The Raman peak at 79 cm^{-1} lies in the phonon gap and the other three, at 60, 106 and 148 cm^{-1}, lie near maxima in the phonon density of states in KI [5]. The last two are new peaks not seen before in absorption. There is no sign in the Raman scattering of the 71 cm^{-1} gap mode prominent in absorption [1,4].

The dynamics of the NO_2^- ion are complex. It probably occupies a position off center in the [110] direction and thus lowers the site symmetry. It may also rotate or librate about its three principal axes [1]. At this time we are unable to offer a definite interpretation of the Raman spectra. Work is in progress to improve the resolution of the equipment and to extend the measurements to other alkali halides.

We wish to thank C. J. Buchenauer for his assistance, and Professor R. O. Pohl and Dr. V. Narayanamurti for providing crystals and for helpful discussions.

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VORTEX WHEELS IN SUPERFLUID HELIUM *

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It is suggested that the continuous reversal of apparent circulation around a vibrating wire in liquid He II is due to the motion of a vortex-line array called a "vortex wheel".

There are some persistent puzzles in the interpretation of the vibrating wire experiments which demonstrate the quantization of circulation in superfluid liquid helium. Although the system is unusually stable at the predicted quantum levels, it is capable of changing its apparent circulation in a slow and continuous fashion, passing through a sequence of intermediate states whose nature has been the subject of some speculation.

In the experiments [1,2], liquid helium II is contained in a doubly connected region bounded on the outside by a cylindrical wall and on the inside by a thin wire strung along the cylinder axis (z-direction). The effect of the rotating helium upon the fundamental vibration of the wire is governed by the average circulation

$$\bar{\kappa} = \frac{2}{L}\int_0^L \kappa(z)\,\sin^2(\pi z/L)\,dz\ , \qquad (1)$$

L being the length of the cylinder. An example of the observed variation of $\bar{\kappa}$ while the apparatus was not being rotated or otherwise deliberately disturbed is shown in fig. 1. That this type of behavior will repeat for several hours seems to rule out changes of a dissipative nature.

It has generally been assumed [1-3] that the non-quantized values of the circulation must be associated with vortex lines which are not attached to the wire over its whole length. It remains to explain, however, how the circulation can vary without the total energy of the system changing, and how any free sections of vortex line, which must move with the superfluid, can avoid losing energy through friction with the necessarily stationary normal fluid [e.g. 4].

Suppose a plane perpendicular to the axis to divide the cylindrical apparatus into two regions

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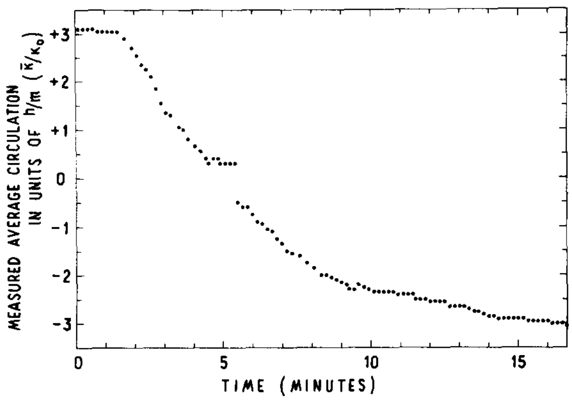

Fig. 1. Average circulation, in units of $\kappa_0 \equiv h/m$, as a function of time. The points are taken from run H-2 of ref. 2.

of *equal and opposite* circulations $\pm\kappa = \pm n\kappa_0 = \pm nh/m$. The plane itself contains an array of $2n$ quantized vortex lines arranged like spokes; we call such a structure a "vortex wheel", and show it schematically in fig. 2. Except for end effects (see below), the total energy of the system is independent of the location of the wheel. When its axial position is constant, there is no azimuthal motion of the spokes. Thus no dissipation results from the presence of the wheel. On the other hand, if the wheel were to drift from one end of the apparatus to the other, the measured circulation, eq. (1), would change continuously (at constant energy!) from $+n\kappa_0$ to $-n\kappa_0$.

The data of fig. 1 can be approximately explained by assuming an axial heat current of $\sim 10^{-4}$W, the wheel moving along the axis with the superfluid and rotating so as to produce a Magnus force opposing the drag due to the normal component. It would be desirable, in future experiments, to provide heaters for producing such currents deliberately, and to study higher vibrational modes of the wire in order to clarify the dependence of κ upon z.

Motion of a vortex wheel near either end of the cylindrical container will be perturbed by image forces whose analysis seems rather complicated; in addition, the drift may be affected by irregularities in the actual experimental vessel. If the vortex wheel were replaced by a plane sheet of discontinuity, the end effects would be absent. Presumably, however, such a configuration would be unstable against breakup into vortex lines [5,6].

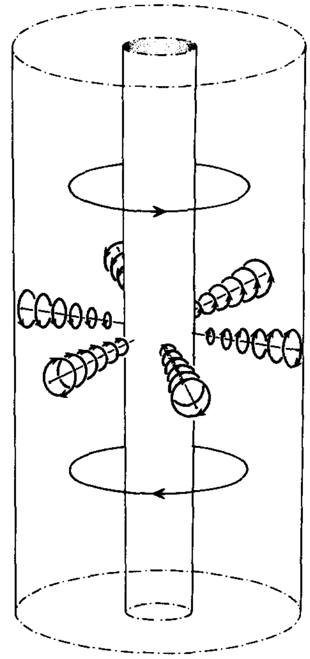

Fig. 2. Schematic representation of streamlines associated with a vortex wheel.

We are indebted to S.C.Whitmore, both for a stimulating talk which began our thoughts on this subject and for helpful information regarding the experiment.

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