The anisotropy of the absorption of transverse elastic waves in uniaxial magnetic materials, connected with the deviations of the vectors of spontaneous magnetization from the "easy" directions, is described.

The absorption of energy in the field of a longitudinal stress wave in uniaxial ferromagnetic materials, due to reversible rotation processes, was considered in [1], and in triaxial and tetraxial ferromagnetic materials in [2, 3]. The anisotropy of the absorption of transverse elastic waves in triaxial magnetic materials is described in [4].

It is of interest to investigate this phenomenon in uniaxial ferromagnetic materials, where the domain structure contains only 180-degree domain boundaries, if we ignore edge effects, and consequently there are no losses due to magnetoelastic hysteresis in such systems even for unblocked domain boundaries. Hence, the absorption of elastic waves (its magnetic component) is due solely to reversible rotations of the spontaneous magnetization vectors \( \mathbf{I}_s \), whereas in triaxial and tetraxial magnetic materials these losses are not found in pure form. However, there is no information on this problem for uniaxial magnetic materials with hexagonal symmetry either on its experimental or theoretical aspects.

A typical representative of uniaxial magnetic materials is cobalt, in which, in the initial state, when there is no stress wave \( \sigma \), the vectors \( \mathbf{I}_s \) of the two magnetic phases are directed along the "easy" [001] axis. Using this magnetic material as an example we will also initially consider the orientational dependence of the magnetoelastic relaxation in a polydomain crystal containing domains of the same size. Because of the evenness of the magnetostriction we will write the equations of the rotational moments [1-5] for one magnetic phase with \( \mathbf{I}_s \parallel Z \). We will confine ourselves, as in [1], to the case when the form factor can be neglected. Then, for small deviations of the vectors \( \mathbf{I}_s \) from the "easy" directions by an angle \( \varphi \), we have

\[
\frac{\partial F_A}{\partial \varphi} + \frac{\partial F_A}{\partial \varphi_z} + \beta' \varphi_z = 0,
\]

\[
\frac{\partial F_A}{\partial \varphi} + \frac{\partial F_A}{\partial \varphi_z} + \beta' \phi = 0,
\]

where, according to [6, 7], the anisotropy energy density and (when there is no torsion) the magnetoelastic energy density, have the following form, respectively

\[
F_A = K_1 \sin^2 \varphi + K_2 \sin^2 \varphi_z + K_3 \sin^6 \varphi_z + K_4 \sin^2 \varphi_z \cos^2 \psi,
\]

\[
F_o = -\sin^2 \varphi_1 \left[ \alpha_s (\lambda_1 \cos^2 \varphi + \lambda_3 \sin^2 \varphi) + \alpha_{xx} (\lambda_1 \sin^2 \varphi + \lambda_3 \cos^2 \varphi) + \sigma_{xx} (\lambda_4 - \lambda_8) \sin 2 \varphi \right] - \lambda_4 (\sigma_{xx} \cos \varphi + \sigma_{xy} \sin \varphi) \sin 2 \varphi_1.
\]

Here \( K_{1,2,3,4} \) are the magnetic anisotropy constants, \( \psi \) is the angle between the projection of \( \mathbf{I}_s \) onto the XY plane and the \( X \parallel [100] \), \( Y \parallel [010] \) axis; \( \lambda_A, \lambda_B, \lambda_C \) are the magnetostriction constants, \( \lambda_E = 2\lambda_B - (\lambda_A + \lambda_C)/2 \); and \( \beta' \) is the overall dissipative coefficient. It also contains the eddy-current component [5], which is equal to \( \mu_0^2 L_1^2 a^2/3 \rho' \), where \( \mu_0 = 4\pi \times 10^{-7} \) H/m, \( a \) is the size of the domain in the form of a cube, and \( \rho' \) is the mean value of the resistivity.

It should be noted that in (1), as in [1,4], we assumed that \( \beta' \) is independent of the frequency \( \omega \) of the external action, while the absorption coefficient of the waves \( \gamma \) is such that its attenuation within the dimensions of the domain \( a \) is small.
However, this is possible if the vector potential for the domain, obtained in [5], is independent of the coordinates. This is true provided \( \epsilon \alpha \ll 1 \) and \( \omega a/\nu \ll 2\pi \), which are completely realizable. Otherwise \( \beta' \), which is defined in terms of the specific power of the microeddies losses, averaged over the domain volume, will depend both on \( a \) and \( \omega \), as follows from the algorithm for calculating \( \beta'(a, \omega) \), described in [5]. Similar conditions must also be satisfied with respect to the other components of the dissipative coefficient.

By specifying, in a system of coordinates with axes \( X', Y', Z' \) having direction cosines \( \alpha_1, \beta_1, \gamma_1 \), \( \alpha_2, \beta_2, \gamma_2 \), \( \alpha_3, \beta_3, \gamma_3 \) respectively, only the shear component of the stress tensor \( \sigma_{x'y'} \) and using the tensor conversion law \( \sigma_{pq} = \sigma_{pq}' \), \( \epsilon_{ij} \) are the unit vectors of the corresponding systems of coordinates, and summing over repeated subscripts from 1 to 3, taking into account the matrix of the transfer coefficients, derived in [8], we obtain

\[
\alpha_{x'y'} = \alpha_1 \alpha_2 \beta_2 \gamma_2, \quad \sigma_{xy} = \alpha_1 \beta_1 \gamma_1 \gamma_2, \quad \sigma_{zz} = \alpha_1 \beta_1 \gamma_3, \quad \sigma_{yz} = \beta_1 \beta_2 \gamma_2, \quad \sigma_{zx} = \alpha_1 \beta_1 \gamma_1 \gamma_2.
\]

Taking these into account in (1) and (2) and also the fact that \( \alpha_{x'y'} = \sigma = \sigma_0 \exp(-\gamma \tau) \sin(\omega t - \omega a/\nu) \), we have, in the linear approximation (\( \sin \varphi_3 = \varphi_3 \))

\[
\begin{align*}
\beta' \varphi_3' + 2K_1 \varphi_3 &= 2\lambda_\xi (\cos \varphi \cdot \sigma_{xz} + \sin \varphi \cdot \sigma_{yz}) = L \cdot \sigma(t), \\
\beta' \varphi'_3 &= 2\lambda_\xi \varphi_3 (\cos \varphi \cdot \sigma_{xz} - \sin \varphi \cdot \sigma_{yz}) = Q \varphi_3 \sigma(t).
\end{align*}
\]

When \( K_4 > 0 \) the angle \( \psi = 90^\circ \), while when \( K_4 < 0 \) we have \( \psi = 0 \), which also determines the values of \( L \) and \( Q \). It follows from (3) that \( \varphi_3 = \varphi_3 \sin(\omega t - \delta - \omega a/\nu) \), where \( \delta = \beta' \omega /2K_1 \), \( \varphi_3 = L \cdot \sigma_0 \exp(-\gamma \tau /\beta' \omega/2K_1) \), while \( r \) is directed along the \( Z' \) coordinate axis. Taking the value of \( \varphi_3 \) obtained into account we have

\[
\psi(t) = \varphi_3 \sigma(t) + Q \varphi_3 \sigma(t) = Q \psi(t).
\]

Hence, we obtain for the energy scattered per period of the oscillations, averaged over the period, \( \Delta W = 2\pi \beta' < \psi(t) > \), while the internal friction

\[
Q^{-1} = \Delta W/2\pi W = 4\pi G_a e_\xi \beta_1 \gamma_1 /\cos(\beta' \omega \sin \delta + 2K_1 \cos \delta) = 2\lambda_\xi G_{x'y'} \beta_1 \gamma_1 /\cos(\omega t - \delta - \omega a/\nu) = Q^{-1}/\cos(\omega t - \delta - \omega a/\nu)
\]

for \( \psi = 0 \) when \( K_4 < 0 \). Here we have taken into account the fact that \( W = \sigma_3 \exp(-\gamma \tau) /2G_{x'y'} \), while \( \tau = \beta'/2K_1 \).

It is easy to show that when \( K_4 > 0 \), for an arbitrary value of the angle \( \psi \), in the case of a uniform distribution of the projections of \( I_s \) on the basis plane we have the following relation for the average value of \( Q^{-1} \),

\[
< Q^{-1} > = G_{x'y'} < L Q > /2K_1 (1 + \cos \omega t)^2, \text{ where } < L Q > = 4\pi e_\xi /\pi (\beta_1 \gamma_1 - \beta_2 \gamma_2 - \beta_3 \gamma_3).
\]

In particular, when \( K_4 > 0, \psi = 90^\circ \), taking into account the fact that \( L = 2\lambda_\xi \beta_1 \gamma_2 \), and \( Q = -2\lambda_\xi \sigma_0 \gamma_2 \), we obtain \( \sigma_{ij}: Q^{-1} \). Hence, \( Q^{-1} \), corresponding to \( \psi \)-oscillations of the vectors \( I_s \), decreases with frequency as \( \sim \omega^{-2} \), and there is no mechanostriction deformation corresponding to them in the linear approximation. However, the main losses, as can be seen by comparing the right-hand sides of system (3), are due to \( \varphi_3 \) — the deviation of \( I_s \) from the "easy" directions in the field of the wave \( \sigma \). Since in this case mechanostriction oscillations of the magnetic material occur, in order to take its inertial properties into account we need to supplement system (3) with the wave equation

\[
\frac{\partial^2 \varphi}{\partial t^2} - \frac{p}{G} \frac{\partial^2 \varphi}{\partial t} = \frac{p}{G} \frac{\partial^2 \varphi}{\partial t^2},
\]

where \( G_{x'y'} = G \), and \( \rho \) is the density of the magnetic material. We will determine the mechanostriction \( \varepsilon_{x'y'} = 0.5(\varepsilon_{x'z'} - \varepsilon_{y'z'}) \). When \( \psi = 90^\circ \) the direction cosines of the vector \( I_s \) are equal to 0, \( \varphi_3 \), and 1. Then from [6] for \( K_4 > 0 \) we obtain in the linear approximation

\[
\varepsilon_{x'z'} = \beta_1 \gamma_1 \varphi_3 \{4\lambda_\xi (\lambda_4 + \lambda_5) \};
\]

\[
\varepsilon_{y'z'} = \beta_2 \gamma_2 \varphi_3 \{4\lambda_\xi (\lambda_4 + \lambda_5) \} - 4\lambda_\xi \varphi_3, \text{ and } r = (\beta_2 \gamma_2 - \beta_1 \gamma_1) (\lambda_4 + \lambda_5 - 4\lambda_\xi) \varphi_3 /\varphi_3.
\]

In exactly the same way, when \( K_4 < 0 \) and when the direction cosines of \( I_s \) are equal to \( \varphi_3, 0 \), and 1, we obtain