EFFECTIVE MUTUAL FRICTION BETWEEN THE SUPERFLUID AND NORMAL COMPONENTS OF HeII ALONG ITS AXIS OF ROTATION

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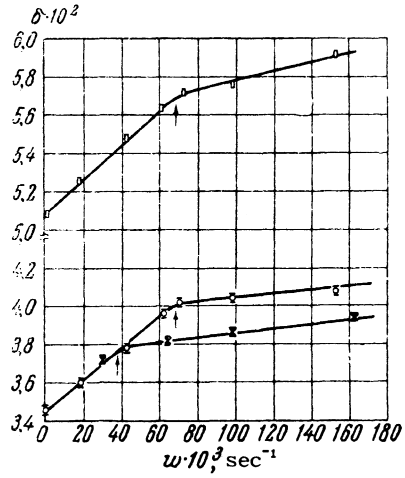
Waves traveling along vortex lines cause them to become distorted. In contrast to the case in which the normal component moves along a straight vortex line, which yields a zero value for the mutual friction, flow of the normal component along a distorted vortex line gives rise to a non-zero mutual friction between the two components. Data are presented on measurements of this quantity, and on the conditions for artificial generation of waves.

WE have previously shown [1] that mutual friction does not arise between the superfluid and normal components of rotating He II as they move relative to one another along vortex lines. The mutual friction coefficient was found in this case to be zero to within an accuracy of ± 0.025.

An effective mutual friction along the axis of rotation could arise in the event of distortion of the vortex lines by transverse waves traveling along them. The sensitivity of the apparatus employed in [1] was, however, insufficient to detect the small effect due to intrinsic (zero-point and thermal) oscillations in the vortices. It nevertheless proved possible for us to study this phenomenon using artificially-generated waves.

For this purpose, using the same apparatus, a roughened disk, set into torsional oscillation at frequencies Ω_1 of 0.619 and 0.336 sec^{-1}, was placed below a cylinder oscillating vertically in He II along its axis of rotation. The cylinder thus oscillated along vortices which were distorted by transverse waves running along them. Under these conditions the damping of the oscillations (measured by the method described in [1,2]) was found to depend upon the rate of rotation. According to Mamaladze [3], this indicates the presence of mutual friction along the axis of rotation.



Dependence of the damping of vertical oscillations of a hollow cylinder upon rotational velocity with vortex lines artificially distorted. Curve $1 - \Omega_1 = 0.619$ sec^{-1}, T = 1.80° K; curve $2 - \Omega_1 = 0.619$ sec^{-1}, T = 1.58° K; curve $3 - \Omega_1 = 0.336$ sec^{-1}, T = 1.58° K. In all cases, the frequency of the vertical oscillations $\Omega = 0.311$ sec^{-1}. Arrows indicate the location of the points at which the curves begin to fall off, in accordance with Eq. (1).

The experimental results are shown in the figure. It is noteworthy that the change in slope in each of the curves takes place near a value for the rotational velocity:

$$\tilde{\omega}_0 = \tfrac{1}{2}\,\Omega_1/(1 + 4\nu_s m/\pi\hbar) \qquad (1)$$

($\nu_s = 8.5 \times 10^{-4}$ cm^2/sec, m is the mass of the helium atom), at which the vortex oscillations become collectivized (i.e., the effective radii over which the superfluid oscillates with the individual vortices begin to overlap). As is well known [4], the slippage of the vortices along the surface of the disk generating the oscillations increases sharply at this point, which results in a reduction in the amplitude of the wave travelling along a vortex line. This will lead to a diminution of the mutual friction, i.e., to a reduction in the slope of the curve.

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[1] D. S. Tsakadze, JETP **42**, 985 (1962), Soviet Phys. JETP **15**, 681 (1962).

[2] D. S. Tsakadze and K. B. Mesoed, Trudy Instituta fiziki AN Gruz.S.S.R. (Trans. Physics Institute, Acad. Sci., Georgian S.S.R.) **7**, 37 (1961).

[3] Yu. G. Mamaladze, JETP **39**, 859 (1961), Soviet Phys. JETP **12**, 595 (1962).

[4] Andronikashvili, Mamaladze, Matinyan, and Tsakadze, UFN **73**, 3 (1961), Soviet Phys. Uspekhi **4**, 1 (1961).

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