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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

$$E_x = R_0 H + R_I I. \qquad (1)$$

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-

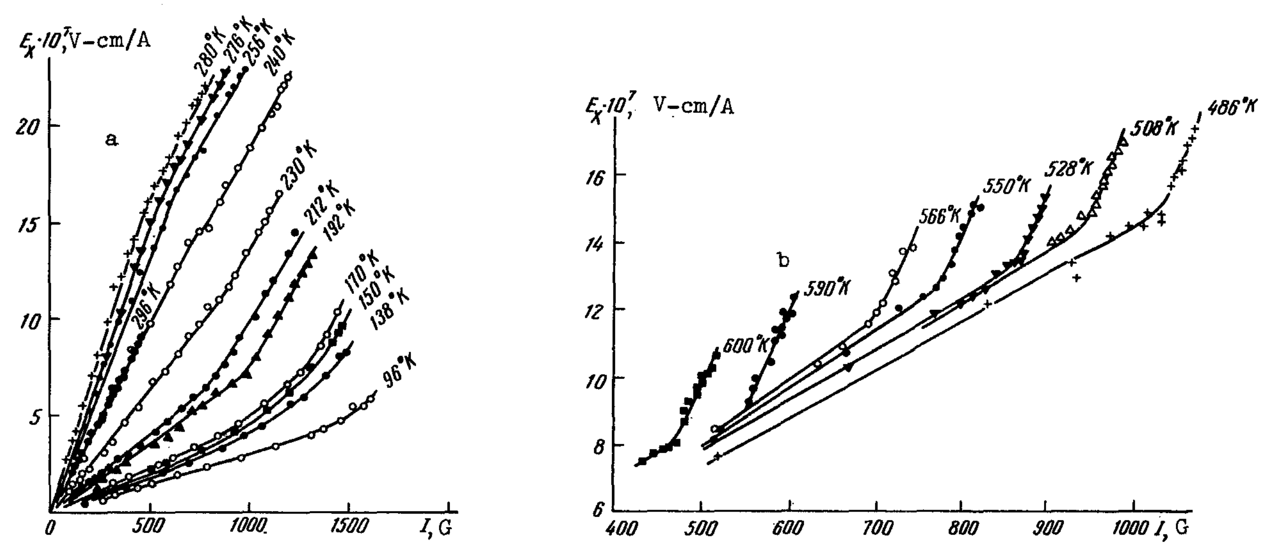

Fig. 1. Hall emf vs. magnetization at different temperatures: a - gadolinium, b - alloy of the invar type (36% Ni, 58% Fe, 6% Co).

process region by means of the three-term expression:

$$E_x = R_0H + R_I I_s + R_i I_i, \tag{2}$$

where R_i is the Hall coefficient corresponding to the true magnetization I_i, equal to the difference $I - I_s$.

Subsequently, Volkov and Kozlova [8] have shown that relation (2) describes well the Hall emf in nickel.

The question connected with the presence of the coefficient R_i is not treated theoretically in the literature. It is assumed that in the region of the para-process the change in the slope of the curve is due to a decrease in the magnetic inhomogeneities with increasing true magnetization [3,11].

Our experimental data, shown in Figs. 1 and 2, indicate that the coefficient R_i is independent of the temperature, and consequently also of the degree of spin disorder.

The numerical values of the coefficients R_I and R_i at the same temperature differ noticeably. For example, for

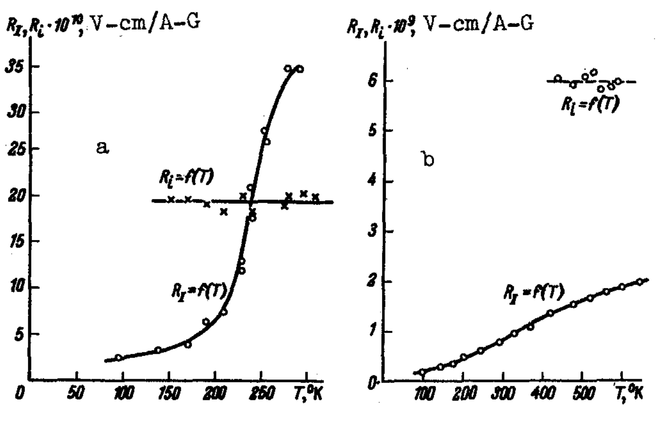

Fig. 2. Temperature dependence of the anomalous Hall coefficients corresponding to the technical part of the magnetization curve R_I and to the para-process region R_i: a - gadolinium, b - invar-type alloy.

gadolinium near the Curie point the coefficient R_i is almost half as large as the coefficient R_I, and for the invar alloy R_i is three times the value of R_I.

It is interesting to note that, according to the data of Babushkina [7], the paramagnetic constant R_p of gadolinium, measured at temperatures greatly exceeding the Curie point, is numerically close to the values of R_i obtained by us by measuring the Hall effect in gadolinium at temperatures below the Curie point. It follows therefore that the change of the Hall emf in the paramagnetic and in the para-process regions can be described by the same constant $R_p \simeq R_i$, which does not depend on the temperature, and consequently does not depend on the over-all magnetic resistance ρ_m.

This fact is essentially new and calls for a special theoretical examination of the nature of the anomalous Hall field in the region of the para-process.

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SINGLE-FREQUENCY RUBY LASER WITH ACTIVE Q-SWITCH

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It was shown in [1] that if radiation from another laser is introduced into the resonator of a ruby laser at the instant of Q-switching, then the laser emission spectrum coincides fully with the spectrum of the introduced radiation. Further experiments were performed by us using a single-frequency master generator (henceforth - first generator) operating in the free-running regime (Fig. 1). The mode selector for the first generator was made up of four TF-5 glass prisms with a total dispersion 15 ang. sec/cm^{-1} at λ = 6943 Å, and a diaphragm D_1 of 1.2 mm diameter. A single-frequency generation regime of the first laser was ensured at 5% excess above threshold.

The electronic circuitry switching the Q of the second laser was triggered by one of the spikes of the first laser. The time delay of the electronic circuitry did not exceed 0.5 μsec, thus ensuring rigid synchronization of the Q-switching time of the second laser