields. Thus, for example, if the linear increase continues, then the values of  $\delta$  ( $\lambda = 0.45 \mu$ ) and  $K_1$  of nickel should double at  $H = 200 \text{ kOe}$ . It would also be of interest to investigate the influence of a strong magnetic field on the orbital part of the g-factor.

We are grateful to Professor E. I. Kondorskii for a discussion of our results.

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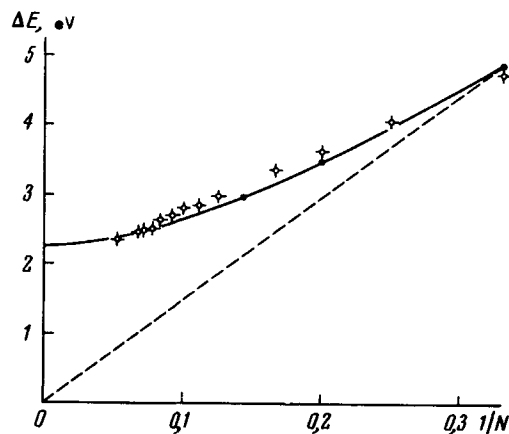
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#### ELECTRONIC STRUCTURE OF LONG MOLECULES WITH CONJUGATED BONDS

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It is usually assumed that when the length of a molecule with conjugated bonds increases (we shall consider molecules of the type of polyene,  $(CH)_{2N}$ ) the distances between the electronic levels vary like  $1/N$ , so that for sufficiently large  $N$  the molecule becomes a one-dimensional metal. The experimental data, however, contradict these notions. Indeed, with increase in the length of the polyene chain the magnitude of the first electronic transition tends to a finite value  $\sim 2.24$  eV [1,2] (see the figure).

The fact that the metal becomes a dielectric at a sufficiently large electron repulsion was noted already by Mott [3]. For polyenes, however, Mott's arguments are not valid, since the repulsion is actually not too large. It is known, in particular, that graphite is a metal at the same electronic parameters. The presence of a gap in the spectrum might be attributed to the transition of the molecule into a state with alternating bond lengths as  $N \rightarrow \infty$  [4]. For real parameters of the electron-phonon interaction [5], the gap is one order of magnitude smaller than the experimental value. Finally, Langmuir oscillations in a one-dimensional system have an acoustic character, and consequently cannot explain the observed spectrum [6]. We propose below an explanation of the indicated experimental fact, on the basis of an allowance for the electron repulsion.



First electronic transition of the molecule  $C_{2N}H_{2N}$  vs.  $1/N$ : -○- - experiment, -●- - our calculations, --- - electronic transition without allowance for electron repulsion.