Neutron Diffraction by Liquid Helium

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Preliminary results of a measurement of the angular distribution of 1.08A neutrons scattered by liquid helium at 4.2°K over the angular range 3.8° to 31° are reported. A maximum in the scattering occurs at 21.3°±1°, corresponding to a peak at 3.6A in the radial distribution of density about any atom in the liquid.

RECENTLY we undertook an investigation of neutron scattering by liquid helium. As this work has been interrupted, it seems worthwhile to publish the results already obtained. In a single run of short duration, the angular distribution of 1.08A neutrons scattered from liquid helium at a temperature of 4.2°K was measured over the angular range 3.8° to 31°.

The geometry of the scattering chamber was similar to that used by Hurst and Alcock[1] in their study of neutron scattering by deuterium gas. The present chamber was larger, having a diameter of 5 inches. Details of the scattering chamber will be published in a forthcoming paper on other liquids.

The results, corrected for background and effective scattering volume, are shown in Fig. 1, the statistical accuracy of the points being ±7 percent. Background was measured without the helium, and should possibly be reduced in part by the attenuation through the helium. This reduction would have a negligible effect at the larger angles and has not been applied owing to the uncertainty in the fraction of the background affected. Corrections for double scattering and instrumental resolution are small compared to the statistical errors and have not been applied. Measurements of the transmission by the helium gave a cross section of 0.8 barn±20 percent.

The main feature of the pattern is the peak at 21.3° ±1° where the limits ±1° were set by inspection of Fig. 1. On the simple picture of scattering applicable to x-rays, the peak is attributable to a maximum at 3.6A in the radial variation of density about any chosen atom in the liquid. The peak in the helium pattern is relatively lower and broader than the corresponding peak in the liquid argon pattern.[2] This could mean that the degree of order in helium is less than in liquid argon and that the number of neighbors at 3.6A is probably somewhat less than the 8.2 found for argon.

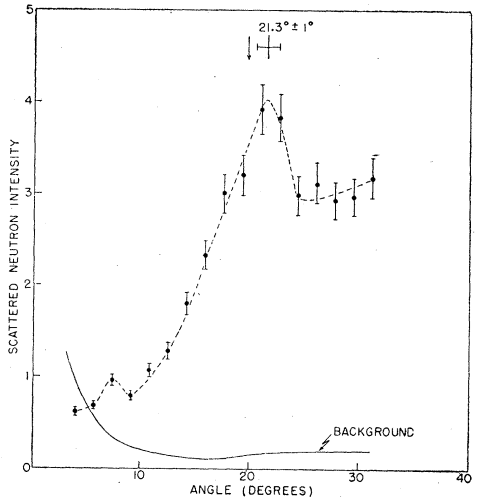

FIG. 1. The angular distribution of 1.08A neutrons scattered by liquid helium at 4.2°K. The background as measured without the helium is also shown. An arrow at 19.5° marks the predicted position of a 1.08A x-ray peak based on the published position of the peak at 28° for 1.54A x-rays with helium at 2.15°K.

Keesom and Taconis[3] and Reekie[4] measured the scattering of Cu$K\alpha$ x-rays from liquid helium at slightly lower temperatures (2.4°K and 2.15°K, respectively). A broad maximum in the scattering was found at an angle of 28°. Changing this to the angle predicted for 1.08A according to the usual diffraction formula ($\sin\theta/\lambda$=constant) gives 19.5° to be compared with the angle 21.3°. If a correction is made for change in density between the two temperatures, the difference between the x-ray and neutron results is increased by approximately one degree.

[1] D. G. Hurst and N. Z. Alcock, Can. J. Phys. **1**, 36 (1951).
[2] Henshaw, Hurst, and Pope (to be published).
[3] W. H. Keesom and K. W. Taconis, Physica **5**, 270 (1938).
[4] J. Reekie, Proc. Cambridge Phil. Soc. **36**, 236 (1940).