MAGNETOACOUSTIC RESONANCE IN ALUMINUM

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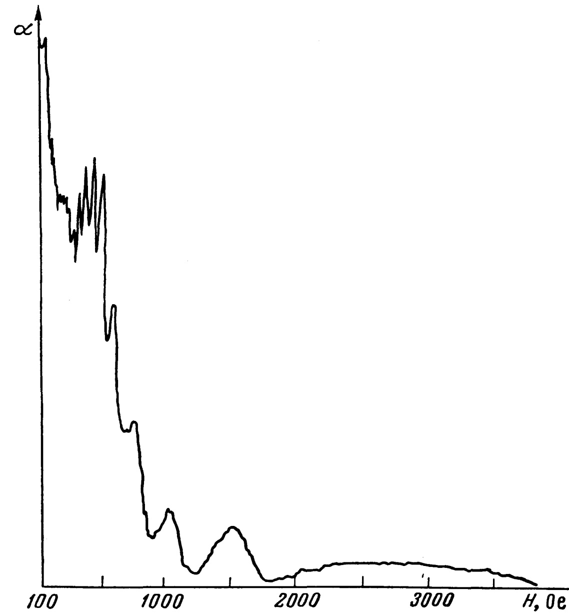
The dependence of the absorption coefficient of a 200 Mc longitudinal ultrasonic wave on the magnetic field intensity was studied in a monocrystalline sample of aluminum in fields up to 4000 Oe at 4.2°K. When the ultrasonic wave vector **q** was approximately parallel to the direction [111] and **H** was perpendicular to **q**, oscillations of the coefficient with three periods in the reciprocal field were observed for some directions of **H**. The dependence of the absorption coefficient on the magnetic field in aluminum was found to differ significantly from its dependence in other metals.

THERE are only two published papers on magnetoacoustic resonance in aluminum. Morse and Bohm [1] failed to observe oscillations of the ultrasonic absorption coefficient because of insufficient purity of their samples and relatively low ultrasound frequency. Roberts [2] was the first to report oscillations of the absorption coefficient using 10—100 Mc longitudinal waves. Roberts found only a small number of oscillations from which he deduced an approximate value of the extremal momentum. Roberts' data are in qualitative agreement with the Fermi surface model suggested by Harrison. [3]

The present note describes experiments on monocrystalline aluminum in magnetic fields up to 4000 Oe using 200 Mc longitudinal ultrasonic waves at 4.2°K.

A sample of very pure aluminum, prepared by B. N. Aleksandrov, was disk-shaped with 10 mm diameter and 2 mm thick. It was prepared from material for which $R_{4.2^\circ K}/R_{293^\circ K} = 6.7 \times 10^{-5}$. The ultrasonic absorption coefficient was measured as a function of the magnetic field intensity using a pulse technique described by Galkin and Korolyuk. [4] To separate the transmitted ultrasound pulse from the main pulse a quartz delay line was placed between the receiver and the radiator, both made of quartz. The ultrasonic wave vector **q** was aligned, to within 5°, with the [111] direction of the monocrystal. The magnetic field **H** was always perpendicular to **q**.

The results obtained by means of an automatic recorder are shown in the figure in the form $\alpha(H)$, where α is the transmission coefficient in relative units. The figure shows that there were at least two periods of oscillations in the reciprocal



field: a short period with $\nu\Delta H^{-1} \approx 6 \times 10^4\ \mathrm{sec^{-1}\ Oe^{-1}}$, which was practically identical with Roberts's result, [2] and a long period with $\nu\Delta H^{-1} \approx 32 \times 10^4\ \mathrm{sec^{-1}\ Oe^{-1}}$.

A study of the anisotropy of the oscillations as deduced from the character of $\alpha(H)$ showed that in several directions there were oscillations with three periods which were approximately in the ratio 1:3:6.

Experiments on cyclotron resonance in aluminum [5,6] have shown the existence of electrons with three effective masses. It is possible that the oscillations of the ultrasonic absorption coefficient with three different periods correspond to these three effective masses. A simultaneous study of magnetoacoustic and cyclotron resonances in the same sample should give the extremal Fermi velocities for which only order-of-magnitude values are available at present.

The result for short-period oscillations does not contradict the Fermi surface model for aluminum proposed by Harrison.[3] The long-period oscillations may be due to structure of the third zone but the present results are not sufficient to give a reliable conclusion on this subject.

The dependence of the ultrasonic absorption coefficient on the magnetic field intensity in aluminum differs significantly from the same dependence for other metals,[7-10] in which the absorption coefficient rises less rapidly with the magnetic field.

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[1] R. W. Morse and H. V. Bohm, Proc. of the Fifth Intern. Conf. on Low Temperature Physics and Chemistry, Madison, Wisconsin 1957.

[2] B. W. Roberts, Phys. Rev. **119**, 1889 (1960).

[3] W. A. Harrison, Phys. Rev. **116**, 555 (1959); **118**, 1182 (1960); **118**, 1190 (1960).

[4] A. A. Galkin and A. P. Korolyuk, PTÉ No. 6, 99 (1960).

[5] D. N. Langenberg and T. W. Moore, Phys. Rev. Letters **3**, 137 (1959).

[6] E. Fawcett, Phys. Rev. Letters **3**, 139 (1959).

[7] T. Alsen and R. W. Morse, Bull. Am. Phys. Soc. **4**, 167 (1959).

[8] A. A. Galkin and A. P. Korolyuk, JETP **37**, 310 (1959), Soviet Phys. JETP **10**, 219 (1960).

[9] R. W. Morse and J. D. Gavenda, Phys. Rev. Letters **2**, 250 (1959).

[10] J. R. Neighbours and G. A. Alers, Phys. Rev. Letters **3**, 265 (1959).

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