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THE EXTENSION OF THE KRONMÜLLER THEORY OF THE MAGNETIZATION CURVE FOR THE REGION OF LARGER MAGNETIC FIELDS

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Kronmüller in papers [1], [2] worked out a statistical theory of the magnetization curve in the region of small magnetic fields. The number of domain walls in the region is constant and it was shown in papers [1] and [2] that the linear term in Rayleigh's law describes reversible and the quadratic term irreversible displacements of the domain walls.

These conclusions are not valid in the region of larger magnetic fields. The domain walls gradually disappear in the increasing external field and in a sufficiently high field the sample is homogenously magnetized. It is necessary therefore to consider the change of the domain wall number above Rayleigh's region and this is the aim of the present paper.

The following assumption will be used: a) Domain walls begin to disappear only in the field in which Rayleigh's law is no more valid (in Kronmüller's designation it is for $H > H_G$). b) In the sufficiently small interval of the acting field $(H, H + \delta H)$ no more that one domain wall will disappeart. c) The probability of the disappearing of the domain wall in the interval δH is directly proportional to the magnitude of this interval. d) The disappearing of the domain wall in the interval $(H, H + \delta H)$ is independent on the disappearing of another domain wall in some other interval of the acting field, which is not overlapping with the considered interval.

The following formula follows from these assumptions for the probability that no one domain wall has disappeared in the field interval $(H_G, H + \delta H)$:

$$G(v - v_G) = \exp\{-\lambda(v - v_G)\}, \tag{1}$$

where $v = p_0 F_b I_s H$ and p_0 is the geometrical factor of the domain wall, F_b is the area of the domain wall, I_s is the saturation magnetization.

Then the total probability of the irreversible displacement of the domain wall has in our case the following form:

$$N(v) = n(v) G(v - v_G), \tag{2}$$

where $n(v) = 1/\sqrt{2\pi B(0)}\ \Phi(v/\sqrt{2B(0)})\exp\{-v^2/2B(0)\}$ is —like in papers [1, 2] — the probability of the irreversible displacement of the domain wall when the number of the domain wals remains constant.

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The same procedure as that in papers [1, 2] gives for the contribution to the magnetization in the region of fields $H > H_G$, that is in the region of the changing number of the domain walls, the following expression

$$\Delta J(v) = \frac{2L_0 p_0 I_s}{L_3\sqrt{2\pi B(0)}} \exp(\lambda v_G) \int_{v_G}^{v} \Phi\left(\frac{v'}{\sqrt{2B(0)}}\right) \exp(-\lambda v')dv' =$$

$$= \frac{2L_0 p_0 I_s}{L_3\sqrt{2\pi B(0)}} \frac{\exp(\lambda v_G)}{\lambda} \left\{\exp\left(\frac{\lambda^2 B(0)}{2}\right)\left[\Phi\left(\lambda\sqrt{\frac{B(0)}{2}} + \frac{v}{\sqrt{2B(0)}}\right) - \right.\right.$$

$$\left.- \Phi\left(\lambda\sqrt{\frac{B(0)}{2}} + \frac{v_G}{\sqrt{2B(0)}}\right)\right] - \Phi\left(\frac{v}{\sqrt{2B(0)}}\right)\exp[-\lambda v] +$$

$$\left. + \Phi\left(\frac{v_G}{\sqrt{2B(0)}}\right)\exp[-\lambda v_G]\right\} \tag{3}$$

in which all symbols have the same meaning as in papers [1, 2].

The parameter λ in the expression (1) in the case that during the magnetization of a ferromagnet the processes of the domain wall displacement are predominant, will be determined from the condition

$$\lim_{v \to \infty} \Delta J(v) = I_s - J(v_G), \tag{4}$$

where $J(v_G)$ is the change of the magnetization in the region where the assumption of the constant number of the domain walls is valid.

On the basis of equation (3) the complete expression for the change od magnetization in the total interval of the acting magnetic field can be written as follows

$$\Delta J(H) = \Delta J_{rev}(H < H_G) + \Delta J_{irr}(H < H_G) + \Delta J_{irr}(H > G_G), \tag{5}$$

in which the first two terms on the right -hadn side are Kronmüller's terms and the third term $\Delta J_{irr}(H > H_G)$ is given by equation (3).

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