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1) It is assumed that the observer is always far from the star, where the field is weak. In the Friedmann cosmological model this is not the case; the change of contraction into expansion was considered for this case in [6].

2) We emphasize that these external spaces differ in principle from the spaces that are made continuous through Wheeler's topological "knobs" [4]. The latter can be joined by a single space-like section.

3) In the case of a charge concentrated in the center, the equation can be integrated rigorously [8]. Crossings of the dust particles are then unavoidable.

QUANTUM OSCILLATIONS OF SURFACE RESISTANCE OF ZINC AT 1 Mc

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It is presently known that low-frequency resistance oscillations in zinc, corresponding to a needle-like Fermi surface, do not constitute the ordinary Shubnikov - de Haas effect. The giant amplitude of these oscillations is attributed to magnetic breakdown of the Fermi surface of zinc [1,2].

To investigate in greater detail these unusual oscillations, we measured the surface resistance R(H) of zinc single crystals at 1 Mc, using a type IMI-2 nuclear magnetic-field pickup. The sample was placed in the oscillator coil. The detector output was fed to a low-frequency narrow-band amplifier with phase detector. The absorption signal was recorded with a two-coordinate automatic plotter. This method of investigating quantum oscillations was first used in [3].

The measurements were made in fields up to 22 kOe at 1.4°K. The modulation frequency of the external magnetic field was 20 cps. The zinc samples were the same as used in [2], with $\rho_{300°K}/\rho_{4.2°K} \approx 18{,}000$. The samples were cylinders ~2 mm in diameter and ~30 mm long or plates measuring 1 x 2 x 20 mm. Different polarizations of the high-frequency current relative to the direction of the constant magnetic field $\bar{H}$ were used for the same crystallographic direction. The field could be either parallel or perpendicular to the skin-layer surface. The geometry of the samples made it possible to carry out dc measurements simultaneously with the high-frequency measurements.

The measurements disclosed oscillations of $\partial R(H)/\partial H$, connected with different parts of the Fermi surface of zinc (with period up to 1×10^{-7} Oe^{-1}). Principal attention was paid, however, to oscillations due to the needle-like Fermi surface, and the following results were obtained for this case.

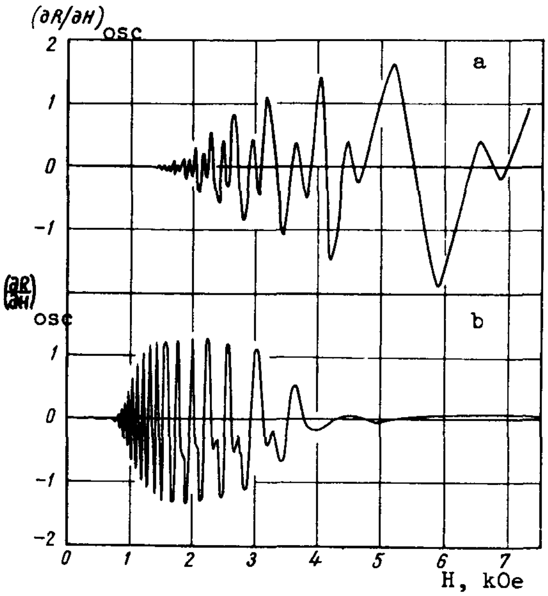

Fig. 1. Plot of the oscillating increment to the derivative of the surface resistance of zinc vs. the magnetic field (T = 1.4°K, f = 1 Mc). a - Magnetic field perpendicular to skin layer and parallel to [0001] axis; b - magnetic field parallel to skin layer and inclined $\theta \approx 10°$ to [0001] axis.

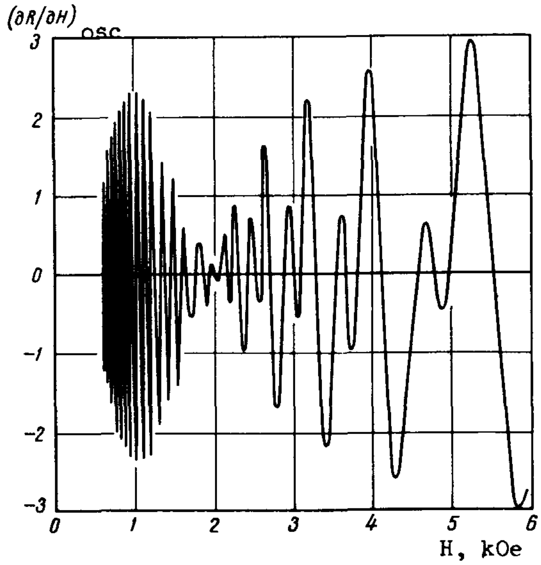

Fig. 2. Oscillating increment to the derivative of the surface resistance of zinc vs. the magnetic field (T = 1.4°K, f = 1 Mc). The magnetic field is parallel to the skin layer and to the [0001] axis. The hf field is perpendicular to the magnetic field.

Two types of oscillations having the same period have been observed. These oscillations differ distinctly in form and are shifted one-half cycle relative to each other. The oscillations of the first type have the following features (Fig. 1a):

1. They exist for all directions of the magnetic field relative to the crystal axes.

2. The oscillations are observed starting with small fields (~200 Oe). Their amplitude increases sharply and reaches a maximum at H_1 and then decreases. In fields $H_2 \approx 2H_1$ no oscillations are observed. When the angle θ between the [0001] axis and the magnetic field increases, the values of H_1 and H_2 increase. $H_1 \approx 2$ kOe at $\theta \approx 0°$.

3. The oscillation amplitude depends little on the direction of the high-frequency current and depends significantly on the direction of $\bar{H}$ relative to the skin layer. The best conditions for the observation of the oscillations is when the hf current is perpendicular to $\bar{H}$ and $\bar{H}$ is parallel to the skin layer.

4. Comparison with the results obtained with direct current show that this type of oscillations is not observed in the static resistance $\rho(H)$.

The oscillations of the second type had the following features (Fig. 1b):

1. They existed only for the direction H $\parallel$ [0001] and for magnetic-field directions that lead to the appearance of open electron trajectories in the (0001) plane. These directions are in the main parallel to the $\{10\bar{1}0\}$ planes [2].

2. The oscillations are observed starting with approximately 2 kOe. Their amplitude

increases smoothly with increasing magnetic field.

3. The amplitude of the oscillations depends essentially on the polarization of the hf current in the sample relative to the crystal axes and the magnetic field. Thus, for example, no oscillations are observed if the hf current is parallel to $\bar{H}$, and also if it is parallel to the open trajectories in the (0001) plane.

4. When comparing the curves obtained in measurements of the samples at 1 Mc and with direct current it turns out that $(\partial R(H)/\partial H)_{osc} \sim \partial\rho(H)/\partial H$, where $\rho(H)$ is the static resistance in the magnetic field.

5. The best conditions for observation of the oscillations occur when the magnetic field is perpendicular to the surface of the skin layer.

The unique behavior of the oscillations of these two types makes it possible to observe them simultaneously under certain conditions (Fig. 2).

It is seen from Fig. 1 that the oscillation maxima are split. This splitting is apparently of the spin type, with g-factor equal to 89 [4]. The character of the spin splitting does not change on deviation from the sixfold axis, and then the g-factor decreases in exact agreement with the decrease in the period of the oscillations.

Comparing Figs. 1a and 1b we can see that the form of one type of oscillation can be replaced by mirror reflections of the oscillations of the other type about the abscissa axis.

We attribute the results to the fact that in a magnetic field there are two possible mechanisms for formation of surface resistance: in weak fields, when $2r_{extr} \gg \delta_{sk}$ (where $2r_{extr}$ is the diameter of the extremal electron orbit in the magnetic field and δ_{sk} the thickness of the skin layer) the quantum oscillations of the surface resistance, considered in [5], take place. It is important here that the electron orbit be only partially in the skin layer. This case corresponds to the observed oscillations of the first type.

When the entire electron orbit is in the skin layer, the mechanism of formation of the surface resistance differs noticeably from the first. The quantum oscillations observed in this case are apparently analogous to the effect observed with direct current. This type of oscillation occurs in large fields, when $2r_{extr} \ll \delta_{sk}$, or when the magnetic field is perpendicular to the skin layer.

The absorption should be proportional to the number of effective electrons for the first mechanism and inversely proportional for the second. This explains the observed difference in phase and form of the two types of oscillations. The maximum of the oscillation amplitude of the second type occurs apparently when half of the electron orbit lies in the skin layer. The oscillations should accordingly vanish at the instant when the entire orbit is in the skin layer.

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CORRECTIONS:

In the article "Inertial Echo and Coherent Gravitational Waves," by U. Kh. Kopvillem and V. R. Nagibarov, vol. 2, No. 12, p. 331 (Russ. p. 532), the 12th line from the bottom should read B. Ya. Zel'dovich and not Ya. B. Zel'dovich.

In the article "Dispersion of Sound in Superfluid Helium," by I. M. Khalatnikov and D. M. Chernikova, vol. 2, No. 12, p. 352 (Russ. p. 568), the formula in the 7th line from the bottom should read

$$u_{2\infty} = \{(\rho_{sr}/\rho_{nr})(\sigma_r^2/\partial\sigma_r/\partial T)_\rho)\}^{1/2},$$

formula (2) on p. 353 should read

$$\varphi = z_{phr} - 3\frac{u^2 \ln a + [2uz_{phr}+z_{phr}^2(1-\beta(1-z_{phr}))+3u^2(1-z_{phr})][-2+(z_{phr}+z_{phph}-1)\ln a]}{2 + [1-z_{phph}+(1-\beta)(1-z_{phr})] \ln a + 3(1-z_{phr})[1-\beta(1-z_{phr})][-2+(z_{phr}+z_{phph}-1) \ln a]}$$

and a factor (ρ_{nph}/ρ) has been omitted after the braces in formula (6).