THERMAL EXPANSION COEFFICIENT AND COMPRESSIBILITY OF SOLID He^3†

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Liquid helium has been the object of extensive research for many years, while considerably less attention has been devoted to solid helium. Particularly lacking have been direct measurements of the thermal expansion coefficient and compressibility of solid helium, although theoretical calculations[1-3] and calculations from other data[4,5] have been made. This lack of experimental data is due to the difficulty of measuring accurately the small changes in pressure resulting from changes in temperature of the solid. We report here direct observations of the thermal expansion coefficient and compressibility of solid He^3. The measurements are all in the bcc phase for molar volumes from 22.39 to 24.61 cm^3/mole and over the temperature range from 0.3°K to the melting point.

A capacitance-type strain gauge which permitted observation of changes in pressure on the solid sample of less than 10^{-3} atm was used. The details of the sample chamber and pressure measuring apparatus will be reported elsewhere.[6]

For each sample studied the solid was obtained by applying pressure at a temperature just above the melting point. The filling capillary above the sample chamber was then blocked by quickly cooling it below the melting point, usually to 0.3°K, where it was held during the course of the measurements on a given sample. Observations of pressure versus temperature, made for both decreasing and increasing temperature with up to several hours time lapse between, showed good reproducibility. This indicated that there was negligible slipping of the solid blocking the capillary and very little hysteresis in the strain gauge. For a change in temperature from 0.3°K to the melting temperature the fractional change in pressure was of the order of 1%, while the fractional change in volume due to stretching of the sample chamber was calculated to be of the order of 0.001%. Therefore, for all practical purposes, the process was at constant volume.

To obtain the compressibility, $P(T)$ was measured for various molar volumes. The molar volume for each sample was determined from the intersection of the isochore with the melting curve using the data of Mills, Grilly, and Sydoriak.[4] A plot of V vs P for fixed temperatures was then made, with the slope of these curves determining the compressibility $\beta = -V^{-1}(\partial V/\partial P)_T$. The values of β obtained in this way are shown in Fig. 1. Because of the extremely small temperature dependence of β, only the values at 0.3°K are shown. Data from other sources are shown for comparison. Our results compare reasonably well with those