This result, which confirms the presence of the Fermi interaction along with the Gamow-Teller interaction in muon capture, excludes the possibility that G_F is considerably greater than G_G and is quite compatible with the value expected on the basis of the theory of the universal (V−A) interaction.

Of course, the existence of the vector interaction more clearly follows from our measurements if it is assumed that $g_A^\mu = g_A^\beta$ (see [2]) $g_P^\mu = 8g_A^\mu$ (see [7]). As a matter of fact, if the vector interaction is not present, the probability of reaction (1) under these assumptions is expected to equal $0.93 \times 10^3\ \mathrm{sec}^{-1}$, i.e., much less than the measured value. However, the values of g_A^μ and g_P^μ which were used cannot be considered equally well founded.

The authors express their sincere gratitude to S. S. Gershteĭn and V. S. Evseev for discussion of the results and to A. G. Zhukov, N. V. Lebedev, V. N. Orekhov, V. F. Poenko, A. G. Potekhin, A. I. Tokarskaya, and E. A. Shvaneva for aid in the measurements.

[1)]A similar conclusion also follows from analysis of the asymmetry of neutrons emitted in muon capture by complex nuclei.[4]

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ANOMALOUS REFLECTION OF SOUND FROM THE SURFACE OF A METAL AT LOW TEMPERATURES

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Submitted to JETP editor May 31, 1962

J. Exptl. Theoret. Phys. (U.S.S.R.) **43**, 358-360 (July, 1962)

WE shall show that in certain cases the conduction electrons can significantly alter the reflection coefficient for sound incident from a liquid onto the surface of a metal. A treatment is presented of the low temperature case for which the absorption of sound in a metal is chiefly due to the electrons.

Consider a liquid occupying the semi-infinite space $z > 0$, from which a plane sound wave is incident upon a metal surface. The velocity field is defined in the liquid by specifying the scalar potential φ, namely $\mathbf{V} = \mathrm{grad}\ \varphi$; and in the solid by a scalar potential Φ and a vector potential Ψ such that $\dot{\mathbf{u}} = \mathrm{grad}\ \Phi + \mathrm{curl}\ \Psi$, where $\mathbf{u}$ is the displacement vector. If the wave vector $\mathbf{k}$ for the incident wave lies in the xz plane, Ψ can be chosen in such a way that only its y component differs from zero; we shall call this component Ψ. Let the angle of incidence of the sound be θ, and its frequency ω; then

$$\varphi = \{A_0 \exp[ik(x\sin\theta - z\cos\theta)] + A\exp[ik(x\sin\theta + z\cos\theta)]\}e^{-i\omega t},$$
$$\Phi = A_l \exp\{ik_l(x\sin\theta_l - z\cos\theta_l) - i\omega t\},$$
$$\Psi = A_t \exp\{ik_t(x\sin\theta_t - z\cos\theta_t) - i\omega t\},$$
$$k = \frac{\omega}{c},\quad k_l = \frac{\omega}{c_l},\quad k_t = \frac{\omega}{c_t};\qquad \frac{\sin\theta}{c} = \frac{\sin\theta_t}{c_t} = \frac{\sin\theta_l}{c_l}, \tag{1}$$

where c is the velocity of sound in the liquid, and c_l and c_t are, respectively, the velocities of the longitudinal and transverse components of the sound in the metal. For simplicity, we assume the metal to be isotropic. Further, we assume that $c < c_t$.

The coefficients A, A_l, and A_t are determined by the system of boundary conditions at $z = 0$, which equate the normal displacements and pressures on either side of the boundaries.

If $\theta > \theta_0$, where $\sin\theta_0 = c/c_t$, total internal reflection occurs. This is true only insofar as we neglect the absorption of sound in the metal.

The presence of absorption naturally reduces the reflection coefficient. The oscillation amplitudes A_l and A_t in the metal possess a sharp maximum when the angle of incidence is near θ_1, where $\sin\theta_1 = c_l/c_t\xi$, $\xi = \xi(c_l/c_t)$ being a function of order unity (shown graphically in [1]); Rayleigh waves are then generated within the metal. It is clear that the absorption of sound in the metal has a strong influence on the reflection coefficient for θ near θ_1. Since $\xi < 1$, θ_1 lies in the total internal reflection region.

In the presence of the sound field (1), additional forces (besides those determined by the elastic constants), resulting from the presence of electrons, will arise at the surface of the metal; these may be determined by solving the kinetic equation for the electron distribution function, and must be taken into account in establishing the system of boundary conditions required to determine A, A_l, and A_t.

For the case in which $\omega\tau \ll 1$ (τ is mean free time of flight for the electrons), while $v_0\tau \gg c_t/\omega$ (v_0 is the Fermi velocity), this system possesses, in the neighborhood of $\theta = \theta_1$, the following solutions:

$$\frac{A}{A_0} = \frac{Z_l\cos^2 2\theta_t + Z_t\sin^2 2\theta_t + Y - Z}{Z_l\cos^2 2\theta_t + Z_t\sin^2 2\theta_t + Y + Z}, \tag{2}$$

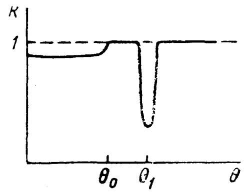
$$\frac{A_l}{A_0} = \frac{\rho}{D}\,\frac{2Z_l\cos 2\theta_t}{Z_l\cos^2 2\theta_t + Z_t\sin^2 2\theta_t + Y + Z}, \tag{3}$$

$$\frac{A_t}{A_0} = -\frac{\rho}{D}\,\frac{2Z_t\sin 2\theta_t}{Z_l\cos^2 2\theta_t + Z_t\sin^2 2\theta_t + Y + Z}, \tag{4}$$

$$Z_l = Dc_l/\cos\theta_l,$$

$$Z_t = Dc_t/\cos\theta_t, \qquad Z = \rho c/\cos\theta, \tag{5}$$

where ρ and D are the densities of the liquid and the metal, respectively; $Y = f(c_t/c_l)p_0^4/(\pi\hbar)^3$, where p_0 is the Fermi boundary momentum, and f is a function of order unity (for details of this calculation, see [2]).



We note that when $\theta = \theta_1$ the sum of the first two terms in the denominators of (2)—(4) goes to zero. The nature of the dependence of the reflection coefficient $R = |A/A_0|^2$ upon θ is illustrated in the figure. At $\theta = \theta_1$ there is indeed a sharp minimum, with $1 - R(\theta_1) \sim p_0^4/(\pi\hbar)^3$, which, for example, gives for liquid helium a value of the order of unity. For the case in which $v_0\tau \ll c_t/\omega$, the effect of the electrons upon the reflection coefficient is small.

Since the presence of a surface wave at the boundary of the metal gives rise to an electric field oscillating with the frequency ω, it is of interest to consider the dependence of $R(\theta_1)$ upon a magnetic field applied to the metal, parallel to its surface and perpendicular to the plane of incidence of the sound. In a strong magnetic field, an effect of the cyclotron resonance type should appear. For this, however, it is necessary that $\omega \sim \Omega_{\text{Larmor}}$, and that $v_0\tau \gg v_0/\Omega_{\text{Larmor}}$, from which it follows that $\omega\tau \gg 1$. The appropriate calculations are therefore extremely complex.

I am grateful to A. A. Abrikosov, L. P. Gor'kov, I. E. Dzyaloshinskiĭ, and I. M. Khalatnikov for discussions and valued comments.

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