calculated with an optical potential whose parameters were chosen on the basis of the authors' experimental data [5]. Thus, the experimentally observed form of the differential cross sections can be well described under the assumption that only nuclear and Coulomb scattering exist. Apparently the use of more reliable nuclear-potential models for each nucleus, and not a model purposely averaged over the entire periodic table, is essential for estimates of the upper limit of the neutron polarizability coefficient [6] and the "force" of the peripheral part (tail) of the nuclear potential [7]. Comparison of the squares of the imaginary part of the forward nuclear-potential scattering, calculated with the aid of the optical theorem from the experimental data on the total interaction cross sections with the data on the forward nuclear elastic scattering cross sections obtained by extrapolation to $\theta = 0°$, shows that at 4-MeV neutron energy the fraction of the contribution of the square of the real part to the cross section of forward nuclear-potential scattering is small for the investigated nuclei.

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NUCLEAR MAGNETOACOUSTIC RESONANCE AND SPIN-LATTICE RELAXATION IN ANTIFERROMAGNETS OF THE EASY PLANE TYPE

E. A. Turov and A. I. Timofeev
Institute of Metal Physics, USSR Academy of Sciences; Ural State University

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In this note we report results of calculation of the coefficient (α) of resonant absorption of ultrasound (at the NMR frequency) and of the rate of spin-lattice relaxation of the nuclear spins ($1/T_1$) in antiferromagnets of the "easy plane" type (AF-EP). The mechanism of interaction between the nuclear spins and the lattice is taken to be their indirect coupling via the spin wave [1].

Let the coordinate axis be chosen such that X is parallel to the external magnetic field H, which lies in the "easy plane" (EP), and Y is directed along the antiferromagnetism axis L. Then the lattice vibrations produce at the nuclei, as a result of the indicated mechanism, an effective magnetic field with components

$$\delta H_x \approx H_n \sum_k \frac{\omega_E\, \omega_{ms}^{(1)}}{\omega_{1k}^2}\, u_{xy}(\mathbf{k})\, e^{-i\mathbf{k}\mathbf{R}}, \tag{1}$$

$$\delta H_z \approx H_n \sum_k \frac{\omega_E [\omega_{ms}^{(2)} u_{yz}^{(\mathbf{k})} + \omega_a \epsilon_{yz}^{(\mathbf{k})}]}{\omega_{2k}^2}\, e^{-i\mathbf{k}\mathbf{R}}. \tag{2}$$

Here H_n is the hyperfine field at the nucleus; the antiferromagnet is characterized by the following parameters (dimensions of frequency): ω_E - exchange-interaction parameter, ω_{1k} and ω_{2k} - frequencies of spin waves with wave vector k for the low- and high-frequency branches, respectively, $\omega_{ms}^{(1)}$ and $\omega_{ms}^{(2)}$ - two magnetostriction parameters, and ω_a - parameter of the magnetic anisotropy that retains the antiferromagnetism axis in the EP. The lattice deformation is described by the Fourier components of the symmetric deformation tensor $u_{\alpha\beta}$ and the antisymmetric rotation tensor $\epsilon_{\alpha\beta}$.

From the form of (1) and (2) it follows that $\delta H_x \gg \delta H_z$ inasmuch as $\omega_{1k} \ll \omega_{2k}$ (for the wave vectors k of interest to us, which satisfy the condition $v_s k_0 = \omega_n$ where v_s is the speed of sound and ω_n is the NMR frequency).

By regarding as the cause of δH_x either thermal lattice vibrations [2] or ultrasound [1,3] we can calculate respectively the rate of thermal (spin-lattice) relaxation $1/T_1$ and the coefficient of resonant ultrasound absorption α due to the described mechanism:

$$\frac{1}{T_1} = \left(\frac{\omega_E}{\omega_{10}^2}\right)^2 \frac{(\omega_{ms}^{(1)})^2\, \omega_n^2\, (\gamma_n H_n)^2\, T}{6\pi\rho v_s^5}, \tag{3}$$

$$\alpha_\lambda' = \left(\frac{\omega_E}{\omega_{10}^2}\right)^2 \frac{N_n I(I+1)(\hbar\omega_{ms}^{(1)})^2 \omega_a^2 (\gamma_n H_n)^2 \Gamma_\lambda(\Theta_k, \Phi_k)}{24\rho v_s^3\, \Delta\omega_n\, T}, \tag{4}$$

where N_n is the number of resonant nuclei per cm^3, ρ the density of matter, $\Delta\omega_n$ the width of the NMR line, and T the absolute temperature in ergs; $\omega_{10} \equiv \omega_1(k_0)$ and is approximately equal to the lower frequency of the antiferromagnetic resonance ω_1; $\Gamma_\lambda(\Theta_k, \Phi_k)$ is a factor determining the dependence of α on the direction of the wave vector k and the polarization e_λ of the ultrasound. Without writing out the form of Γ_λ, we note only that the optimal conditions ($\Gamma_\lambda = 1$) occur when k and e_λ lie in the EP. For transverse waves k should be directed along H or L, and for longitudinal waves it should be directed at 45° to these vectors.

The essential difference between (3) or (4) and the corresponding formulas [1,2] for the "easy axis" type of antiferromagnet (AF-EA) lies in the appearance of the factor $(\omega_E/\omega_{10}^2)^2$ in lieu of $(1/\omega_a)^2$. This is the consequence of the presence in the AF-EP of spin waves with small energy gap $\hbar\omega_1$. This means that the spin-lattice coupling mechanism considered by us yields for $1/T_1$ and α values which are prroximately 10^4 times larger in AF-EP than in AF-EA. A numerical estimate for hematite (α-Fe_2O_3) gives a value of $1/T_1$ which agrees with experiment [4]. (For other AF-EP the parameter $\omega_{ms}^{(1)}$ is unknown, and furthermore there are no data on $1/T_1$.)

The preferred method of observing acoustic NMR is to suppress the ordinary NMR acoustically (using ultrasound at the NMR frequency). We therefore present also an estimate for the sound flux necessary for acoustic saturation of the nuclear spin system:

$$\Pi \approx \frac{\rho\omega_{10}^4 v_s^3 \Delta\omega_n}{(\omega_{ms}^{(1)})^2 \omega_E^2 (\gamma_n H_n)^2 T_1}. \tag{5}$$

(Here T_1 must be obtained from experiment.) For hematite $\Pi \approx 10^{-7}$ W/cm^2.

For AF-EP for which the position of the antiferromagnetic resonance ω_1 at low temperature depends essentially on the temperature of the nuclear spin system, we can propose one more method of observing acoustic NMR. The latter can be observed by determining the shift of the frequency ω_1 when ultrasound of frequency ω_n is applied to the sample. The required sound-flux power must again be estimated from (5). It should be noted that the field δH_x, being due to the coupling of the nuclear spins with the lattice via the low-frequency branch of the spin waves (ω_{1k}), nevertheless excites that branch of the nuclear-spin oscillations, which interacts with the high-frequency branch of the spin waves (ω_{2k}). The frequency ω_n of this NMR branch remains undisplaced (see, e.g., [5]).

The field δH_x gives analogous formulas for $1/T_1$ and α, except that ω_{10} is replaced by ω_{20} and $\omega_{ms}^{(1)}$ is replaced by a combination of $\omega_{ms}^{(2)}$ and ω_a (which depends on the direction of k and e_λ). This component of δH excites the nuclear-spin oscillation branch interacting with ω_{1k}. For such weakly-anisotropic ferromagnets as $RbMnF_3$ and $KMnF_3$, for which $\omega_{20} \approx \omega_{10}$, the effects due to δH_z and δH_x are comparable in magnitude.

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On page 24, line 12 from bottom, read $\bar{\nu}_\mu = \bar{\mu}_0$ instead of $\nu_\mu = \mu_0$

" " 24, " 9 " " , " $\bar{P}$ and $\bar{N}$ " " P and N

" " 25, " 7 " top , " $\bar{\Sigma}_-$ " " Σ_-