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EFFECT OF ROTATION ON THE DIELECTRIC CONSTANT OF ROTATING HELIUM

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The dielectric constant of He II has been experimentally found to be independent of rotation to 1 part in 10^7, the sensitivity of the measurement, for angular rotation rates up to 12 rad/sec between 1.4 and 2.15°K.

The surprising results reported by Andronikashvili and Tsakadze[1] on the density of rotating He II heightened our interest in a measurement of the effect of rotation on the dielectric constant of He II. Andronikashvili and Tsakadze reported that the density increased with the rotation rate much more than could be accounted for on the basis of the known compressibility of He II. Since the relation between the density and dielectric constant of liquid helium is accurately described by the Clausius-Mosotti equation, the large density increase seen by Andronikashvili and Tsakadze should be accompanied by a correspondingly large increase in the dielectric constant. We have measured the difference in dielectric constant between rotating and nonrotating He II to 1 part in 10^7, and do not find any increase. This implies that the density does not change more than 2 parts in 10^6. Andronikashvili and Tsakadze, on the other hand, report density increases up to 90 parts in 10^6 over the same experimental region.

The measurement was made by monitoring the frequency of a 1.4-MHz tunnel-diode oscillator having a helium-filled capacitor in the tank circuit. The capacitor, the rest of the oscillator circuit, and two temperature-sensing resistors were enclosed in a copper and brass can which was immersed in a temperature-controlled helium bath. Communication to the inside of the can was by means of a thin-walled stainless-steel tube suspended from the Dewar cap. Thus, good thermal contact could be maintained between the inside of the can and the helium bath, and, at the same time, the helium level inside the can was independent of the bath level. Under these circumstances, the frequency of the oscillator was stable to better than 0.1 Hz out of 1.4 MHz. The entire cryostat, including the helium and the nitrogen Dewar, was rotated as a unit in order to minimize changes in the environment of the measuring apparatus.

Two different capacitors were used—one coaxial (2.5 cm diam, 2.7 cm long, and 0.025-cm spacing), the other parallel plate (1.1-cm^2 area, 10^{-3}-cm spacing). The capacitors were mounted with their axes of rotational symmetry along the rotation axis of the cryostat.

Several checks were made to see if the frequency of the oscillator would indeed change if the dielectric constant of the liquid helium changed. In all cases, the system correctly measured the change in dielectric constant. For example, when we condensed helium inside the can at the start of the run, we could see frequency shift as the space between the

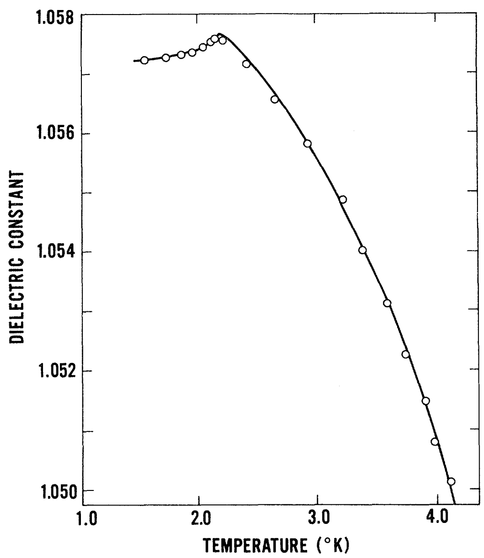

FIG. 1. The dielectric constant of liquid helium versus temperature. The solid curve represents the data of Chase, Maxwell, and Millett. The circles are our data, adjusted downward by 0.03% to fit at 1.4°K. These data are shown only as an example of the response of our system to change in the dielectric constant.

capacitor plates filled with liquid helium. Once the plates were filled, we could then measure the temperature dependence of the dielectric constant of liquid helium. Figure 1 shows the agreement between our values and those of Chase, Maxwell, and Millett.[2]

Rotational measurements were made in two ways: (1) At a given temperature, the cryostat was alternately rotated and held fixed. Starting and stopping rates were widely varied. Rotation was continued as long as 30 min. (2) The cryostat was set into rotation with the temperature above the λ point. It was then cooled down, while rotating, to some temperature below the λ point. Rotation was then stopped and the frequency observed for the next hour.

No measurement indicated any change of the dielectric constant with rotation for rotation rates up to 12 rad/sec over the temperature range from 1.4 to 2.15°K. The sensitivity of this dielectric-constant measurement is 1 part in 10^7 for the coaxial capacitor and 1 part in 10^6 for the parallel-plate capacitor. The corresponding sensitivity for density changes is 2 parts in 10^6 for the coaxial capacitor and 20 parts in 10^6 for the parallel-plate capacitor. Within these limits we saw no evidence for any change in density. In the same region of temperatures and rotation rates, Andronikashvili and Tsakadze report density changes as large as 90 parts in 10^6.

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[1]E. L. Andronikashvili and J. S. Tsakadze, Zh. Eksperim. i Teor. Fiz.—Pis'ma Redakt. 2, 278 (1965) [translation: JETP Letters 2, 177 (1965)]; Phys. Letters 20, 446 (1966); Zh. Eksperim. i Teor. Fiz. 51, 1344 (1966). See also E. L. Andronikashvili and Yu. G. Mamaladze, Rev. Mod. Phys. 38, 614 (1966).

[2]C. E. Chase, E. Maxwell, and W. E. Millett, Physica 27, 1129 (1961).

ABNORMAL DAMPING BY UNSTABLE DISLOCATIONS IN ANISOTROPIC CRYSTALS

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In an elastically isotropic crystal under zero stress, a dislocation segment which runs between two pinning points will have minimum energy when it is straight. This is not necessarily so in an anisotropic crystal if it would place the dislocation in a high-energy orientation.[1] In this case the straight dislocation is unstable and the minimum energy configuration will be a zig-zag with alternate segments parallel to two specific directions. These directions can be predicted from the elastic constants of the crystal. Such zig-zag dislocations have been observed in β brass and their properties agree well with predictions.[2]

For pinning points A, B (Fig. 1), all possible zig-zags lie within the parallelogram formed by the two extreme V-shaped configurations ACB, ADB and all have the same total energy