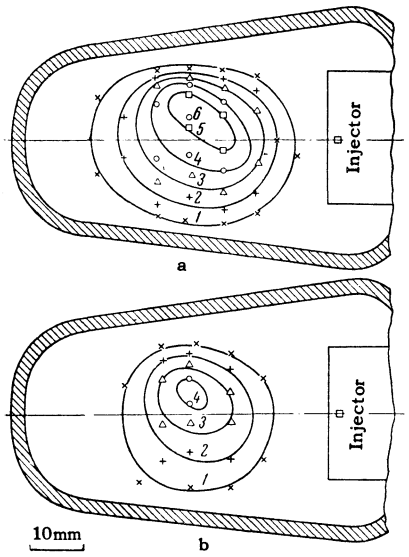

Curves of equal charge density. a—measured after 20 revolutions; b—measured after 100 revolutions after termination of injection. The numbers at the curves denote the charge density in percent of the maximum possible charge density.

interval Δt is approximately given by the expressions

$$\frac{\Delta N}{N} = -e^{-u}\frac{\Delta t}{\tau_p}, \qquad \frac{\Delta a}{a} = -\frac{ue^{-u}}{1-e^{-u}}\frac{\Delta t}{\tau_p}, \tag{3}$$

where $u = (\rho_m/\rho_0)^2$, ρ_m is the smallest relative distance of the doughnut walls from the beam center, and τ_p is the relaxation time. For the conditions of our experiment $\tau_p \sim 1$ μsec.

The following capture picture emerges from the foregoing. The injected electrons, which start out in a nonequilibrium distribution, try to approach the equilibrium distribution. As a result of the described cooling mechanism, the beam cross section decreases. Since the relaxation time is much larger than the time of one revolution, the number of the captured electrons depends on the mean life of the injected electrons. Matveev's mechanism increases this lifetime. For small values of the injected current this time increases, owing to a suitable ratio of the frequency of the betatron oscillations[5] and the orbital frequency.

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244

ANISOTROPY OF THE ABSORPTION OF ULTRASOUND IN METALS IN A MAGNETIC FIELD

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THE absorption of ultrasound in metals at low temperatures has been the subject of relatively few investigations, and principal attention has been paid to an investigation of the difference in absorption coefficients in the superconducting and normal states.[1,2] It has been noted that for longitudinal sound, the coefficient of absorption in tin depends on the magnetic field, but if the field is perpendicular to the sound wave vector **k**, a weakly pronounced maximum of absorption is observed in certain fields. A similar phenomenon was observed in polycrystalline copper[3] and in indium[4] and was not observed in zinc.

We report in this communication experiments set up to study the influence of the magnetic field on the absorption of ultrasound in single-crystal specimens of very pure metals. We prepared tin specimens with a residual resistivity less than 1.6×10^{-5} and of zinc with $R_{4.2}/R_{300} = 2 \times 10^{-4}$. The specimens were 12 mm in diameter and 12 and 15 mm long, respectively. The absorption coefficients were measured by known[5] pulse techniques at 17.3, 23.3, 51, and 70 Mcs.

Figure 1 shows the measured values of the coefficient of absorption of longitudinal sound in tin and zinc as a function of the magnetic field intensity at 4.2° K. The magnetic field is perpendicular to the wave vector. The ordinates represent the difference in the absorption coefficients with

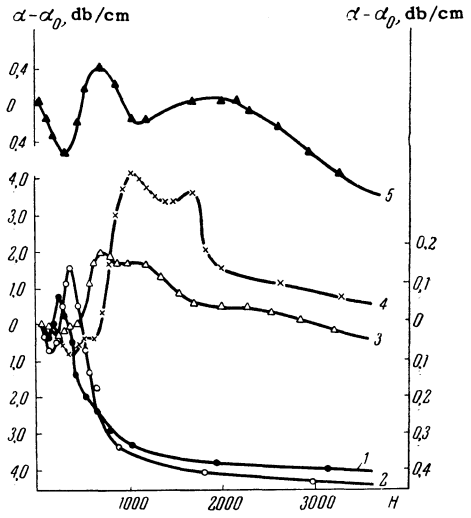

FIG. 1. Dependence of the coefficient of ultrasound absorption on the magnetic field H. Curves 1, 2, 3, 4 – tin; frequencies 17.3, 23.3, 51, and 70 Mcs. Curve 5 – zinc, 70 Mcs. Temperature 4.2°K. The vertical scale for curves 1 and 2 is on the right.

and without the field. It should be noted that when the temperature is reduced to 2° K the values of the absorption maxima increase, particularly in strong fields. A similar effect is produced by increasing the sound frequency. The value of the magnetic field at the maximum depends linearly on the ultrasound frequency, and the peak on the absorption curve is proportional to the square of the frequency. The effect is observed also in the case when the magnetic field is directed along the wave vector, but its magnitude is substantially smaller.

If the magnetic field is rotated in a plane perpendicular to the specimen axis, the character of the curves is substantially changed: the positions and magnitudes of the maxima change; in some directions the maxima smear out and disappear, while in others the maxima exist only at angles from 15 to 20°. Figures 2 and 3 (curves a) show

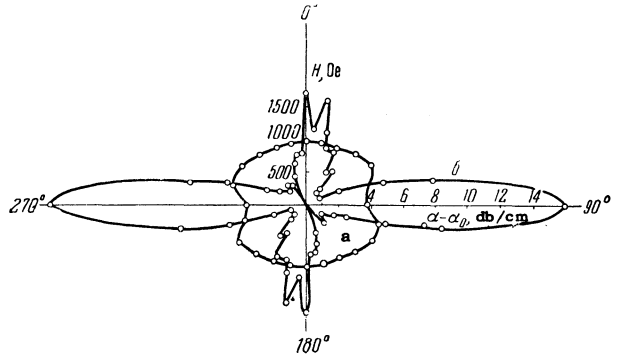

FIG. 2. a – rotation diagram of the maximum absorption of sound at 70 Mcs in tin, b – the same for the limiting absorption coefficient.

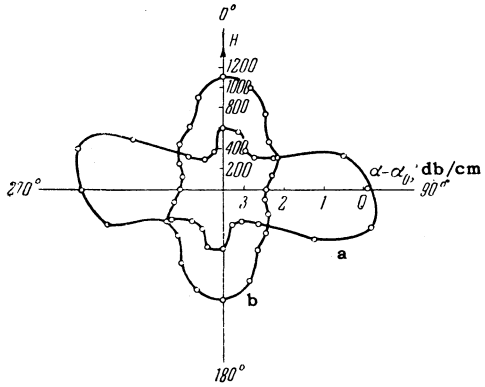

FIG. 3. a – rotation diagram for maximum absorption of sound at 70 Mcs in zinc, b – the same for the limiting absorption coefficient.

rotation diagrams for the first absorption maximum for tin or zinc. The length of the radius vector represents here the value of the field at the maximum. In tin the specimen axis makes 65° with the tetrangonal axis and lies in a plane making an angle of 62° with the (100) plane. The angle $\varphi = 0$ on the diagram corresponds to a field directed along this plane. In zinc the cylinder axis is perpendicular to the hexagonal axis and is inclined 7°30′ to the binary axis, while $\varphi = 0$ corresponds to a field along the hexagonal axis.

At frequencies on the order of 70 Mcs the coefficient of absorption of ultrasound tends to saturation at fields on the order of 5000 or 6000 oe, while its limiting value depends on the orientation of the specimen in the field. The results of the experiments made to determine the dependence of $\alpha - \alpha_0$ on the specimen orientation in a field of 10,000 oe at 70 Mcs are shown in Figs. 2 and 3 (curves b).

The irregularity of the coefficients of ultrasound absorption in a magnetic field and the presence of effects for both the longitudinal and transverse sound, as well as the existence of an effect for $\mathbf{H} \| \mathbf{k}$ indicate that the qualitative explanation offered by Pippard is inadequate for most observed phenomena.

It is possible that the observed effects can be attributed to diffraction scattering of the electrons by the space lattice, produced by the high-frequency fields. In this case the conditions to reflection or scattering under conditions when the Pippard relations[6] holds will be different than the scattering conditions in the absence of a field or in large fields. The presence of several absorption maxima and their anisotropy may be due to the existence of a series of effective electron masses ($0.2 - 1.0\ m_0$).

The rotation diagram for limiting values of the

coefficients of absorption in large fields apparently describes the anisotropy of electric conductivity in a magnetic field.

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245

RANGES OF MU-MESIC ATOMS IN HYDROGEN CHAMBERS

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IN the experiments of Alvarez et al.,[1] who observed nuclear reactions catalyzed by μ^- mesons in a hydrogen chamber, the origin of the track of a μ^- meson that had carried off energy from a nuclear reaction was often separated from the point at which the μ^- meson was stopped by a "fissure" on the order of 1 mm in size. The same kind of fissure not infrequently separates the point at which the μ^- meson was stopped from the beginning of the track of the electron generated in the μ^- meson decay. Alvarez et al.[1] attribute the appearance of the fissure to the recoil energy (of the order of $\frac{1}{3} \times 135$ ev $\simeq 45$ ev) of the mesic deuterium atom during the capture of the μ^- meson from the proton by the deuteron. They believe that this energy creates a gap equal to the fissure. This view is confirmed by the effective cross sections for $d_\mu + p$ and $d_\mu + d$ scattering computed by Cohen et al.[2] The effective $d_\mu + p$ cross section is small, and, as calculations have shown, a d_μ mesic atom with an energy of 45 ev actually does travel a distance on the order of 1 mm in hydrogen. Therefore, for a slight increase in the concentration of deuterium, the fissure is observed more often, because then a greater number of μ^- mesons are captured by the deuterons. When the deuterium concentration is increased still more (to about 4.3%[1]), the d_μ track becomes very short (on the order of a few hundredths of a millimeter) because of $d_\mu + d$ collisions (whose effective cross section are computed to be large[2]), and the fissure is not observed. (Here the essential thing is that in collisions of d_μ atoms with protons at rest the d_μ atoms are not deflected into angles exceeding 30°, while in $d_\mu - d$ scattering the angle of deflection may be as great as 90°.)

In $p_\mu - p$ scattering, transitions may occur between levels of the hyperfine structure of the mesic atom. For energies considerably exceeding that of hyperfine dissociation ($\Delta\epsilon \approx 0.183$ ev) an analytic expression can easily be provided for the $p_\mu + p \rightarrow p_\mu + p$ cross section calculated by Cohen et al.[2] The cross section for p_μ scattering by protons is

$$\sigma = 2\pi\left(\frac{1}{4}\,\frac{\lambda_g^2}{1+k^2\lambda_g^2} + \frac{3}{4}\,\frac{\lambda_u^2}{1+k^2\lambda_u^2}\right), \qquad (1)$$

where* $k^2 = (M_p\epsilon)^{1/2}/\hbar$, ϵ is the energy of the relative motion of p_μ and p in the center-of-mass system, and λ_g and λ_u are the scattering lengths of protons by the mesic molecular potentials $E_q(R)$ and $E_u(R)$, which correspond respectively to symmetric and antisymmetric wave functions (in the proton coordinates) for the 1s σ_g and the 2p σ_μ system (in the first the total spin of both protons is equal to zero and in the second, equal to 1). The potentials $E_g(R)$ and $E_u(R)$ which include a correction for the influence of μ meson motion,[4] accurate to order m_μ/M_p, can be approximated accurately by a Morse potential and an exponential.[5] The scattering lengths λ_g and λ_u are easily expressed in terms of the parameters of these functions.[6] However, the approximation given formerly by this author[6] is too rough; more exact values have been obtained for these parameters by Zel'dovich et al.[5] (in their Fig. 2 the value of α has been rounded off to 0.67 from 0.673). If the more accurate values are employed, then $\lambda_g \approx -17.3$ and $\lambda_u \approx 5.25$ (in mesic atom units). When $kR_0 < 1$, the pp_μ mesic molecular level and cross section (1) are in good agreement with the computations published by Cohen et al.[2] The rather large value for λ_g can be attributed to the presence of a virtual level near zero[6,7] in