temperature. Our extensive studies of the effect of thermal history on the relative proportion of forms I and II cannot be accounted for by the explanation due to Wertheim,[15] relating the effect to cation vacancies in CoO. We regard the x-ray determination of only CoO(I) by Triftshäuser and Craig[15] as inconclusive. While Fe^{3+} is stable in CoO(II), and Fe^{2+}, in CoO(I), the observation that the Néel temperature is nearly equal may indicate that these two forms are very similar. Studies are underway to determine if any difference in crystal structure or Néel temperature can be observed for the two forms of CoO, and further experiments are planned on the hydrated compounds at low temperatures.

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He^4 MELTING CURVE BELOW 1°K*

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Using a capacitive method of measuring pressure with a sensitivity of 10^{-4} atm, we have determined the melting curve of He^4 below 1°K. The minimum was found at 0.775°K with an increase in pressure of 7.5×10^{-3} atm on cooling to 0.35°K.

From thermodynamic arguments Goldstein,[1] in 1960, concluded that there should be a slight minimum in the low-temperature He^4 melting curve. In later work[2] calculations placed the minimum at $T \lesssim 1^\circ$K, and 0.052 atm below the melting pressure at 0°K. The basis for the minimum, as given by Goldstein, is that in the solid there are transverse as well as longitudinal phonons, whereas in the liquid there can be only the latter. Thus at low enough temperatures, where phonons are the only type of excitation, the entropy of the solid may be greater than that of the liquid, giving a negative slope to the melting curve by the Clapeyron equation. This prediction has been verified experimentally, although with considerable disagreement in the temperature and depth of the minimum.

Indirect verification was made by Wiebes and Kramers,[3] who observed warming on melting He^4 below 0.76°K. From their measurements, the depth of the minimum, $P(0^\circ\text{K})-P_{\text{min}}$, was computed to be only 0.008 atm, almost seven times less than the predicted value. In a similar experiment, Zimmerman[4] computed an average slope of -0.2 atm/°K between 0.147 and 0.630°K, which would give $P(0^\circ\text{K})-P_{\text{min}}$ greater than that predicted by Goldstein. Sydoriak and Mills,[5] on the basis of calculations using the entropy of melting, place the minimum at $T_{\text{min}} = 0.857^\circ$K, with an increase in the melting pressure of 0.027 atm on cooling 0.6°K. In the only direct measurement, Le Pair et al.[6,7] worked with a pressure sensitivity of only 0.003 atm, resulting in considerable scatter and uncertainty in the location of the minimum and the increase in pressure below the minimum. Although they express confidence in the reliability of their results, they indicate two sources of possible error.

Using a sensitive capacitive strain gauge, we have measured the He^4 melting curve from 1.2 to 0.35°K. The minimum has been observed at 0.775 ± 0.005°K with a subsequent rise in pressure of 7.5×10^{-3} atm on cooling to 0.35°K. In order to determine the melting curve, pressure as a function of temperature was measured for a sample of liquid with a small amount of solid confined in the chamber by a plug of solid He in the filling capillary. This technique was used by Baum et al.[8] to measure the He^3 melting curve below the minimum.

The low-temperature portion of the apparatus is illustrated schematically in Fig. 1. Temperatures down to 0.3°K could be obtained with the He^3 bath. A carbon resistor, calibrated against the He^3 vapor pressure, served as a thermometer. Vapor pressures were measured in the pumping tube, but with the valve to the pump closed to obtain hydrostatic conditions. Accuracy of the temperatures is estimated to be ±0.005°K. A lead heat switch connecting the He^3 bath to the sample chamber allowed the two to be thermally insulated, or brought into equilibrium. The low-temperature portion of the stainless steel filling capillary consisted of a 15-cm length of 0.030-cm i.d., with a 0.025-cm diameter wire inside, thermally anchored to the 1°K He^4 bath, followed by a 30-cm length of 0.020-cm i.d., with a 0.013-cm diameter wire inside, thermally anchored to the 0.3°K He^3 bath. Only about 2 cm of this small capillary separated the sample chamber from the 0.3°K He^3 bath. No difficulty was encountered in maintaining the solid plug in the capillary.

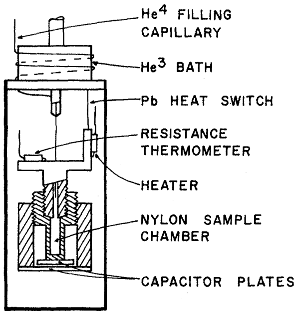

FIG. 1. Schematic drawing of the pressure chamber.

Determination of sample pressure was by means of a capacitive strain gauge consisting of a nylon chamber 1.25 cm long, 0.32 cm inside diameter, and wall thickness of 0.06 cm, with a 0.64-cm diameter capacitor plate attached to the lower end. Separated from this by 0.0025 cm was a fixed capacitor plate, giving a capacitance of about 8 pF, which could be determined to 1 aF using a General Radio Type 1615-A bridge. The resulting smallest detectable change in pressure was 10^{-4} atm.

Calibration of the capacitance as a function of pressure was performed using a dead-weight gauge in the external pressure system. The calibration extended from 0 to 30 atm, with C vs P very nearly linear over this range. The accuracy of the dead-weight gauge was 0.05%; however, other factors in the pressure system limited the absolute accuracy to 0.05 atm, while relative pressures are accurate to 10^{-4} atm, determined by the strain-gauge sensitivity.

There was a slight temperature dependence of the capacitance, which was determined in two ways: Capacitance as a function of temperature was measured with a constant pressure of 24.5 atm supplied by the dead-weight gauge, and the capacitance as a function of temperature was determined with the chamber evacuated. The two methods gave consistent results, but the latter was more reliable since the dead-weight gauge would not maintain a pressure constant to 10^{-4} atm. The temperature effect on the calibration was equivalent to about 7×10^{-3} atm/°K, shown by the dashed straight line of Fig. 2. In converting capacitances to pressure, this was subtracted from the raw data to obtain the melting pressure.

The melting curve from 0.35 to 0.95°K is shown in Fig. 2. The points are for three different samples, each of which was alternately cooled and warmed through the minimum several times. The scatter on a given run was much less than the over-all scatter. Also shown in Fig. 2 are the results of Le Pair et al.[6,7] Together with the slope of the melting curve, dP/dT, smoothed values of $P - P_{\min}$ taken from the curve drawn through our data are tabulated, where $P_{\min} = 24.96$ atm. Goldstein[9] has pointed out that, with the minimum at 0.775°K instead of 1°K, the calculated increase in pressure would be

$$P(0°\mathrm{K}) - P_{\min}(0.775°\mathrm{K}) = 0.052(0.775)^4 = 0.019 \text{ atm},$$

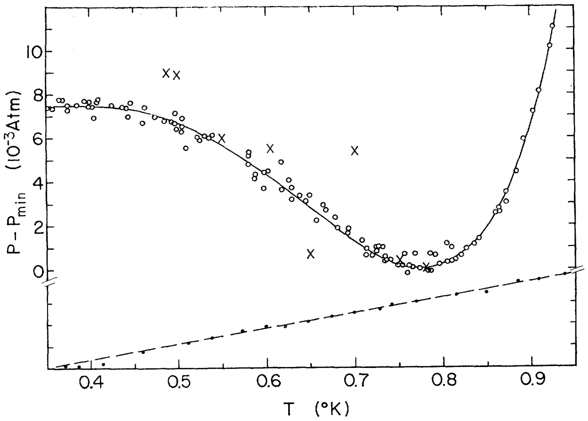

FIG. 2. The He^4 melting curve below 1°K. $P_{\rm min}$ is the minimum pressure of 24.96 atm. Open circles, this work; X's, Le Pair *et al.*[6,7] The dashed straight line is the temperature effect on the capacitive strain gauge which was subtracted from the raw data to obtain the melting curve.

rather than 0.052, which is much closer to the measured value of 7.5×10^{-3} atm.

Each of the samples was prepared by keeping the chamber temperature near 1.2°K, but different in each case, with the filling capillary at ~0.35°K, then increasing the external pressure to about 35 atm. The capillary did not block instantly at $P_{\rm min}$ but near 25.2 atm, about 0.2 atm above $P_{\rm min}$. This procedure gave samples with a very small amount of solid along the melting curve, the freezing temperatures being between 1.19 and 1.32°K, corresponding to molar volumes from about 23.10 to 23.06 cm^3/mole according to the data of Grilly and Mills.[10] Coincidence of the isochores in the P-T plane below 1.19°K indicated that the melting curve was being followed. Several other samples with higher freezing points, and consequently with more solid present, were also studied. For these samples, the minimum could not be reproduced consistently on an absolute scale, being displaced in pressure by $\Delta P \sim 10^{-3}$ atm. The reason for this is not clearly understood, but it is believed that with more solid present the very slight motion of the chamber is inhibited.

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TEMPERATURE DEPENDENCE OF THE CRITICAL VELOCITY OF POSITIVE IONS IN LIQUID HELIUM*

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Measuring the dependence of the mobility of positive ions in liquid helium, Careri, Cunsolo, and Mazzoldi[1] found small periodical discontinuities at velocities which are integral multiples of a characteristic critical velocity, $\langle v_c\rangle$. The interesting phenomenon has been confirmed with two different techniques,[2] and also in another laboratory.[3] In the temperature range investigated (from 0.88 to 1.02°K) the critical velocity, $\langle v_c\rangle$, has the temperature-independent value of 5.2 m/sec. Some tentative explanations have been proposed,[1,4-6] all based on the two essential experimental facts, namely the periodical nature of the phenomenon and the temperature independence of the critical velocity.

We want to point out here that the critical velocity, $\langle v_c\rangle$, is no longer temperature independent above 1.1°K. We have carried out experiments at higher temperatures, and we find