

### A New Isotopic Effect in Liquid Helium\*

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IN continuing experiments<sup>1,2</sup> on the behavior of the rare isotope He<sup>3</sup> in the liquid phase, gas containing varying initial concentrations of He<sup>3</sup> has been employed and a new effect found, a preliminary notice of which may be of interest.

In effecting the filtration of He<sup>3</sup> by superfluid flow through supra-surface films, an isothermal technique has been employed in addition to the thermomechanical method previously reported.<sup>1</sup> This technique is illustrated in Fig. 1. The apparatus consisted essentially of an inverted U-tube, in one limb of which was placed a constriction, namely, a ground-glass plug, serving to prohibit the flow of vapor while allowing the free flow of liquid through the supra-surface film. At the bottom of each limb copper end caps were attached at "s-s," through which gas could be introduced via the tubes a and b. This whole apparatus was immersed in liquid helium II.

In a typical run helium gas<sup>3</sup> having an initial concentration of He<sup>3</sup>/He<sup>4</sup> =  $2.4 \times 10^{-5}$  was condensed in the right-hand limb at 1.57°K. After a period of waiting, liquid flowed through the supra-surface film past the constriction into the left-hand limb isothermally and equilibrium was finally reached with the right-hand level remaining 2.1 mm above the left-hand level.

In order to decide whether this difference in levels constituted a real effect, rather than being due to temperature inhomogeneity (the mechano-caloric effects in liquid helium II being very large<sup>4</sup>) the experiments were repeated using "gas-well" helium under otherwise identical

conditions. The known concentration<sup>5</sup> of He<sup>3</sup>/He<sup>4</sup> in gas-well helium is  $1.6 \times 10^{-7}$ ; and with this *no* equilibrium difference in levels was observed.

Assuming the flow through a supra-surface film prohibits the passage of He<sup>3</sup>,<sup>1</sup> the differences in the levels observed in these experiments with the higher concentrations could be explained as the manifestation of an osmotic pressure of He<sup>3</sup>, the supra-surface film acting as a semi-permeable membrane. Considerable care, however, must be taken in this interpretation, since as yet no satisfactory measurements of the relative concentration of He<sup>3</sup> (using initial concentrations of the order of  $3 \times 10^{-5}$ ) in the vapor phase above liquid helium II are available. Such experiments are now being carried out. A discussion of the complete behavior of solutions of He<sup>3</sup> in He<sup>4</sup> is therefore postponed until this information is obtained.

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<sup>1</sup> J. G. Daunt, R. E. Probst, J. L. Johnston, L. T. Aldrich, and A. O. Nier, *Phys. Rev.* **72**, 502 (1947).

<sup>2</sup> J. G. Daunt, R. E. Probst, and H. L. Johnston, *J. Chem. Phys.* **15**, 759 (1947).

<sup>3</sup> We wish to express our thanks to Professor A. O. Nier for the enriched samples used in these experiments.

<sup>4</sup> J. G. Daunt and K. Mendelssohn, *Nature* **143**, 719 (1939); P. L. Kapitza, *J. Phys. U.S.S.R.* **5**, 59 (1941); W. H. Keesom and G. Duyck-aerts, *Physica* **13**, 153 (1947); J. H. Mellink, *Physica* **13**, 180 (1947); L. Meyer and J. H. Mellink, *Physica* **13**, 197 (1947).

<sup>5</sup> L. T. Aldrich and A. O. Nier, *Phys. Rev.* **70**, 983 (1946).

### Interconversion of *Ortho*- and *Para*-Deuterium Due to the Deuteron Quadrupole Moment

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THE interaction of the quadrupole moment of the deuteron with an inhomogeneous electric field will result in interconversion of *ortho*- and *para*-D<sub>2</sub>.<sup>1</sup> In materials like H<sub>2</sub>O which have a permanent electric moment but no atomic magnetic moments, this process can compete with the magnetic conversion due to interaction of the deuteron's magnetic moment with the spin and rotational moments in the molecule.

Casimir<sup>2</sup> has given a theoretical estimate of the relative efficiency of the two interactions in producing conversion. Uncertainties concerning the wave functions of the colliding particles are eliminated by replacing the electric dipole by an "equivalent" charge, which results in both interactions having the same spatial dependence. Using the accepted value for the quadrupole moment,<sup>3</sup> Casimir found a total conversion rate in H<sub>2</sub>O of  $2.3 \times 10^{-5}$  l mole<sup>-1</sup> min.<sup>-1</sup>, in reasonably good agreement with the experimental value,  $2.6 \times 10^{-5}$ .<sup>4</sup> Unfortunately, there is an error in the evaluation of the diagonal sums which occur in the calculation. After the corrections are made, the reaction rate caused by the quadrupole moment is reduced by a factor of five, so that the calculated total rate is only  $1 \times 10^{-5}$ . This could be reconciled with the experimental result by the expedient of doubling the equivalent charge. It is, however, apparent that a detailed calculation is necessary.

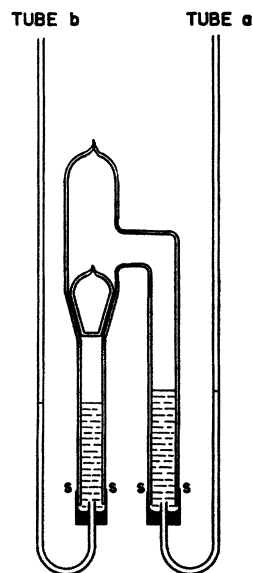


FIG. 1.