Creation of quantised vortices at a moving surface in superfluid ^{4}He

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We describe an experiment to explore how quantum turbulence is created by relative motion between superfluid ^{4}He and a solid surface. Following a suggestion by the late W.F. (Joe) Vinen, we aim to eliminate the analogue of the classical instability where fluid flows over a convex surface: large-scale classical turbulence can then be emulated by bundles of quantised vortices acting coherently. Rather we use a pillbox-shaped experimental cell in which all internal surfaces are concave. The cell, filled with pure superfluid near 20 mK, is rigidly fixed to a high Q torsion oscillator [1]. Measurements of changes in the frequency and Q of the oscillator+cell are used to infer dissipation in the superfluid connected to the creation and dynamics of vortex lines. A second experiment, where the cell included small cones to provide convex moving surfaces, yielded distinctly different results, with a lower critical velocity for the onset of dissipation. It is concluded that dissipation in the first experiment involved the creation of individual quantised vortices which then reconnected and tangled, whereas the second experiment involved an emulation of classical flow by coherent bundles of vortices. The measurements were extended to higher temperatures, up to the λ-transition, where viscous normal fluid was present and shown to be in satisfactory agreement with theoretical expectations based on the known normal fluid viscosity. These early results and their implications for future investigations will be discussed.

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