ON THE INFLUENCE OF DOMAIN STRUCTURE ON THE ELECTRICAL RESISTIVITY OF IRON AT LOW TEMPERATURES

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THE electrical resistivity of a ferromagnet can be written in the form $R = R_0 + R_1 + R_2 + R_3$, where R_0 is the residual resistance, R_1 the phonon part, R_2 the ferromagnon part of the resistivity,[1] and R_3 the resistivity caused by the scattering of the conduction electrons at the domain boundaries. The R_3 part of the resistivity will show up when the other components are small, i.e., for pure specimens and at low temperatures when the mean free path approaches or becomes larger than the domain dimensions. It was possible to show up R_3 by measuring the electrical resistivity of a metal by enlarging the domain structure in a magnetic field.

A measurement was carried out of the electrical resistivity of iron in its dependence on the magnitude of the longitudinal and transverse magnetic fields at temperatures from room temperature down to liquid helium temperatures. At these temperatures the magnetization curves were obtained.

For our investigation we took a sample of very pure iron grown in the form of a needle by distillation in vacuo. The sample had transverse dimensions of 0.1 mm, and a length of 38 mm. The grain size was approximately equal to the sample diameter.

In the demagnetized state in such a thin specimen the domains are oriented mainly perpendicularly to the longitudinal axis; their width is $\sim 10^{-3}$ cm.[2,3] The mean free path at room temperature in iron $\lambda \sim 10^{-5}$ to 10^{-6} cm; the domain boundaries will therefore not influence the electrical resistivity. If the temperature is lowered, the mean free path will increase and approach the domain dimensions, and scattering by domain boundaries begins to be important for the magnitude of the electrical resistivity.

The results of the measurements are given in Figs. 1 and 2 in the form of graphs of the dependence of the change in relative electrical resistivity $\Delta R/R$ (along the ordinate axis) on the external magnetic field (along the abscissa axis), where $\Delta R = R_H - R$; R is the value of the electrical resistivity without a field, and R_H the resistivity in the magnetic field. The earth field was compensated within an accuracy of 0.5%.

In a longitudinal magnetic field of ~ 10 Oe

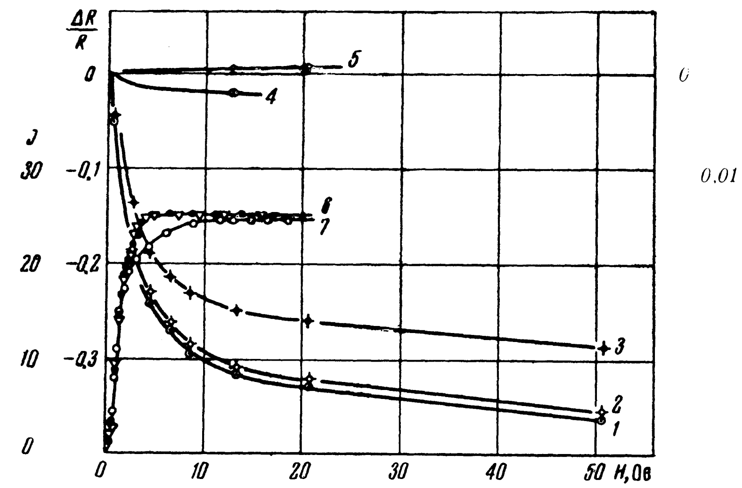

FIG. 1

(Fig. 1) at a temperature of 300°K (curve 5) when the mean free path is appreciably less than the domain size, an increase in the electrical resistivity (of $\sim 0.02\%$), which is characteristic for ferromagnets[4-6] is observed, but already at 77°K (curve 4) a decrease in the electrical resistivity of $\sim 0.2\%$ takes place, reaching a value of $\sim 23\%$ at 20.4°K (curve 3) and of $\sim 30\%$ at helium temperatures (curve 1 refers to measurements at 1.3°K, curve 2 at 4.2°K). Curves 4 and 5 are drawn to a larger scale along the ordinate (scale on the right). In this graph we have drawn to an arbitrary scale the magnetization curves. Curve 7 refers to measurements at 300°K, curve 6 to measurements at a temperature of 20.4°K (triangles) and of 4.2°K (black points). The basic effect of a decrease in the electrical resistivity is observed in the region of the technical magnetization of the specimen. This can be explained by two circumstances: mainly by an extension of the domain structure in the magnetization process, i.e., by a decrease in the number of boundaries and, apart from that, by a rotation of the magnetic moment of the region in the direction of the external magnetic field.[6]

From the magnitude of the decrease in electrical resistivity of ~30% at helium temperature in a longitudinal magnetic field, and from the theoretical work on the determination of the influence of the specimen size on the electrical resistivity,[7] we can determine the magnitude of the mean free path, $\lambda \sim 10^{-3}$ cm. This value coincides with the estimate of the domain width for the given sample in the demagnetized state.

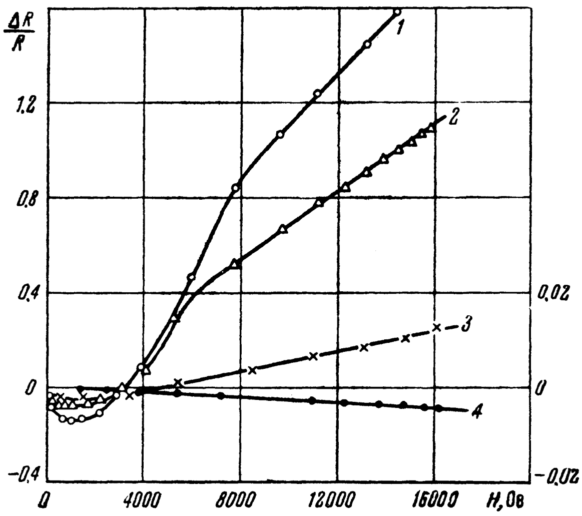

FIG. 2

In a transverse magnetic field (Fig. 2) two effects take place: an extension of the domain structure (decrease of the electrical resistivity in weak fields) and the ordinary galvanomagnetic effect which dominates in high fields.[8] The curves 1, 2, 3, and 4 refer to measurements at temperatures of 4.2, 20.4, 77, and 300°K, respectively. The scale on the right refers to curves 4 and 5 [sic!].

An influence of the measuring current on the magnitude of the electrical resistivity was detected. An increase by 20% in the resistivity was observed when the measuring current increased from 0.1 to 1000 ma. Unfortunately the literature contains no data at all considering domain structure in the field of a current. Apparently, the measuring current leads to a decreased domain structure, since it produces in the sample an inhomogeneity in the magnitude and direction of the magnetic field.

We must still remark that to determine the residual resistivity of a ferromagnet as a criterion for the purity it is necessary to take into account the dependence of the electrical resistivity on the measuring current and the magnetic field. For the specimen under investigation the relative residual resistivity was 4×10^{-3} if the influence of the domain structure was not taken into account and 3×10^{-3} if it was taken into account.

In conclusion the authors express their gratitude to B. G. Lazarev, S. V. Vonsovskii, and M. I. Kaganov for discussing the results and showing an interest in this work.

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ANGULAR CORRELATION OF CIRCULARLY POLARIZED GAMMA QUANTA ON THE μ-MESONIC ATOM

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THE μ-mesonic atom, produced as a result of capture of a polarized μ^- meson on the external