"GIANT" OSCILLATIONS OF ACOUSTOELECTRIC CURRENT

A.P. Korolyuk and V.F. Roi
Institute of Radiophysics and Electronics, Ukrainian Academy of Sciences
Submitted 30 December 1972
ZhETF Pis. Red. 17, No. 4, 184 - 186 (20 February 1973)

An acoustoelectric (AE) effect was observed and investigated in a conductor (single-crystal bismuth with $R_{292}/R_{4.2} \simeq 300$) at helium temperatures. Quantum (including "giant") oscillations of the AE current were observed in magnetic fields up to 30 kOe. A new method of investigating the energy spectrum of the carriers in a conductor, which makes it possible to determine the sign of the carriers, is proposed.

The phenomena accompanying and connected with the propagation of acoustic waves in metals at low temperatures in a magnetic field have been the subject of several studies [1, 2]. Principal attention was focused on the study of the transverse magnetoelectric and quantum magnetoelectric effects. The oscillatory picture observed in these phenomena is connected principally with the oscillations of the components of the magnetoresistance tensor in a quantizing magnetic field and contains relatively little information on the energy spectrum of the carriers in the conductor. Yet greatest interest would attach to a direct observation of the acoustoelectric current and its oscillations in a magnetic field, which are connected with quantum oscillations of the sound-absorption coefficient. In this case, at different orientation of the sound and magnetic-field vectors $\vec{q}$ and $\vec{H}$ relative to the sample crystallographic axes, it becomes possible to study the different carrier groups in the conductor, since each group makes its own contribution to the oscillation picture of the AE current.

The advantage of the proposed method over those already known is that it determines unambiguously the sign of the effect. In the particular case when the magnetic field vector $\vec{H}$ and the acoustic flux vector $\vec{S}$ are collinear, it becomes really possible to observe separately the oscillations due to the electrons and holes, since the oscillation pictures due to the two carrier groups will have opposite signs.

A diagram of the experiment, which was performed on bismuth single crystals, is shown in Fig. 1. The magnetic field vector $\vec{H}$ could be rotated 180° relative to the sound vector $\vec{q}$ in the plane of the binary and besector axes of the crystal. The AE current was measured in all cases in a direction parallel to the sound vector q. The experiments were performed on y-cut single-crystal bismuth samples measuring 3 × 3 × 1.5 mm. In single crystals with $R_{292}/R_{4.2} \simeq 300$ we observed and investigated the AE effect at helium temperatures. The tests were made at 165 and 500 MHz in the temperature interval from 4.2 to 1.5°K. The AE waves were excited with a longitudinal-wave piezoconverter consisting of a lithium niobate plate with fundamental frequency 165 MHz. The largest value of the AE effect measured in the experiment was 5×10^{-6} V-cm^{2}W^{-1}. The intensity of the sound flux was in this case 0.01 W/cm^2. The sign of the effect in the absence of a magnetic field corresponded to electrons as carriers. In strong magnetic fields ($\Omega\tau \gg 1$) at temperatures T < 4.2°K we observed quantum oscillations of the AE current, with characteristic singularities of "giant"

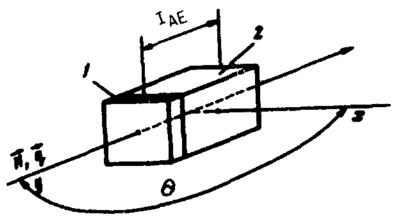

Fig. 1. Experimental setup: 1 - piezoconverter, 2 - sample, θ - angle between the magnetic field direction and the binary axes of the sample.

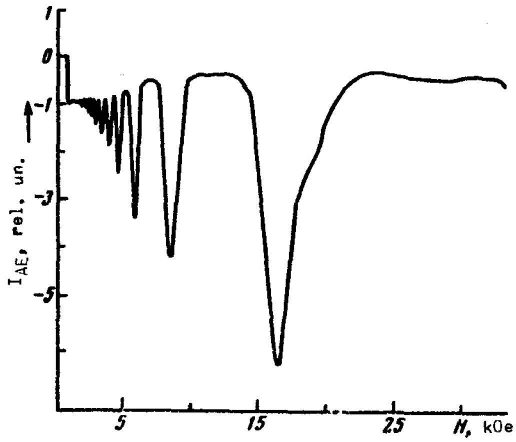

Fig. 2. Dependence of AE current amplitude on the magnetic field, $\vec{q} \parallel \vec{H} \parallel y$, f = 500 MHz, T = 3°K.

oscillations of the sound absorption coefficient. Their amplitude depends linearly on the magnetic field, in agreement with the theory [3, 4]:

$$\Gamma = \frac{\Gamma_0 e\hbar H}{8m^* ckT}, \qquad (1)$$

where Γ_0 is the electronic assorption coefficient in the absence of a field, m* is the effective mass, H is the magnetic field, and the remaining symbols are standard. Figure 2 shows the dependence of the amplitude of the AE current on the magnetic field for the case $\vec{q} \parallel \vec{H} \parallel y$. The interaction of the longitudinal sound wave with the electrons is characterized in this case by the fact that its value predominates for one of the electronic ellipsoids, which is elongated along the y axis, and is negligible for the two others. This results in AE current oscillations having one period and due to the indicated ellipsoid. The amplitude of the oscillation and the absorption line shape agree quite well with data on sound damping [5], so that one can talk of using the proposed method to study the energy spectra of the carriers in conductors.

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EXPERIMENTAL OBSERVATION OF ELECTRON PARAMAGNETISM OF MUONIC ATOMS

V.G. Varlamov, Yu.P. Dobretsov, B.A. Dolgoshein and V.G. Kirillov-Ugryumov
Moscow Engineering Physics Institute

Submitted 28 December 1972
ZhETF Pis. Red. 17, No. 4, 186 - 190 (20 February 1973)

As established by us, in noble gases with spinless nuclei there is no Larmor precession of the μ^--meson spin at the precession frequency of the free muon [1, 2]. It is shown in the present article that this is due to spin-orbit interaction of the muon with the electron shell of the muonic atom[1].

We consider a nucleus Z with a negative muon in the K-orbit, comprising a system measuring $\sim 10^{-10}$ cm and having an effective charge Z - 1 and the magnetic moment of the muon. We shall henceforth call a nucleus with a muon on the K orbit a "mesic nucleus." When the electron shell of the mesic nucleus is completely filled and is disintegrated by cascade transitions of the muon, a muonic atom is produced on the mesic nucleus Z - 1 and has properties equivalent to those of the ordinary atom of the element with charge Z - 1. We note

[1]) Preliminary results were reported at the Fourth International Conference on the Physics of High Energy and Nuclear Structure, Dubna, 1971 (p. 415).