GALVANOMAGNETIC PROPERTIES OF FERROMAGNETICS NEAR ABSOLUTE ZERO

K. P. BELOV and A. V. PED'KO

Moscow State University

Submitted to JETP editor June 20, 1957

J. Exptl. Theoret. Phys. (U.S.S.R.) 33, 815-817 (September, 1957)

THE electrical resistance of ferromagnetics in fields above saturation (paramagnetic region) always diminishes; therefore $\Delta R/R$ is here a decreasing function of H (linearly decreasing in first approximation — see Fig. 1). According to the usual theory the quantity $\rho = -R^{-1}\Delta R/\Delta H$ should decrease as absolute zero is approached, owing to the decrease in the concentration of non-oriented spins in a domain as a consequence of reduced thermal motion. At 0° K absolute saturation occurs, hence $\rho = 0$.

In the work of Smith,[1] however, the 42% Ni, 58% Fe alloy is shown to behave exceptionally in this respect. The quantity ρ at liquid nitrogen and hydrogen temperatures not only does not decrease for this alloy, but even increases slightly. This interesting result is discussed by Gorter.[2] Smith's finding is explained on the assumption that the alloy in question possesses structural peculiarities; a negative exchange interaction is possible in its lattice, with the consequence that parallel orientation of spins is incomplete even at 0° K (antiferromagnetic state).

To check these conclusions we have performed more detailed measurements of the longitudinal galvanomagnetic effect, accompanying paramagnetism, in a number of ferromagnetics (including the 42% Ni, 58% Fe alloy) at low temperatures including that of liquid helium. We have use a more accurate method for determining ρ than used by Smith, who obtained this quantity graphically from the curves of $\Delta R/R$ vs. H. In our experiments ρ was determined in the following way. First the sample was subjected to a sufficiently strong field to magnetize it to technical saturation. The resulting galvanomagnetic effect, caused by motion and rotation, was compensated for by adjusting the bridge resistance; the bridge was then set for maximum sensitivity. Next the sample was subjected to an additional field $-\Delta H$ and the corresponding ΔR, due to paramagnetism, was measured. The quantity $\Delta R/\Delta H$ was referred to the resistance R at the given temperature. Our method allowed measurement of ρ with a 5% accuracy. In Fig. 2 $\Delta R/\Delta H$, R and ρ are given as functions of temperature for the 42% Ni, 58% Fe alloy. The points on the curves correspond to room and liquid nitrogen, hydrogen, and helium temperatures. One sees that $\Delta R/\Delta H$ and R are monotonic functions of the temperature, whereas ρ varies in a complicated manner. As the temperature decreases ρ first increases (this was also observed by Smith), then it reaches a maximum value and decreases. However at 0° K it does not reach zero as required by the above-mentioned theoretical considerations (i.e., at 0° K there exists a "residual" galvanomagnetic effect due to paramagnetism). The dashed lines in Fig. 2 represent the corresponding curves for the same sample after annealing. It is seen that the character of the curves, particularly of the curve ρ(T),

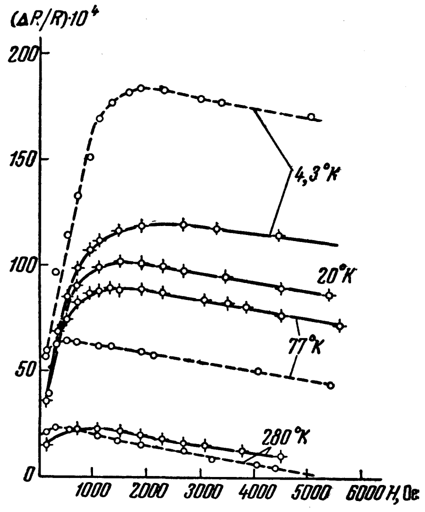

FIG. 1. Resistance as a function of magnetic field intensity for the 42% Ni, 58% Fe alloy. Solid curves refer to the unannealed sample, dashed curves refer to the sample after annealing at 800° C, 3 hours of aging.

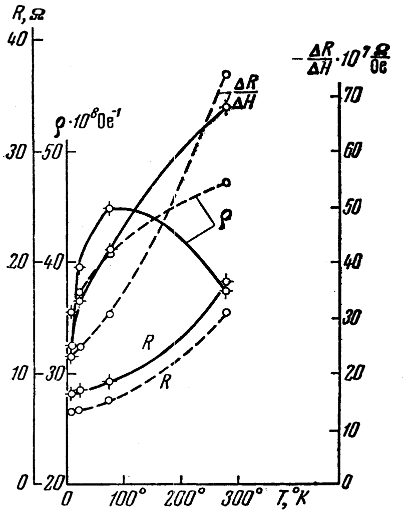

FIG. 2. $\rho = -R^{-1}\Delta R/\Delta H$ for the 42% Ni, 58% Fe alloy. Solid curves refer to the unannealed sample, dashed curves refer to the sample after annealing.

has changed substantially (the maximum has disappeared). The existence of the maximum in the curve $\rho(T)$ and its location as a function of temperature is determined by the form of the temperature dependence of $\Delta R/\Delta H$ and R; a change in the temperature dependence of $\Delta R/\Delta H$ and R shifts the maximum towards lower temperatures, or obliterates the maximum, or emphasizes it. It therefore follows that the increase in ρ with decreasing temperatures, first observed in Ref. 1, is not of great significance. The important factor in the phenomenon under discussion is the existence of a "residual" galvanomagnetic effect at 0° K due to paramagnetism.

Besides the 42% Ni, 58% Fe alloy we have investigated pure nickel, iron-nickel alloys containing 50% and 78% Ni, copper-nickel alloys containing 20% and 25% Cu, and a 23% Mn, 77% Ni alloy (in a hardened, non-ordered state). With the exception of Ni and permalloy (78% Ni, 22% Fe) in which ρ is very small at low temperatures, we have obtained for all the alloys curves very similar to those in Fig. 2. Therefore, contrary to Smith, one may conclude that the phenomenon in question is not peculiar to the 42% Ni, 58% Fe alloy; it also occurs in certain other ferromagnetic alloys. We give below values of ρ measured by us at liquid helium temperature in unannealed Ni-Fe and Cu-Ni alloys and in a hardened Mn-Ni alloy.

Alloy	$\rho \times 10^8$
42% Ni, 58% Fe	31.6
50% Ni, 50% Fe	15.6
20% Cu, 80% Ni	25.5
25% Cu, 75% Ni	11.6
23% Mn, 77% Ni	23.6

The existence of the "residual" galvanomagnetic effect due to paramagnetism at 0° K in other ferromagnetic alloys beside the 42% Ni, 58% Fe alloy raises doubts as to the validity of the explanation given in Ref. 1. We believe that the existence of this effect is connected with the influence of structure imperfections on the exchange interaction.

We take this opportunity to express appreciation to A. J. Shalnikov for his advice and interest in this work.

[1] J. Smith, Physica 17, 612 (1951).
[2] C. Gorter, J. Phys. Rad. 12, 279 (1951).

Translated by A. Bincer
163

GREEN'S FUNCTION FOR DIFFUSION OF RADIATION

B. A. VEKLENKO

Moscow Energy Institute

Submitted to JETP editor June 20, 1957

J. Exptl. Theoret. Phys. (U.S.S.R.) 33, 817-819 (September, 1957)

BIBERMAN[1] suggested a theory for the diffusion of resonance radiation, which takes account of the possibility of changing the photon frequency in each reradiation event. It was assumed that the mean free time of a photon is small compared to the duration of the excited state. The integral equation obtained was solved numerically for various stationary problems. Later a similar equation was obtained by Holstein.[2] In solving the nonstationary problem, Holstein was interested only in the first eigenfunction of the equation, and obtained it using the Rayleigh-Ritz method.

In the present note it is shown that by maintaining Biberman's assumptions and treating the diffusion of radiation in an infinite medium, one can obtain an analytic expression for the Green's function $f(\mathbf{r}, t)$ of this problem.