Superflow in Solid $^4$He WAYNE SASLOW, Texas A&M University — Kim and Chan have recently observed Non-Classical Rotational Inertia (NCRI) for solid $^4$He in Vycor glass, porous gold, and bulk. Using a microscopic theory where each atom has the same local superfluid velocity (which depends on the microscopic atomic mass density), we show that their low $T$ value of the superfluid fraction, $\rho_s/\rho_0 \approx 0.015$, is consistent with what is known of atomic delocalization in this system. In the macroscopic theory, we explicitly include a lattice mass density $\rho_L$ distinct from the normal fluid density $\rho_n$, thus making the superfluid hydrodynamics consistent with Galilean transformations, which implies that $\rho_0 = \rho_s + \rho_n + \rho_L$. We also show that $\rho_L(T) = \rho_0(T) - \rho^*_s(T)$, where $\rho_0(T)$ is the average mass density and $\rho^*_s(T)$ is computed from the microscopic mass density. This added complexity makes determination of $\rho_n/\rho_0$ from the measured $\rho_s/\rho_0$ non-trivial, although an excitation energy of about 0.35 K is relevant as $\rho_n/\rho_0$ rises from its low temperature value of zero. The macroscopic phase inferred from the observation of NCRI suggests quantum vortices, whose cores must reside between the lattice sites.

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