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THERMODYNAMIC PROPERTIES OF bcc He4

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Publication Date
1968-08-01

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THERMODYNAMIC PROPERTIES OF bcc He^4

J. K. Hoffer, W. R. Gardner, C. G. Waterfield
and N. E. Phillips

August 1968

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Talk to be presented at the
11th International Conference on
Low Temperature Physics in St.
Andrews, Scotland, August 22-29, 1968.

UCRL-18384
Preprint

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Lawrence Radiation Laboratory
Berkeley, California

AEC Contract No. W-7405-eng-48

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0.3°K and the entropy was evaluated. In the two-phase regions the S-V isotherms (see Fig. 2) are straight lines and their slopes give the temperature derivative of the equilibrium pressure. The values of $P-P_0$ in the vicinity of the bcc phase are compared with direct measurements[2,5,6] in Fig. 3. (The data of Ref. 2 have been adjusted by 0.2 atm to correspond to $P_0 = 25.00$ atm.) The relatively large scatter in the direct measurements of the bcc-hcp equilibrium pressure and their poor agreement with the values calculated thermodynamically presumably reflect the difficulty in measuring the equilibrium pressure in a solid-solid mixture. As Fig. 3 shows, the shape of the bcc phase in the P-T diagram obtained in this work differs substantially from that given by the direct measurements. As a consequence, the thermal expansion determined from Figs. 1 and 3, i.e. $\Delta V/\Delta T$ at constant P, is everywhere positive whereas the direct measurements gave

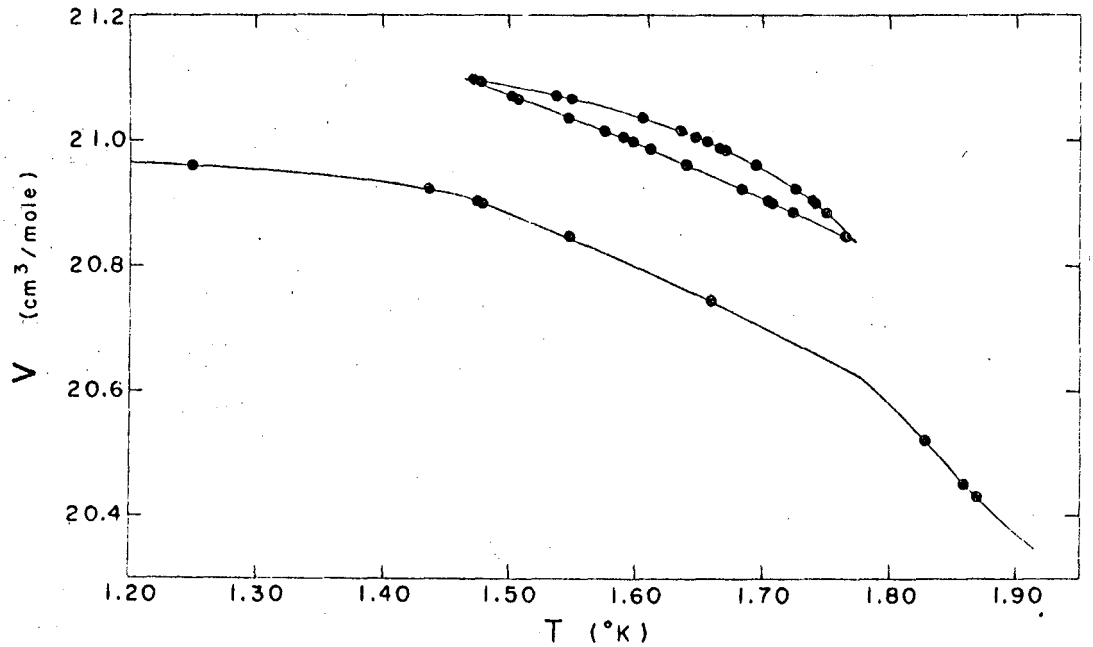

Fig. 1. The V-T diagram of He^4 in the vicinity of the bcc phase.

regions of negative value.[3,5]

The bcc-phase measurements for eleven of the sixteen runs that passed through this phase are presented in Fig. 4 and show that $(\partial C_V/\partial V)_T > 0$. Furthermore, $(\partial S/\partial V)_T$ has normal values (between 2.07 and 2.70 atm/°K) showing that the suggested anomalies do not occur. The expected discontinuous increase of C_V at the melting temperature of the bcc phase is preceded (and at the higher molar volumes obscured) by a rapid but smooth increase beginning 0.02°K lower, which is accompanied by an increase in the thermal relaxation time of the sample. This behavior is independent of the thermal history of the sample and was even observed when the heat capacity points were taken with decreasing temperature (by balancing a negative heat leak with a power input that was interrupted to produce a decrease in sample temperature). There is some theoretical basis[7] for expecting

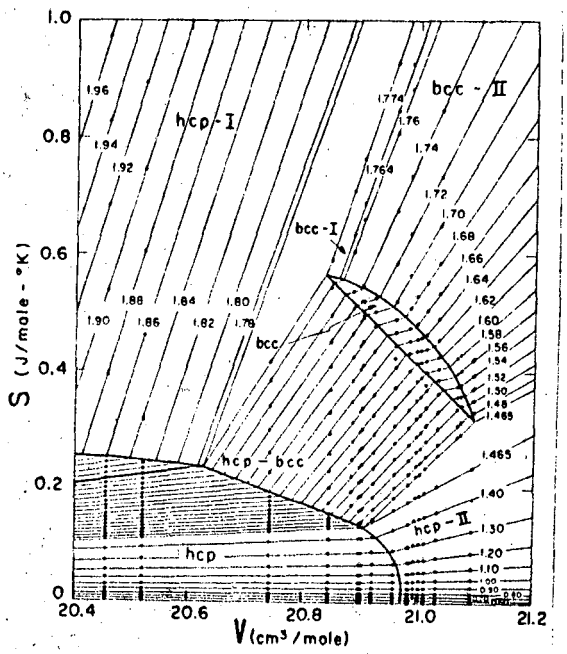

Fig. 2. The S-V diagram of He^4.

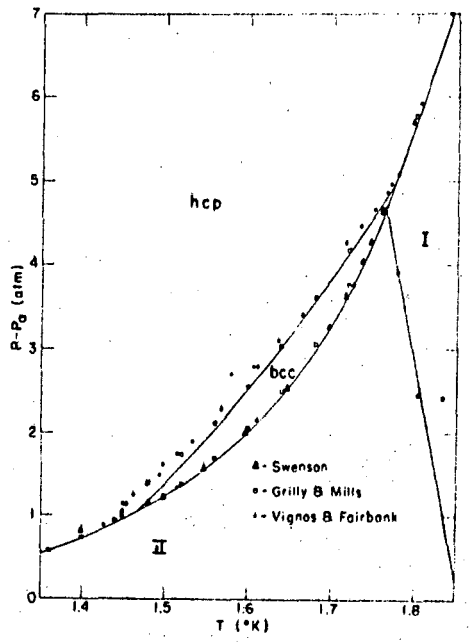

Fig. 3. The P-T diagram.

anomalous thermal properties very close to the melting point and also for expecting them to be more conspicuous in He, and particularly in bcc He, than in most solids.

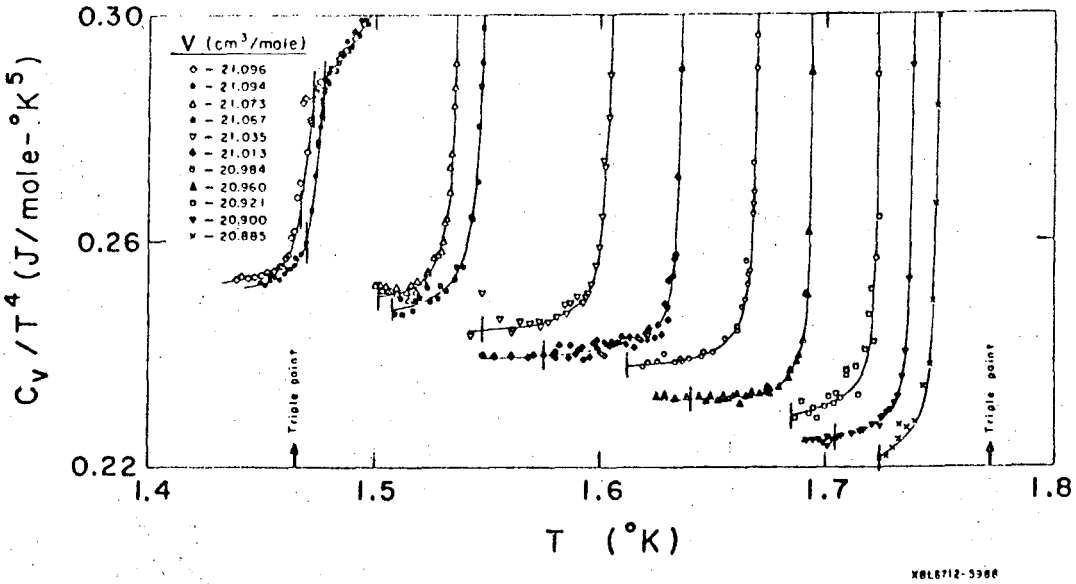

Fig. 4. The heat capacity of bcc He^4. The vertical bars indicate stability limits of the phase.

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