CONCERNING THE ROTATION OF HELIUM II NEAR THE λ POINT

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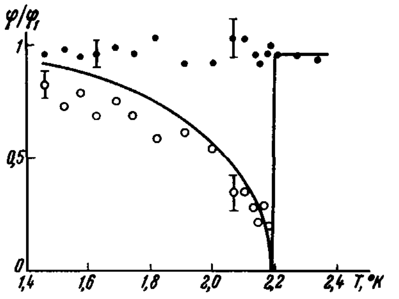
While measuring the deflection of a Rayleigh disc in rotating liquid helium, Pellam[1,2] observed that the effect has a temperature dependence (curve in Figure) producing a rather strange impression: the helium I participates fully in the rotation, but only the superfluid component of helium II rotates. This interpretation of the experimental data was so contradictory to the existing views on the nature of rotation of helium that Pellam, refraining from decisive conclusions, carried out a series of additional measurements [3], but found no satisfactory solution to the problem.



We have called attention to the fact that in Pellam's experiment the Rayleigh disc served simultaneously as the mirror used to measure the deflection by reflecting a light ray. This was unavoidably accompanied by addition of energy to the helium II, giving rise to convection currents that distorted the velocity field of the rotating helium II. These currents, as in the case of the fountain effect, should be specially intense just in the vicinity of the λ point, where the maximum discrepancy between the results and those obtained in helium II occurs.

We have therefore repeated Pellam's experiment, using an instrument essentially similar to his, but in which the Rayleigh-disc deflection could be measured with light reflected not only from the disc itself but also from a mirror located outside the liquid.

The Rayleigh disc employed was a thin rectangular mirror 0.46 mm thick, measuring 7.9 x 4.0 mm.

Our data, pertaining to helium rotation up to 5 rpm, are shown in the Figure in the form of light circles for the case when the Rayleigh disc was illuminated, and full circles, denoting the results obtained by illuminating the mirror located outside the liquid. φ is the disc deflection and φ_1 the average deflection measured by illumination of the upper mirror.

When the Rayleigh disc was illuminated in the stationary instrument near the λ point, a weak deflection was observed in a direction opposite to that of the rotation.

Thus, the assumption that Pellam's paradoxical result is caused by heat currents due to the illumination of helium II has been fully confirmed. There remains no doubt that near the λ point the liquid helium II rotates, on the average, as a unit. It seems to us, however, that the phenomena occurring when the vessel with rotating helium II and the body immersed in it are illuminated deserve a more detailed study.

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THE ROLE OF THE ANISOTROPY OF SCATTERING IN TELLURIUM

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The bulk of the experimental data on annealed tellurium single crystals at low temperatures points to the conclusion that the equal-energy surface of the hole carriers is an ellipsoid of revolution whose axis coincides with the threefold axis and whose center is at $k = 0$ [1,2]. Recently Mendem and Dexter [3] measured the effective masses of the holes in tellurium, confirming such a model, and obtained values $m_1 = m_2 = 0.126m_0$, and $m_3 = 0.24m_0$, i.e., $m_{11}/m_{33} = 0.525$. In such a model we have $\sigma_{33}/\sigma_{11} = m_{11}/m_{33}$ for isotropic scattering. From galvanometric measurements at 4.2°K, they obtained for pure tellurium single crystals $\sigma_{33}/\sigma_{11} = 1.3 \pm 0.1$ which leads to $m_{11}/m_{33} \simeq 1.3$, assuming isotropic scattering. The reason for this apparent contradiction lies in the fact that anisotropy of scattering is expected in tellurium. Then, under the condition that we can introduce the relaxation-time tensor [4], we have

$$\frac{\sigma_{33}}{\sigma_{11}} = \frac{\langle \tau_{33} \rangle}{\langle \tau_{11} \rangle} \cdot \frac{m_{11}}{m_{33}} . \tag{1}$$

The anisotropy of the scattering of holes by ionized impurities in tellurium is connected both with the anisotropy of the carrier energy spectrum and with the dielectric constant anisotropy which leads to anisotropy of the scattering potential itself. The theory of galvanomagnetic effects for arbitrary scattering anisotropy was developed in [5,6]. It was shown in [5] that for the scattering of carriers by ionized impurities in a uniaxial crystal one can introduce the so-called "current" relaxation-type tensor, the components of which determine the electric-conductivity tensor

$$\sigma_{ii} = \frac{e^2 n \langle \tau_{ii} \rangle}{m_{ii}}.$$

Following [5] we can obtain, given a single-ellipsoid model of the equal-energy surface and an anisotropic dielectric constant, approximate expressions for τ_{33} and $\tau_{11} = \tau_{22}$. In the case when $m'_{33} > m'_{11} = m'_{22}$, where $m'_{ii}\kappa_{ii}$, and κ_{ii} are the components of the dielectric tensor, we have