scattering of neutrons by NaH crystals.[11] Investigations along this line are in progress in this department. A more detailed account of the present work may appear elsewhere.

It is our pleasure to thank Professor Massey and Dr. Burhop for their interest in this work. We are much indebted to Miss K. Blunt for solving the simultaneous differential equations necessary for the calculation of the phases of the coupled states. Thanks are due to Mr. Yadav for his assistance in the calculation of the angular distribution for the exponential-well case.

* This type of interaction was first suggested by Serber.

[1] M. Camac and H. A. Bethe, Phys. Rev. **73**, 191 (1948).
[2] Barker, Nature **161**, 726 (1948).
[3] J. Ashkin and T. Wu, Phys. Rev. **73**, 973 (1948).
[4] G. F. Chew and M. L. Goldberger, Phys. Rev. **73**, 1409 (1948).
[5] Massey, Burhop and Hu, Phys. Rev. **73**, 1403 (1948).
[6] Burhop and Yadav, Proc. Roy. Soc. (in press).
[7] Massey and Hu, Proc. Roy. Soc. (in press).
[8] Reported in the Birmingham Conference by R. L. Thornton, (1948).
[9] Wilson, Lofgren, Richardson, Wright, and Shankland, Phys. Rev. **72**, 1131, (1947).
[10] Sutton, Hall, Anderson, Bridge, DeWire, Labatelli, Long, Snyder, and Williams, Phys. Rev. **72**, 1147 (1947).
[11] Shull, Wollan, Morton, and Davidson, Phys. Rev. **73**, 842 (1948).

Comparison of the Flow of Iostopically Pure Liquid He^3 and He^4

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IN order to determine whether liquid He^3 has a transition to a superfluid state such as that exhibited by liquid He^4, the isothermal flow of isotopically pure liquid He^3 through a narrow channel or superleak has been studied from 3.02°K (0.18° below the normal boiling point[1,2]) to 1.05°K. The rate of flow of liquid He^3 was observed to decrease monotonically as the temperature was lowered. In contrast, the rate of flow of liquid He^4 through the same channel was observed to decrease as the temperature was lowered, until the lambda-point (2.19°K) was reached, and below this point the rate rose very sharply. The mass rate of flow of the two isotopes as a function of temperature is shown in Fig. 1. From these results it is clear that no superfluid transition occurs in He^3 down to 1.05°K.

The He^3 used in this experiment was obtained from the decay of tritium gas which had been initially freed from helium by passage through a palladium valve. After sufficient He^3 had grown in by decay, the bulk of the tritium was removed from it by means of a palladium valve, and the residual tritium was then removed by circulating the He^3 through a U-tube immersed in liquid helium. No He^4 was detected in a spectrographic analysis of the sample (kindly performed by Mr. J. K. Brody). The limit of detection was estimated to be 0.1 percent.

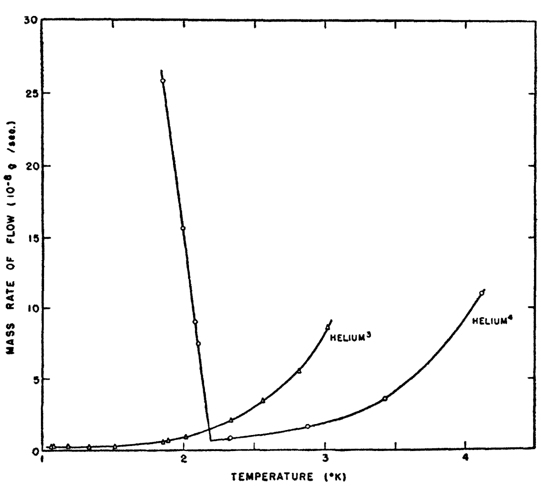

FIG. 1. Mass rate of flow of liquid He^3 and of liquid He^4 through a 7×10^{-5} cm annulus, as a function of temperature.

The experiment was similar to that which Giauque, Stout, and Barieau[3] performed to measure the viscosity of liquid He^4. The superleak was constructed by shrinking 0.05-cm i.d. Pyrex glass capillary around a platinum wire 0.013 cm in diameter and 5.5 cm long. On cooling, a narrow channel was formed due to the difference in the coefficients of expansion of the two materials. By measuring the rate of flow of He^4 gas through the leak at 4.22°K and at various pressures and by using the known viscosity[4] and virial coefficients[5] of He^4 gas, the width of the annulus was estimated to be 7×10^{-5} cm. The whole assembly was in the shape of long U-tube, which was supported vertically in the liquid helium cryostat, with the superleak near the bottom of one leg. The upper part of the superleak was connected to the filling system with 0.05-cm i.d. capillary. The other leg of the U-tube was expanded from 0.05-cm to 0.20-cm i.d. above the helium bath level and went to the measuring system. To make a measurement, liquid He^3 or He^4 was condensed on top of the leak until a liquid height of a few mm was observed. The material that flowed through the superleak expanded into an 1100-cc volume, and the rate at which the pressure developed was observed with a Pirani gauge. A mercury diffusion pump was used to exhaust the measuring system prior to each rate measurement. The exhaust gas from the diffusion pump was fed back to the filling system by means of a Toepler pump.

Other experimenters[6-10] have looked for superfluidity of He^3 by studying transport properties of dilute solutions of He^3 in He^4 at temperatures down to 1.5°K. However, as has been pointed out elsewhere,[6,11] the absence of a superfluid state of He^3 can be demonstrated only by studies of the pure liquid. The present experiment with the pure liquid has demonstrated that there is no superfluid transition in He^3 down to 1.05°K, but the question remains as to whether this temperature is sufficiently low. In this connection, it should be noted that the lambda-transition of He^4 occurs at 0.52 times the normal boiling point, and that the vapor pressure at the lambda-point is 38.3 mm; whereas in this experiment no lambda-transition was observed in He^3 down to a temperature which is 0.33 times the normal boiling point, where the vapor pressure is 11 mm.[2] In any case, the experimental results lend support to the hypothesis that the lambda-transition of He^4 is due to Boise-Einstein statistics.

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[1] S. G. Sydoriak, E. R. Grilly, and E. F. Hammel, Phys. Rev. **75**, 303 (1949).
[2] Abraham, Osborne, and Weinstock, unpublished results.
[3] W. F. Giauque, J. W. Stout, and R. E. Barieau, J. Am. Chem. Soc. **61**, 654 (1939).
[4] A. Van Itterbeek, and W. H. Keesom, Commun. Leiden No. 252a; Physica's Grav. **5**, 257 (1938).
[5] W. H. Keesom, *Helium* (Elsevier Publishing Company, Amsterdam, Inc., 1942), p. 49.
[6] Daunt, Probst, Johnston, Aldrich, and Nier, Phys. Rev. **72**, 502 (1947).
[7] J. G. Daunt, R. E. Probst, and H. L. Johnston, J. Chem. Phys. **15**, 759 (1947).
[8] Lane, Fairbanks, Aldrich, and Nier, Phys. Rev. **73**, 256 (1948).
[9] J. G. Daunt, R. E. Probst, and H. L. Johnston, Phys. Rev. **73**, 638 (1948).
[10] J. G. Daunt, R. E. Probst, and S. R. Smith, Phys. Rev. **74**, 495 (1948).
[11] L. Landau and I. Pomeranchuk, Comptes Rendus, U. S. S. R. **59** (No. 4) 669 (1948).

Yields of Some Photo-Nuclear Reactions

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IT has been shown that in the neighborhood of mass number 60 a transition occurs in the relative yield values for the