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INHIBITION OF THE SCINTILLATION OF He II†

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We have observed the scintillation of liquid helium due to 5.3-MeV alpha particles traversing the fluid at various temperatures between 4.2 and 1.6°K. The intensity of light emitted per alpha particle was found to decrease significantly as the temperature dropped below the λ point. We have exhausted numerous interpretations of the result in terms of light collection efficiency and similar instrumental effects. Although unable to provide a clear, quantitative interpretation, we believe that the phenomenon is attributable to the superfluidity of He II.

The scintillating volume was defined by a $1\frac{1}{2}$-in. by 1-in. diameter polished aluminum container attached to the lower end of a Lucite light pipe and immersed in liquid helium (Fig. 1). Small holes near the top of the container's wall served to admit liquid and release accumulated vapor. Scintillations were produced by a thin Po^{210} alpha source near the bottom of the container.

Helium is known to scintillate in the extreme ultraviolet.[1,2] Presumably the $2P$-$1S$ transition is predominant as in the bombardment of gaseous helium with low energy electrons.[3] Hence, the inside of the container was coated with *p*-bis(2, 5-phenyloxazolyl), a wavelength shifter, which absorbed the ultraviolet and re-emitted wavelengths which could be seen by a photomultiplier coupled to the top of the light pipe. A typical pulse-height spectrum exhibited a peak at a pulse height proportional to the number of photons emitted per alpha particle.

The position of the peak was observed with a multichannel pulse analyzer at various temperatures by vacuum sealing the volume containing the liquid helium and evacuating it with a fast pump. The observed variation of peak pulse height with temperature is shown in Fig. 2. A marked decrease in pulse height is seen below the λ point.

The small decrease in pulse height between 4.2 and 2.2°K is probably due to reduction of the alpha-particle range by the increase in fluid density of about 15% between 4.2° and the λ point. Between the λ point and 1.6°K, however, no significant

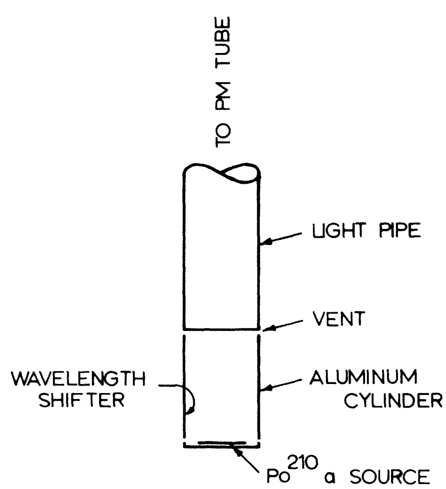

FIG. 1. Scintillation chamber ($1\frac{1}{2}$-in. by 1-in. diameter) and light pipe (15 in. in length).

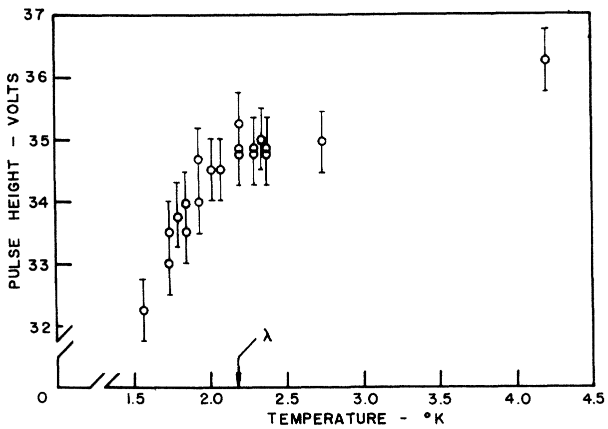

FIG. 2. Peak pulse height (proportional to number of photons per alpha particle) vs liquid helium temperature. The errors are standard deviations.

change in density occurs. In the course of the experiment the temperature was cycled from about 2.4°K to 1.6°K and back to 2.4°K four times. The lowest temperature which we were able to reach with the largest available pump was 1.6°K, this limit probably being determined by the conductivity of the light pipe, which constituted a serious but necessary heat leak.

The effect has been observed in several independent runs in which different wavelength shifters and both Lucite and quartz light pipes were employed. The cessation of internal boiling at the λ point does not appear to be a factor, since this should result in a sharp discontinuity at the λ point rather than the smooth transition which was observed.

We have also observed the scintillations from a plastic scintillator attached to the lower end of the light pipe and immersed in helium and found no change in pulse height below the λ point. This indicated that light collection efficiency (due, for example, to a He II film creeping up the light pipe) was not responsible for the effect.

Whereas we are unable to present a clear-cut interpretation of the phenomenon, we suggest several possibilities. The oscillator strength for a given transition is influenced by the presence of neighboring atoms. In the superfluid the spatial distribution of nearest neighbors is different from that in the normal fluid,[4] which may effect the oscillator strength and, hence, the probability of excitation of an atom by an alpha particle.

Other effects may derive from the reduced atomic collision rate in the superfluid. Calculation of the final momenta of helium atoms excited by 5.3-MeV alpha particles indicates that roughly 40% recoil with velocities less than the Landau critical velocity. If part of the helium radiation reaching the walls involves processes in which metastable states are populated and subsequently depleted in collisions, then the lifetime of such states might be altered in the superfluid. This could result in a change in pulse shape or even a loss of photons, if such metastable atoms diffused to the alpha source and were quenched without emission of light. It should be pointed out that the helium radiation is emitted within about 0.01 cm of the source. Further experiments are in progress which should provide additional information regarding these possible effects.

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[1]J. E. Simmons and R. B. Perkins, Rev. Sci. Instr. 32, 1173 (1961).

[2]S. V. Topp and Frank L. Hereford, Rev. Sci. Instr. 32, 1411 (1961).

[3]N. F. Mott and H. S. W. Massey, The Theory of Atomic Collisions (Oxford University Press, London, 1950), p. 232.

[4]L. Goldstein and J. Reekie, Phys. Rev. 98, 857 (1955).