the interaction with the external field can be treated as a perturbation. We regard the external fields as constants, i. e., we regard the potentials as linear functions of the coordinates. If only terms that are linear in the field are retained, then the operator for interaction with the external field ΔI_{ex} has the form

$$i\Delta I_{\text{ex}} = -e\alpha_{1\mu} A_\mu(1)\left(-\frac{\hbar}{2i}\frac{\partial}{\partial T} + \frac{\hbar}{i}\frac{\partial}{\partial t} - H_2\right) \quad (6)$$
$$+ e\alpha_{2\mu} A_\mu(2)\left(-\frac{\hbar}{2i}\frac{\partial}{\partial T} - \frac{\hbar}{i}\frac{\partial}{\partial t} - H_1\right).$$

The energy of interaction with the external field found by means of (6) in the first approximation exactly coincides with the energy found by us by the usual method in the first approximation of perturbation theory. It is important, however, to emphasize that by means of (6) corrections are obtained to this energy, connected with the relativistic two body problem and its influence on the interaction of positronium with external fields. For $n = 1$ they have the magnitude

$$(V^{\text{rel}}_{\text{ex}})_{ss'} = -\mu_0 \frac{\alpha^2}{12} < \sigma_{1z} - \sigma_{2z} >_{ss'} H_z, \quad (7)$$

where s characterizes the spin states σ_{1z} and σ_{2z} are Pauli matrices, $\alpha = e^2/\hbar c, \mu_0 = e\hbar/2mc$, H_z is the intensity of the magnetic field. This energy produces additional mixing of ortho and para states in positronium.

Since the operator for relative energy enters into operator (6), interest exists in the question to what degree the corrections which have been found are related to the operator $(\hbar/i)(\partial/\partial t)$ and, consequently, with the different times of the particles. If the energy of interaction associated with the part of operator (6) containing $(\hbar/i)(\partial/\partial t)$ is found separately, then exactly (7) is obtained.

The corrections found in this manner are of principal interest, since they are all related to the different times of the particles.

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*The difference between this equation and the Salpeter-Bethe equation [3] is connected with calculation of the specific exchange interaction between electron and positron determined by their virtual annihilation.

Investigation of the Anisotropy of the Surface Resistance of Tin at Low Temperature

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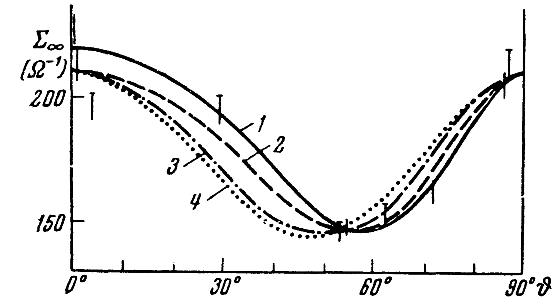
RESULTS of investigations of the anisotropy of the surface resistance of tin at helium temperatures in normal and superconducting states are reported in the papers of Pippard [1-3]. In these studies the properties of the coaxial resonator (at a frequency of approximately 9400 mcs/sec) were experimentally investigated; the specimen under investigation serves as the internal conductor-cylindrical monocrystalline tin, 14 mm in length and 0.25 to approximately 1 mm in diameter, having a different angle of inclination of the major crystalline axis relative to the axis of the specimen. The dependence, arrived at in reference 1, of the active surface conductivity (at normal state) on the angle θ is shown in Figure 1 (solid curve; vertical dashes--Experimental points). A similar dependence of the reactive surface conductivity on the angle θ as well as the penetration depth of the electromagnetic field calculated from it is arrived at in reference 1. These experiments led Pippard to a conclusion as to the non-tensorial character of the anisotropic effects noted.

The principal significance of the above mentioned work is the necessity for careful and detailed consideration of these investigations as to the methods employed. As a first step it may be of interest to determine the experimental results one should expect if we assign a normal tensorial character to the anisotropy of surface conductivity of tin at helium temperatures. This article deals with this important question.

In the coaxial resonator the electrical oscillations may be produced along the axis (usual electromagnetic wave) as well as in the perpendicular direction. Keeping in mind the fundamental frequencies associated with these two types of resonance one



Dependence of active surface conductivity of the samples on the angle θ . 1- As found in reference 1 the vertical dashes indicate experimental points; 2-$f(\theta; 2)$; 3-$f(\theta; 1.4)$; 4-$f(\theta; 1.14)$. The measured curves disclose the high order of their correspondence with the values obtained from the curves of reference 1.

is led to consider the oscillation of a system with two degrees of freedom. In this case, the partial frequency of the transverse oscillation is one to two orders higher than that of the longitudinal oscillation (according to their real geometric dimensions). If the resonator is constructed from an isotropic conductor, then there is no relation between the transverse and longitudinal partial resonant frequencies, and they can be excited independently. If, on the other hand, the internal conductor of the resonator is anisotropic ($\theta \neq 0°$, $\theta \neq 90°$) then the separate resonances are related and the resonator may be excited as a coherent system.

Let us examine the mechanism connecting the longitudinal and the transverse resonances of the coaxial resonator, allowing the longitudinal external electrical field to excite the low frequency resonance of the system. As a consequence of the anisotropic conductivity of the internal conductor of the resonator, the electric field will induce displacement current at an angle to the axis of the resonator with a component of the displacement current perpendicular to the axis of the resonator (with sustained state of oscillation of the system, the current and the electrical excitation field will not be parallel to each other and to the axis of the resonator). Such forms of normal tensorial anisotropy lead to a relationship between the longitudinal and transverse resonances. There is no anisotropy evident and a relation between the resonances does not exist when $\theta = 0$; $\theta = 90°$, for all intermediate orientations of the crystalline axis a correlation exists, passing through a maximum as θ varies from $0°$ to $90°$, and together with it the band width (damping) of the low frequency response passes through a maximum and its own frequency passes through a minimum at that same point.

This qualitative conclusion agrees fully with observations of Pippard[1] as shown in the diagram. The active conductivity of the sample was calculated as inversely proportional in magnitude to the band width of the resonator which, as is evident from the diagram, is maximum for the resonator with a sample having $\theta \approx 55°$.

A qualitative estimate of the effect of these relations on the properties observed in low frequency resonance may be quite simply carried out with respect to the dependence between the coupling and θ. The coupling increases the band width of the resonance (i.e. the longitudinal resonance) due to additional losses caused by the transverse component of the displacement current; these losses are proportional to the square of the average transverse current along the periphery of the sample. This transverse component is the current which would have appeared on an infinite plane surface of the same metal (with the same orientation of the crystal axis relative to the field, it is possible to consider the element in the lateral surface of the sample). Dependence of this component of the current upon θ can be easily found, if we know the anisotropy $\sigma_{\parallel}/\sigma_{\perp}$ of the conductivity of the metal. In this manner, the function $f(\theta, \sigma_{\parallel}/\sigma_{\perp})$ is determined as proportional to the losses occuring at low frequencies (longitudinal resonance in connection with the transverse resonance). The agreement between the forms of the function (f) with the dependence of $\Sigma(\theta)$ in reference 1 (see diagram) is quite obvious.

The effect on the longitudinal resonance due to the coupling with transverse resonance may be considered as a complex resistance which has been introduced as proportional to the resistance of the resonator to the transverse current, i.e. is proportional to the surface resistance of the sample. Therefore, it is evident that the active and reactive resistances introduced are in the same ratio as the active and reactive resistances of the resonator to the longitudinal currents, which means that the relative effect of the coupling on the value observed for the reactive resistance of the sample (calculated from the displacement of the natural frequency of the resonator) must be same as that for the value of the active resistance. This conclusion is also in good agreement with the results presented by Pippard[1]

Therefore, it appears possible that the conclusion concerning the non-tensorial nature of the anisotropy of the surface conductivity of metal at low temperatures and the non-tensorial anisotropy of the penetration depth of the electromagnetic field in superconductor, as arrived at in references 1-3, does not have sufficient experimental basis. The phenomena observed can be explained, at least qualitatively, on the basis of the above mentioned concept concerning the bond between the two fundamental oscillations of the coaxial resonator, with the aid of the usual tensorial anisotropic conductivity.

In any case, it should be most evident that there is a need for further and extensive investigations as to the anisotropy of surface conductivity at low temperatures before final conclusions as to its character can be formulated.

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The Problem of the Invalidity of One Statistical Treatment of Quantum Mechanics

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WIGNER and Szilard [1] have proposed a probability distribution in phase space of a quantum particle

$$F(q;p)=\frac{1}{2\pi}\int\psi^*\left(q-\frac{h\tau}{2}\right)e^{-i\tau p}\psi\left(q+\frac{h\tau}{2}\right)d\tau, \qquad (1)$$

satisfying the time-dependent equation

$$\frac{\partial F}{\partial t}+\frac{p}{m}\frac{\partial F}{\partial q}=\frac{i}{4\pi^2h}\int\left[V\left(q-\frac{h\tau}{2}\right)-V\left(q+\frac{h\tau}{2}\right)\right]F(q;\eta)\,e^{i\tau(\eta-p)}d\eta d\tau. \qquad (2)$$

Here q, p, m are coordinate, momentum and mass of of the particle; $V(q)$, its potential energy; h, Plank's constant; t, the time.

In an extension of this work [2] an interpretation of Eq. (2) has been given as the equation of a certain stochastic process of change of coordinate and momentum of a particle, i. e., a statistical treatment of quantum mechanics. For the validity of such a treatment it is necessary, in the first place, that $F(q;p)$, non-negative at a given moment of time, should remain non-negative at all later moments, proof of which was given by Bartlett (see Moyal [2]). However, in a recent work [3] it was correctly shown that F in general does not preserve its sign with the passage of time. From this follows the conclusion of the invalidity of the quantum mechanical treatment given by Moyal.

It is necessary only to point out Bartlett's error. Bartlett supposed that a quantum system possesses a cyclic coordinate θ (it is obvious that it is always possible formally to incorporate into a given system an additional cyclic degree of freedom). He takes the general solution of the time-dependent equation for such a system in the form

$$F(q,\theta;p,g)=\sum_{\mu}e^{i\mu(t+\theta/\omega)}F_{\mu}(q;p,g), \qquad (3)$$

where g and ω are the cyclic momentum and frequency; and F_{μ}, certain constant functions. It is clear that if $F>0$ at a certain t and arbitrary θ, it will still be >0 at an arbitrary time. The error lies in the fact that the general solution of the time-dependent equation is

$$F(q,\theta;p,g)=\sum_{\mu_1\mu_2}e^{i\mu_1t+i\mu_2\theta}F_{\mu_1\mu_2}(q;p,g). \qquad (4)$$

Therefore Bartlett's discussion necessarily applies only to a narrow class of solutions which actually preserve sign.

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The Fermi Theory of Multiple Particle Production in Nucleon Encounters

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IN calculating the statistical weights of various states, Fermi [1] applied the law of conservation of energy in exact form, but the law of conservation of momentum only in approximate form. The purpose of the present work is the exact application of the law of conservation of momentum for two limiting cases: the non-relativistic limit