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Scintillation of Liquid Helium under Pressure. I. 4.2 > T > 1.3 °K*

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The intensity of α-particle-produced scintillations of liquid helium has been measured in the 1.3–4.2 °K temperature range and at pressures varying from the vapor pressure at 1.3 °K to 28 atm.

I. INTRODUCTION

Among the unusual properties of superfluid liquid helium is a reduction in the intensity of the scintillation of the fluid produced by α particles as its temperature is lowered.[1] A number of investigations have been carried out, involving the effects on scintillation of an electric field,[2] a heat current,[3] and rotation of the fluid.[4]

We present here the results of measurements of the scintillation of pressurized liquid helium. An extension of the measurements to lower temperatures is described in the following paper (II)[5] and the results interpreted in the light of other recent investigations. Specifically, these involve our observations of both the scintillation *pulse* intensity and the *total* intensity of the He II luminescence,[6] with results which confirmed a suggestion made earlier by Moss and Hereford[1] that delayed emission from metastable states could be responsi-

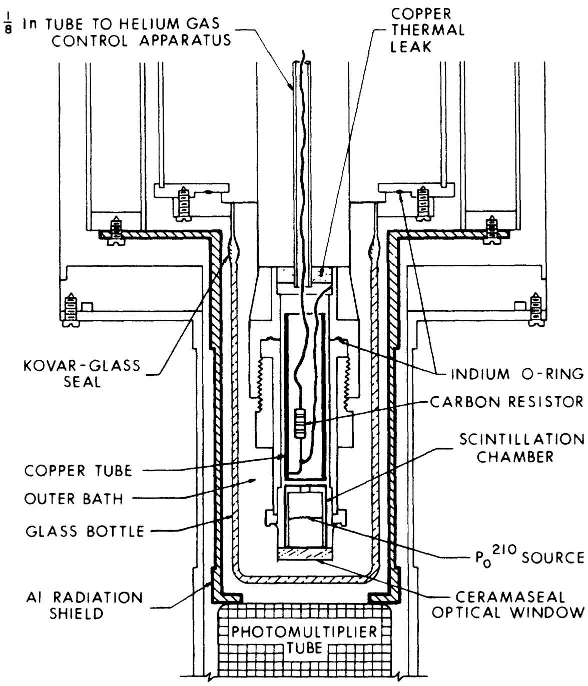

FIG. 1. Details of the pressurized scintillation chamber.

ble for the reduced scintillation intensity in He II. The presence of metastable molecular and atomic states in electron-bombarded He II has now been established firmly by Dennis *et al.*,[7] by Stockton *et al.*,[8] and by Surko *et al.*[9]

In view of this situation, discussion of the experimental data described below will be presented in the companion paper immediately following.

II. EXPERIMENTAL ARRANGEMENT

In the experiments described here, a liquid helium pressure cell was located in a stainless steel Dewar which provided for detection of scin-

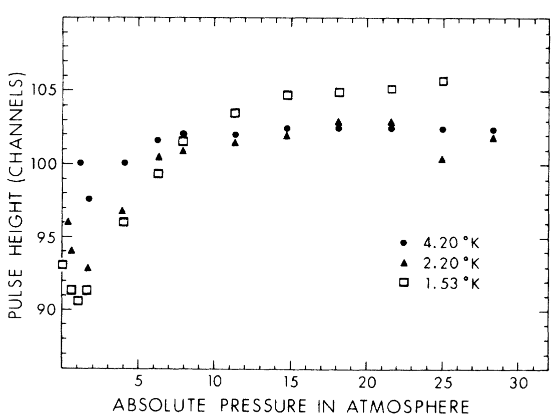

FIG. 2. Scintillation intensity as given by the position of the peak (in channels) vs pressure for fixed temperatures.

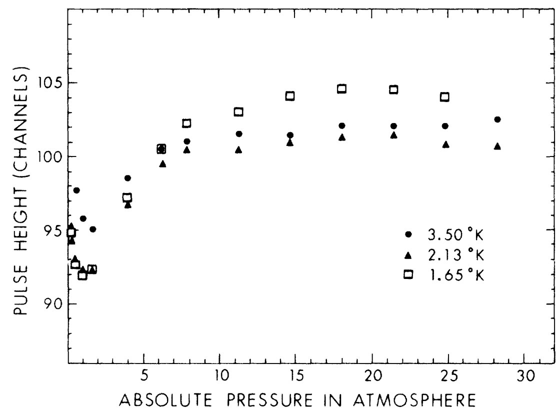

FIG. 3. Scintillation intensity as given by the position of the peak (in channels) vs pressure for fixed temperatures.

tillations of the fluid by a photomultiplier tube, as shown in Fig. 1. The cell was formed by mating a Cajon 12-VC vacuum coupling to a Ceramaseal sapphire optical window. A brass scintillation chamber, 1.59 cm in diam and 1.9 cm high, rested on the face of the optical window at the bottom of the cell. A Po^{210} α source, plated on 0.009-cm-diam Nichrome wire, ran across a diameter of the chamber, and the inside of the chamber was coated with POPOP to "shift" the extreme uv helium scintillation to the visible wavelength region. A photomultiplier tube at the bottom of the cryostat faced the cell and scintillation chamber, and its pulses were fed to a multichannel analyzer. The pulse-height spectra exhibited well-defined α peaks, and the peak positions, proportional to the scintillation intensity (photons per α particle), were found reliable to $\pm\frac{1}{2}\%$. The collection time of the analyzer was approximately 1.25 μsec.

After filling the outer chamber with liquid helium, the pressure cell was filled by admitting He gas via a 0.32-cm-diam stainless steel capillary. Pressure was monitored by a Heise bourdon tube gauge to $\pm\frac{1}{2}$ lb/in^2.

Upon bringing the outer helium bath temperature to a given value, time was allowed for the pressure cell temperature to reach a steady value as indicated by an interior Allen-Bradley carbon resistor. The cell temperature was then assumed to be the same as that of the bath. No effort was made to calibrate and use the interior resistor to determine the cell temperature because its resistance was pressure dependent.

III. RESULTS

The scintillation intensity was measured at fixed temperatures with the pressure ranging up to 28 atm and at fixed pressures with the cell temperature varying between 1.3 and 4.2 °K. Figures 2

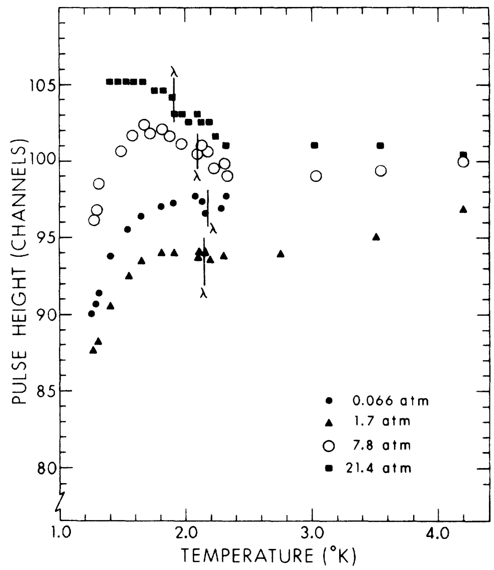

FIG. 4. Scintillation intensity as given by the position of the peak (in channels) vs temperature for fixed pressures.

and 3 show typical data for the former case. The intensity was found to drop initially as the pressure was increased, reaching a minimum, and then to rise and level off at approximately 10 atm.

The variation with temperature is shown for four fixed pressures in Fig. 4. The inhibition of scintillation below T_λ, which is pronounced when measured at the vapor pressure, becomes less so as the pressure is increased. In fact, above several atmospheres the scintillation intensity appears to rise slightly below T_λ.

One aspect of the results shown in Fig. 4 deserves comment at this point. There is some indication that, as the temperature is reduced at the higher pressures, the intensity increases slightly near 2.18 °K (the λ point of the outer bath), even though the pressure cell is well above its λ point. We suggest that this may be due to the cessation of internal boiling in the outer bath just below the sapphire window of the pressurized scintillation chamber which should occur as the outer bath temperature falls below 2.18 °K. Light collection through the outer bath could thereby be slightly enhanced increasing the measured intensity.

The extension of these measurements to temperatures ranging down to 0.3 °K has made it possible to achieve at least a partial understanding of the phenomena involved. These more recent observations are reported and discussed in paper II.[5]

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