COMMENTS AND ADDENDA

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Fermi-Liquid Transport Coefficients of Dilute Solutions of He^3 in He^4: An Addendum

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Using recent exact solutions of the quasiparticle transport equation, we have reexamined the consistency between Bardeen, Baym, and Pines's phenomenological theory of dilute solutions of He^3 in He^4 and measurements of the spin-diffusion and thermal-conductivity coefficients of two solutions in the degenerate Fermi-liquid regime. Previously, Baym and the author had used lowest-order variational solutions for this purpose. Discrepancies of 10–15% persist which, beyond experimental uncertainty, must be attributed to oversimplification in treating the He^3 scattering amplitudes as being independent of spin, velocity, and concentration.

This paper is intended to bring up to date a recent paper by Baym and Ebner[1] (BE) in which it was demonstrated that the phenomenological theory of dilute solutions of He^3 in He^4 as given by Bardeen, Baym, and Pines,[2] is consistent with experimental determinations of the thermal-conductivity[3] and spin-diffusion[4] coefficients of 1.3 and 5.0% systems if simple variational solutions of the transport equation are used to relate the He^3-He^3 effective interaction to the transport coefficients. Previously, the approximate solutions of Abrikosov and Khalatnikov[5] and of Hone[6] had been used for this purpose.

More recently, exact analytical solutions of the transport equation have been determined by Brooker and Sykes[7] and independently by Jensen and co-workers.[8] Using the exact results of Brooker and Sykes, we have repeated the calculations reported in (BE). That is, we begin by assuming that $V(k)$, the Fourier transformed He^3-He^3 effective interaction, may be expanded in powers of k^2 with undetermined coefficients which are chosen by attempting to fit the experimental transport coefficients. In so doing, $V(k)$ is allowed to be only reasonably rapidly varying. A typical result of this procedure is the interaction

$$V(k) = V_0(1 - 3.389y + 6.353y^2 - 9.576y^3 + 5.402y^4), \tag{1}$$

where $y = (k/2k_0)^2$; k_0 is the Fermi momentum of a 5.0% solution of He^3 in He^4, $k_0/\hbar = 0.318$ Å^{-1}; and $V_0 = -0.078\ m_4s^2/n_4$. The mass of a He^4 atom is m_4 and the speed of first sound and the number density in pure He^4 at $T = 0$ are s and n_4, respectively. Figure 1 shows this $V(k)$ and also the interaction found in BE as well as the original interaction of Bardeen, Baym, and Pines.[2] As can be seen, $V(0)$ is close to the original value of Ref. 2; it is also very close to the value deduced by Baym[9] from thermodynamic arguments, which is $V(0) = \alpha^2 m_4 s^2/n_4 \cong -0.077 m_4 s^2/n_4$; α is the fractional excess molar volume of He^3 in He^4.

The present $V(k)$ shows different behavior from

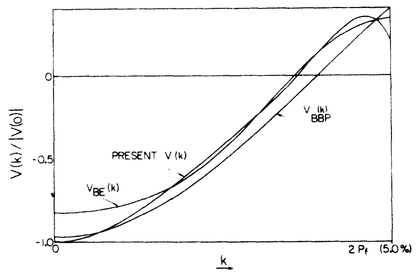

FIG. 1. The effective interaction $V(k)$, as given by Eq. (1) in the text, plotted in units of $|V(0)| = 0.078 m_4 s^2 / n_4$, $V_{BE}(k)$ and $V_{BBP}(k)$ are the interactions of Refs. 1 and 2, respectively.

previous interactions at large k. This effect is very sensitive to the relative input values of the spin-diffusion and thermal-conductivity coefficients at 5%, and may not be significant.

A more interesting implication, we feel, may be noted from Table I, which compares the fit obtained from the interaction (1) with that obtained from the interaction of BE. The fit of the earlier interaction, obtained using approximate solutions to the transport equation, is in fact somewhat better than the present fit. We conclude then that the 10–15% discrepancy between the phenomenological theory and experimental transport coefficients persists even given exact solutions of the transport equation. Beyond experimental uncertainty, this must be attributed to oversimplification in treating the quasiparticle scattering amplitude as being concentration- and velocity-independent.

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TABLE I. Experimental and calculated values of κT (erg/sec-cm) and DT^2 (cm^2-°K^2/sec) for 1.3% and 5.0% He^3 concentrations. The calculated values denoted (BE) were determined in BE; the others, from the present $V(k)$, Eq. (1).

	κT (1.3%)	κT (5.0%)	DT^2 (1.3%)	DT^2 (5.0%)
Experiment	11	24	17.2×10^{-6}	90×10^{-6}
Calculated from $V_{BE}(k)$	10	26	18.6×10^{-6}	82×10^{-6}
Calculated from present $V(k)$	9.6	27	18.6×10^{-6}	80×10^{-6}

[1]G. Baym and C. Ebner, Phys. Rev. 170, 346 (1968).
[2]J. Bardeen, G. Baym, and D. Pines, Phys. Rev. Letters 17, 372 (1966); Phys. Rev. 156, 207 (1967).
[3]W. R. Abel, R. T. Johnson, J. C. Wheatley, and W. Zimmermann, Jr., Phys. Rev. Letters 18, 737 (1967).
[4]A. C. Anderson, D. O. Edwards, R. Roach, R. E. Sarwinski, and J. C. Wheatley, Phys. Rev. Letters 17, 367 (1966).
[5]A. A. Abrikosov and I. M. Khalatnikov, Rept. Progr. Phys. 22, 329 (1959).
[6]D. Hone, Phys. Rev. 121, 669 (1961).
[7]G. A. Brooker and J. Sykes, Phys. Rev. Letters 21, 279 (1968).
[8]H. Højgard Jensen, H. Smith, and J. W. Wilkins, Phys. Letters 27A, 532 (1968).
[9]G. Baym, Phys. Rev. Letters 17, 952 (1966).