INFLUENCE OF THE MAGNETIC FIELD ON THE PHASE TRANSITION IN NICKEL

G. M. Drabkin, A. I. Okorokov, E. I. Zabidarov, and Ya. A. Kasman
A. F. Ioffe Physicotechnical Institute, USSR Academy of Sciences
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Phase transitions in ferromagnets are accompanied by intense magnetization fluctuations. These fluctuations determine to a considerable degree the behavior of the physical quantities at the Curie point, and their study is of great importance in the understanding of phase transitions.

The most direct method of studying magnetization fluctuations is by means of thermal polarized neutrons [1]. As indicated in our earlier paper [2] small-angle neutron scattering near the Curie point has a dual character. Scattering of the first type, with a peak half-width $|T - T_c| \approx 0.5°$ C at different scattering angles, is observed at a fixed temperature that coincides with the temperature of the maximum slope of the plot P(H, T) of the

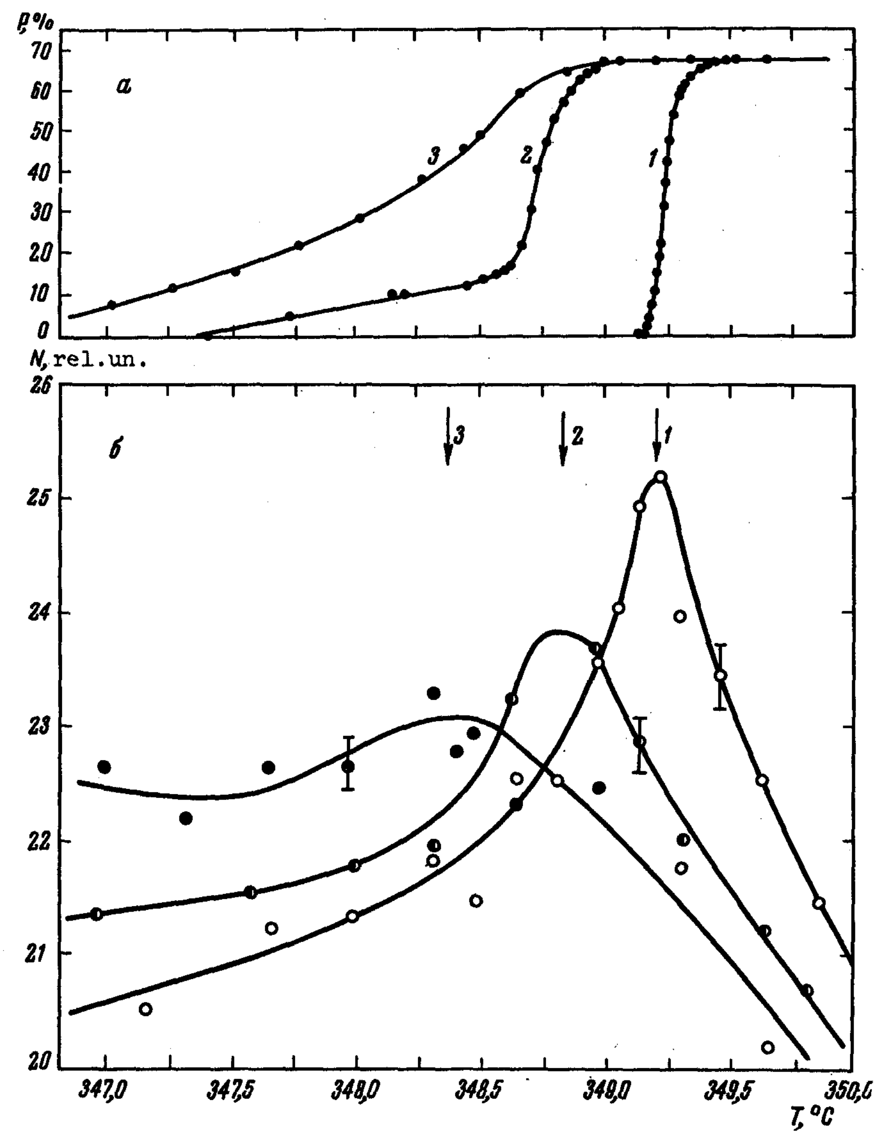

Fig. 1. a - Polarization of transmitted beam: a) H = 0, 2) H = 16 Oe, 3) H = 20 Oe; b - neutron scattering through an angle 34': a) H = 0, 2) H = 16 Oe, 3) H = 20 Oe.

polarization of the transmitted neutrons against the temperature. This scattering practically vanishes at angles > 1°.

The broad maximum of the second type of scattering ($|T - T_c| \sim 10 - 50°$ C) shifts towards T_c with increasing scattering angle, depends little on the field, and predominates at angles larger than 1°. We attribute the scattering of the first type to establishment of long-range order, whereas the gently sloping maximum of the second type is apparently due to the scattering of neutrons by fluctuations of the spin-wave type.

We present in this communication results of an experimental study of the influence of the magnetic field on the picture of neutron scattering. The measurements were made with a setup described in [2]. We determined the polarization of neutrons passing through a sample (nickel single crystal) and the intensity of the neutrons scattered through an angle of 34' as functions of the temperature (we investigated scattering of the first type). The polarization curves were determined in the interval H = 0 - 20 Oe, and the critical scattering was determined at three points, H = 0, 16, and 20 Oe. The magnetic field was parallel to the neutron scattering vector. The results of the experiment are shown in Fig. 1.

Figure 2 shows the influence of the magnetic field on the positions of the neutron scattering peaks and the position of the maximum of the derivative of the depolarization curve $\partial P(H, T)/\partial T$. The data on Figs. 2 and 1 show that the magnetic field shifts the scattering maximum towards lower temperatures and decreases the magnitudes of the peaks, where $\alpha = (3.7 \pm 0.5) \times 10^{-6}$. At the same time, the position of the scattering peaks and of the derivative $\partial P(H, T)/\partial T$ agree sufficiently well.

The position of a scattering peak is determined by the maximum development of the magnetic fluctuations, which in turn are connected with the occurrence of long-range order, i.e., with phase transitions. Thus, the magnetic field causes not only a smearing of the

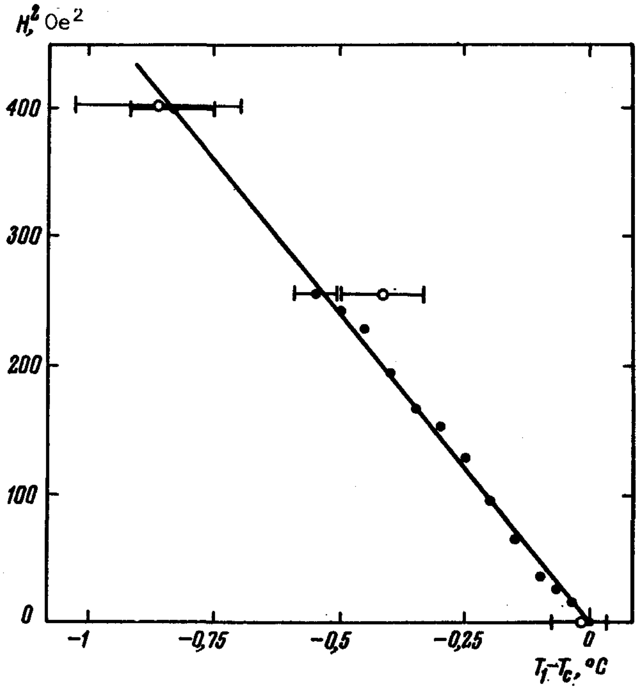

Fig. 2. Shift of Curie point of nickel under the influence of a magnetic field. ● - position of maximum of the derivative; O - positions of critical scattering peaks.

phase transition (a decrease of the scattering maximum), but also a shift of the Curie point towards lower temperatures.

The observed shift of the Curie point can be set in correspondence with the influence of the magnetic field on the start of the decrease of magnetization on the plot of the magnetization against the temperature, as observed by Arais [3]. From the data of Arais it follows that the temperature of the start of the decrease of magnetization also decreases like the square of the applied magnetic field. It can be assumed that the shift of the Curie point under the influence of the magnetic field is connected with the influence of dipole-dipole interaction [4], the role of which greatly increases at the phase transition temperature, when the exchange interaction is compensated by the thermal motion.

[1] G. M. Drabkin, E. I. Zabidarov, Ya. A. Kasman, and A. I. Okorokov, ZhETF Pis. Red. 2, 541 (1965) [JETP Lett. 2, 336 (1965)].

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[3] S. Arais, J. Appl. Phys. 36, 1136 (1966).

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In the article by G. M. Drabkin et al., Vol. 8, No. 10, the two lower-right points of Fig. 1b (p. 335), at T = 349.25 and 346.65°C, should be dark (the pertain to curve 3).