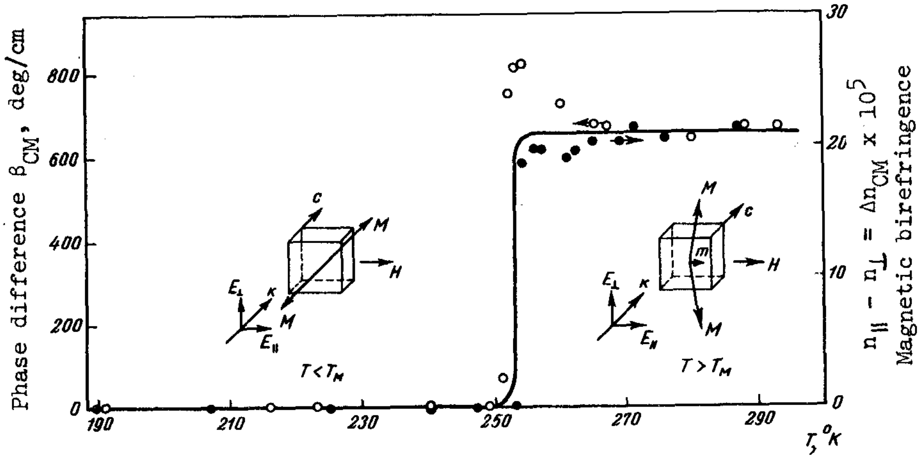

Fig. 3. Temperature dependence of Cotton-Mouton effect in hematite, in a field H = 6.7 kOe.

transition leads to the suppression of the Cotton-Mouton effect.

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[1] R. V. Pisarev, I. G. Siny, G. A. Smolensky, Solid State Communications, 7, No. 12 (1968).
[2] R. V. Pisarev, I. G. Sinii, and G. A. Smolenskii, ZhETF Pis. Red. 9, 112 (1969) [JETP Lett. 9, 64 (1969)].
[3] S. Geller, J. P. Remeika, R. C. Sherwood, H. J. Williams, and J. P. Espinosa, Phys. Rev. 137, A1034 (1965).
[4] N. F. Kharchenko, V. V. Eremenko, and L. I. Belyi, Zh. Eksp. Teor. Fiz. 55, 419 (1968) [Sov. Phys.-JETP 28, (1969)].
[5] A. E. Clark, J. J. Rhyne, and E. R. Callen, J. Appl. Phys. 39, 573 (1968).

CONCERNING THE GRAVITATIONAL MOMENT OF THE PROTON

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The possible existence of a proton gravitational moment violating CP-invariance was considered theoretically earlier [1 - 3].

In the presence of such a moment, the frequency of the proton magnetic resonance depends on the direction of the magnetic field, as follows from the form of the interaction Hamiltonian [3]:

$$(\mu\vec{H} + \xi\vec{g})\vec{\sigma}.$$

Here μ and ξ are the magnetic and gravitational moments of the proton, respectively, $\vec{H}$ is the magnetic field intensity, $\vec{g}$ the acceleration due to gravity, and $\vec{\sigma}$ the spin operator. The maximum change of the proton magnetic resonance frequency, which equals $4\xi g/\hbar$, should occur when the vertical magnetic field is reversed.

The author of [4] did not find this effect, but he did observe that the arithmetic mean value of the proton resonance frequencies in fields directed vertically upward and downward differs from the mean resonance frequency in horizontal fields.

According to existing notions, no such even effect should appear, accurate to terms of of order $(\xi g/\mu H)^2$, at any value of the gravitational moment.

These facts, as well as others of no principal character, cast doubts concerning the validity of the results of [4] and call for their verification.

This was done by measuring the NMR frequencies in vertical and horizontal magnetic fields. We used for this purpose the flow-through sample procedure [5], which made it possible to observe NMR in magnetic fields of low intensity. The flow-through liquid was tap water. The polarizer and analyzer was a single magnet producing a field close to 4 kOe.

The flow-through pickup had an approximate volume of 8 cm^3 and was rigidly coupled to Helmholtz coils that could be rotated around three mutually perpendicular axes.

The external ("terrestrial") magnetic field at the location of the flow-through pickup was compensated by two pairs of Helmholtz coils having an approximate diameter of 1 meter. The compensation was monitored with accuracy not worse than 1 mOe by a permalloy pickup that could be substituted for the flow-through pickup.

ν	H, Oe, approximately		
	0.1	0.2	0.3
$\nu_{\uparrow\downarrow}$	424.9 ±1.2	846.9 ±1.4	1700.1 ±0.2
$\nu_{\downarrow\downarrow}$	424.9 ±1.2	848.8 ±1.1	1701.5 ±0.7
$\nu_{\rightarrow}$	425.1 ±0.4	853.0 ±0.8	1699.8 ±0.6
$\nu_{\leftarrow}$	425.7 ±1.0	841.9 ±0.5	1700.1 ±0.3
$\langle\nu_{\parallel}\rangle$	424.9 ±1.2	847.8 ±1.3	1700.8 ±0.5
$\langle\nu_{\perp}\rangle$	425.4 ±0.7	847.5 ±0.7	1700.0 ±0.5
$\langle\nu_{\parallel}\rangle - \langle\nu_{\perp}\rangle$	−0.5 ±1.9	+0.3 ±2.0	+0.8 ±1.0

In a field of 0.1 Oe, the width of the resonance at half-height was approximately 8 Hz, but the frequency corresponding to the absorption maximum could be determined with an accuracy higher by almost one order of magnitude. The frequency was measured with a scaler device. The measurement results are given in the table. The first line gives the rounded-off values of the magnetic field at which the NMR was observed. In lines 2, 3, 4, and 5 are given the resonance frequencies in magnetic fields directed upward, downward, right, and left, respectively. In lines 6 and 7 are given the mean values of the NMR frequencies (in Hz) in vertical and horizontal fields. The last line gives the difference between the mean values of the NMR frequencies in vertical and horizontal fields.

Thus, according to our measurements, the effect described in [4] was not observed in magnetic fields smaller than one Oersted.

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[1] I. Yu. Kobzarev and L. B. Okun', Zh. Eksp. Teor. Fiz. 43, 1904 (1962) [Sov. Phys.-JETP 16, 1343 (1963).
[2] I. Leitner and S. Okubo, Phys. Rev. 136B, 1542 (1964).
[3] L. B. Okun' and C. Rubbia, Proc. Heidelberg Intern. Conf. on Elementary Particles, 1967, p. 338.
[4] G. E. Velyukhov, ZhETF Pis. Red. 8, 372 (1968) [JETP Lett. 8, 229 (1968)].
[5] P. M. Borodin et al. Yadernyi magnitnyi rezonans v zemnom pole (Nuclear Magnetic Resonance in the Earth's Field), LGU, 1967.

CYCLOTRON WAVES IN BISMUTH

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The study of cyclotron waves (CW) in metals has attracted many workers of late. Their interest is stimulated by the fact that the CW spectrum depends on the Fermi-liquid interaction of the conduction electrons [1, 2]. CW were observed experimentally in alkali metals [1, 3] and in bismuth [4]. The influence of the anisotropy of the Fermi surface of bismuth on the spectrum of the CW in it is also investigated in [4].

We are interested in "ordinary" CW, in which the field $\vec{E}$ is parallel to the external magnetic field $\vec{H}$. At symmetrical field directions (e.g., when $\vec{H}$ is parallel to C_1 or C_2, the bisector or binary axis of the crystal, respectively), when $\vec{K} \perp \vec{H}$, the CW spectrum is given by the equation $\sigma_{zz} + (ic^2/4\pi\omega)k^2 = 0$, where the component σ_{zz} of the conductivity tensor (without allowance for collisions) is of the form [5]

$$\sigma_{zz} = \Sigma \frac{e^2}{2\pi^2 \hbar^3} \int_{-p_z}^{p_z} dp_z \frac{m}{\Omega} \sum_{n=-\infty}^{\infty} \frac{v_z^{-n}(-\psi)\, v_z^{n}(\psi)}{in - i\omega/\Omega}; \qquad (1)$$

here

$$\psi = \int^{\phi} \frac{kv(\phi)}{\Omega} d\phi, \qquad \phi = \Omega t$$

$v_z^n(\psi)$ is the Fourier component of the function $v_z(\phi)e^{i\psi}$; v is the electron velocity, Ω and m its cyclotron frequency and effective mass, p_z the maximum value of the momentum along the magnetic field, and $\vec{k}$ and ω the wave vector and angular frequency of the wave; the first summation is over all sections of the Fermi surface. In a strong magnetic field when $\omega/\Omega \gg 1$, the inequality Im $\sigma_{zz} > 0$ is satisfied and the propagation of undamped waves is impossible. At field values such that $\omega/\Omega \approx 1$ for any one of the carrier groups, an important role is assumed by the terms with n = 1, and

$$\sigma_{zz} \approx \sigma_{zz}^0 - \frac{ie^2}{2\pi^2 \hbar^3} \int_{-p_z}^{p_z} dp_z \frac{m\omega}{\Omega^2} \frac{P(\psi^2)}{1 - (\omega/\Omega)^2}, \qquad (2)$$

where the polynomial $P(\psi^2) > 0$; its form depends on the shape of the Fermi surface in the H direction, and σ_{zz}^0 is a slowly varying function of $\vec{k}$ and $\vec{H}$, containing all the remaining terms. Its magnitude differs little from the value of σ_{zz} when $H \to \infty$. It follows from (2) that when $1 \gg 1 - (\omega/\Omega)^2 > 0$ we have Im $\sigma_{zz} < 0$, which leads to a possibility of propagation