

OBSERVATION OF SUPERFLOW IN SOLID HELIUM.

Authors: E. Kim and M H W Chan.

Recommended and a commentary by P.W. Anderson, Princeton University.

In a previous paper Moses Chan claimed the observation of superflow in solid He4 confined in pores in Vycor glass; using the same methodology of torsional oscillation of an annular sample, he now reports a similar observation on pure solid He.

The experiment consists in measuring the period of a torsional oscillator containing an annular cavity within which the helium is frozen under pressure. At a temperature of about .2K the period begins to decrease with temperature continuously, at an increasing rate, the amount of decrease then saturating at around .05 K; the oscillations are damped somewhat in this range of rapid decrease but regain their Q at low temperature. This period decrease is presumed to signal that the superfluid component must flow irrotationally and hence cannot follow the rotation of the solid; as the classic experiments of Reppy showed, superfluid liquid helium in any substrate shows a similar "dropout" as it condenses.

It is observed that the superfluidity decreases rapidly with the maximum velocity of motion, starting near the velocity associated with a single quantum of circulation. A very good check is achieved by blocking the channel; the effect agrees quantitatively with the irrotational flow hypothesis.

The surprising feature of this experiment is the large magnitude of the effect, in the neighborhood of 1% of the solid's density. A number of theorists starting with Andreev and Lifshitz, and Chester, had proposed the superfluid solid as a possibility, but most estimates of the superfluid density were in the 10^{-10} to the 10^{-5} neighborhood, and Leggett considered this an upper limit. (I disagreed at the time and felt that a "true" solid could not self-consistently form and remain superfluid.) I think Leggett's estimates, a fortiori, suggest that this is not the "commensurate" solid (one atom per unit cell) these theorists were discussing.

I can imagine that either in equilibrium, or because of the nature of the freezing process, it could be that there is a 1% density of either interstitials or vacancies in the crystal, which would then Bose condense. A crucial experiment will be to measure the lattice constant and the moment of inertia simultaneously and to see whether this is the case. If not, we have a real mystery on our hands. Even if so, the question of why the defects repel each other and do not aggregate is a good one.

Kim and Chan report a few previous attempts which did not find the effect. In the most careful one, the sample contained .04% He3, but there is at least a verbal claim to have studied pure He4.