1989

Pair breaking edge in superfluid ^{3}He

Shireen Adenwalla
University of Nebraska-Lincoln, sadenwalla1@unl.edu

Z. Zhao
Northwestern University

J. B. Ketterson
Northwestern University

B. K. Sarma
University of Wisconsin - Milwaukee

.

Pair breaking edge in superfluid ^{3}He

S. Adenwalla, Z. Zhao, and J. B. KettersonB. K. Sarma

Citation: AIP Conference Proceedings **194**, 107 (1989); doi: 10.1063/1.38815
View online: http://dx.doi.org/10.1063/1.38815
View Table of Contents: http://aip.scitation.org/toc/apc/194/1
Published by the American Institute of Physics

PAIR BREAKING EDGE IN SUPERFLUID ^{3}He

S. Adenwalla, Z. Zhao, and J.B. Ketterson
Northwestern University
Evanston, Illinois 60208

B.K. Sarma
University of Wisconsin-Milwaukee
Milwaukee, Wisconsin 53201

We present the first direct, systematic measurements of the superfluid energy gap in the B-phase of ^{3}He. We compare our measurements to the predictions of the weak-coupling-plus model.[1] The comparison depends on the temperature scale used; however weak-coupling theory does not provide an accurate description for either temperature scale. We find the best agreement occurs if we use a combination of the Greywall temperature[2] scale and the weak-coupling-plus model[1] for the gap.

We have measured the pair-breaking edge, 2Δ, using a c.w., single-ended impedance technique, and alternate presssure and temperature sweeps, described elsewhere.[3] The acoustic cell contains two transducers separated by 190.5 μm and thus the round trip path length is 381 μm. Experiments were performed up to the 13th harmonic of our 12.79 MHz fundamental transducer (167 MHz). We used an LCMN thermometer mounted above the acoustic cell out of the field of the demagnetization magnet.[3] To analyze our data, we used the temperature scale, and the values for $\Delta C/C_N$ as a function of pressure, reported by Greywall.[2]

A typical temperature (pressure) trace is shown in Fig. 1. As we cool into the superfluid, there is a step in the impedance at T_c. Below T_c, the attenuation is high due to damping by the pair breaking mechanism and continues to increase as we cool. At a temperature T_{PB}, where $h\nu = 2\Delta(T_{PB})$, the sound attenuation decreases abruptly and we observe the onset of oscillations due to the presence of standing waves in the cell. (The oscillations are caused by changes in the sound velocity with temperature or pressure and can only appear when the attenuation is low enough that the returning (reflected) wave can cause a measurable shift in the transducer response.) The point at which the oscillations appear (implying the presence of a standing wave pattern in the cell, and hence a sudden decrease in attenuation) is taken as the pair-breaking edge, 2Δ.

In Fig. 2, we have plotted our data for the pair-breaking edge in the pressure-temperature plane. The curves are plotted for the frequencies at which data were taken using both Δ_{BCS} and Δ^+, the weak-coupling-plus model of Rainer and Serene.[1] Our data appear to lie between the two curves, but are much closer to the Δ^+ curves. The scatter in our data is chiefly due to our thermometry.

For the pair-breaking edge, the coefficient of the gap, a, (in the expression $h\nu = a\Delta$) must be 2. We have calculated the coefficient for all our data points using both the Helsinki temperature scale[4] and the Greywall temperature scale[2] and find that, if our data points are to cluster around 2, it is necessary to use both the Greywall temperature scale and the weak-coupling-plus gap. These results provide an indirect confirmation of the Greywall temperature scale. The weak-coupling-plus model appears to work well; however, the "center of gravity" of our points appears to be slightly less than 2, which would imply that the weak-coupling-plus gap tends to over-estimate the strong-coupling effects. This can be seen clearly in Fig. 2 (especially for the 141 MHz data) in which our data points lie close to, but not on, the line calculated using the weak-coupling-plus gap.

Acknowledgements: We are grateful to J.A. Sauls for providing the computer program for the weak-coupling-plus gap and to D.W. Hess for useful conversations. This work is supported by NSF grant DMR 86-02857 at Northwestern University and the Office of Naval Research at the University of Wisconsin-Milwaukee.

REFERENCES

1. D. Rainer and J.W. Serene, Phys. Rev. B13. 4745 (1976).
2. D. Greywall, Phys. Rev. B33, 7520 (1986).
3. S. Adenwalla, Z. Zhao, J.B. Ketterson and B.K. Sarma, JLTP, 76 (to be published).
4. T.A. Alvesalo, T. Haavasoja, M.T. Manninen and A.T. Soinne, Phys. Rev. Lett., 44, 1076 (1980).

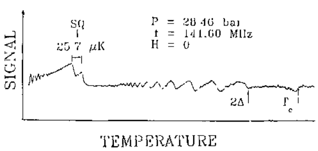

Fig. 1 Typical temperature (pressure) sweep. For details, see text.

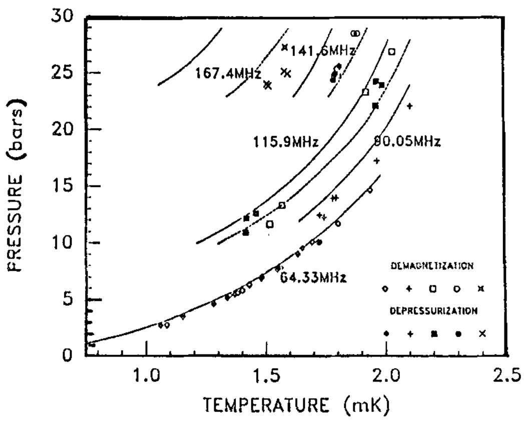

Fig. 2 Pair breaking edge in the pressure-temperature plane. The solid curves correspond to $2\Delta_{BCS}$ and the dashed curve to $2\Delta^{+}$ for each frequency.