minimizes the free energy.[7]

Since the magnetic susceptibility prediction of the BCS theory does not agree with experiment for very low temperatures, the above calculation can only be considered as valid near the critical temperature. The main point is that an attraction in He^3 in relative d states predicts a rather sharp drop in the susceptibility at the critical temperature. This will not be true if it were an attraction in relative s or f states because in this case the Cooper pairs will be formed from particles with parallel spins, and therefore the susceptibility will be the same as that of the normal fluid at all temperatures.

The magnetic susceptibility has been measured by Wheatley et al.,[8] who find no sharp change down to 0.035 degree. Thus the present experimental evidence does not indicate the existence of a highly correlated low-temperature phase of He^3 above 0.035 degree.

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LIMITING VALUE OF DEBYE TEMPERATURE FOR SUPERCONDUCTING AND NORMAL INDIUM FROM LOW-TEMPERATURE ELASTIC CONSTANTS

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A significant difference between the lattice heat capacity of indium in the superconducting and normal states has recently been reported.[1] Since only long-wavelength phonons are excited in a solid at low temperatures, one would therefore expect a corresponding difference in the elastic properties of indium in the two phases. This note gives the results of elastic constant measurements on superconducting and normal indium. These measurements form part of an extended study of the elastic properties of indium to be reported in detail later.

The elastic constants were measured, using the usual ultrasonic pulse technique,[2] on single crystals grown from 99.999% pure indium. By observing a distant echo on an expanded delayed sweep, any change in transit time could be measured to an accuracy of about 1 part in 2×10^4, i. e., a change in the associated elastic constant of about 1 part in 10^4 could be detected. At 1.4°K the change in transit time for every propagation mode was less than the above limit of detectability, when the samples were taken from the superconducting to normal state by applying a quenching field of 800 oersteds. Thus the difference between the values of any elastic constant of indium in the two phases is less than 1 part in 10^4. This result is consistent with the much smaller change in elastic constants on going from the superconducting to normal phase predicted thermodynamically. Such a change, of the order of 1 part in 10^6, has been observed in lead and tin.[3] Now it has been shown that in many metals,[4] and particularly tin,[5] there is excellent agreement between the lattice heat capacity computed from the elastic constants extrapolated to 0°K and that measured calorimetrically. It is therefore felt that the present results show that the difference in lattice heat capacity between normal and superconducting indium is less than 1 part in 6×10^3.

The values of the elastic constants of indium, extrapolated to 0°K, are $c_{11}=5.39$, $c_{12}=3.87$, $c_{13}=4.51$, $c_{33}=5.16$, $c_{44}=0.797$, and $c_{66}=1.68$,

all in units of 10^{11} dyne cm^{-2}. From these data, the limiting value of Debye temperature θ for indium was calculated numerically by the method described elsewhere.[5] The value obtained is

$$\theta = 111.3^\circ\text{K}, \quad (1)$$

with an estimated uncertainty about one percent.

At sufficiently low temperatures, the heat capacity of superconducting indium can be expressed as

$$C_s = \alpha_s T^3 + C_q, \quad (2)$$

where C_q is the nuclear quadrupole heat capacity. Thus a plot of $(C_s - C_q)/T$ versus T^2 should be a straight line through the origin. Such a plot obtained from the calorimetric data[1] is shown in Fig. 1. The straight line through the origin has been drawn to give a slope corresponding to the value of Debye temperature obtained above. A parallel line has been drawn through the normal state points. It can be seen that this latter line gives a good fit to the data below about 0.7°K; the corresponding value of the coefficient of the electronic heat capacity is $\gamma = 1.65$ millijoule mole^{-1} deg^{-2}. At low temperatures the calorimetric data in the superconducting state lie considerably below the computed line. The discrepancy is well outside the estimated uncertainty in the slope of the latter. The calorimetric data for $T > 0.7$°K doubtless include an electronic contribution. Bryant and Keesom[1] state that below this temperature the electronic term is negligible; even if this were not strictly correct, the discrepancy between the lattice heat capacity computed in the present work and that measured calorimetrically would only be greater. No reasonable explanation of this discrepancy can be advanced.

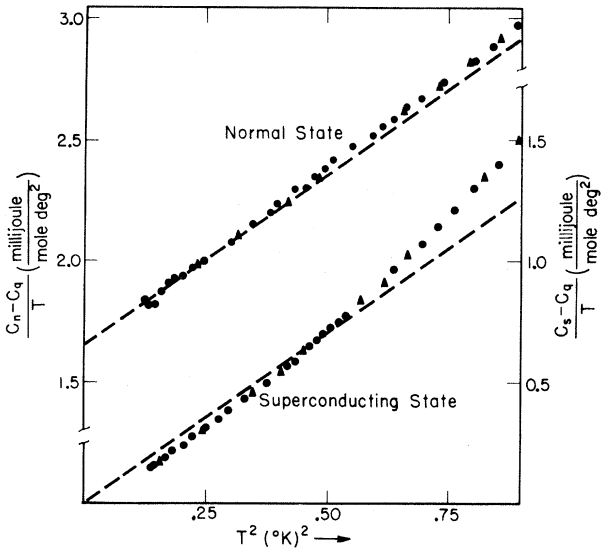

FIG. 1. A plot of $(C_n - C_q)/T$ and $(C_s - C_q)/T$ versus T^2, from reference 1. The broken straight lines are drawn with a slope corresponding to $\theta = 111.3$°K.

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RESOLVED HYPERFINE SPECTRA OF ELECTRON-SPIN PARAMAGNETIC RESONANCE IN IRRADIATED LiF†

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Recently, Holton, Blum, and Slichter[1] reported on the resolved hyperfine spectra of the electron-spin paramagnetic resonance (ESPR) absorption of F centers in x-irradiated single crystals of LiF. Their spectra are nearly Gaussian in shape with a width (ΔH) of 85 ± 10 gauss from peak to center of the derivative of the ESPR absorption curve. The center of resonance (H_0) of each spectrum corresponds to $g = 2.0006 \pm 0.0006$. The resolved hyperfine lines, 35 in number, are uniformly spaced, the spacing being approximately 14 gauss when the magnetic field (H) is parallel to a [100] axis or a [111] axis of the sample. No variation of the spacing with orientations of the samples in the magnetic field was reported. Further, Holton et al.[1] measured, by means of electron-nuclear double resonance, the hyperfine coupling constants of the F-center