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Vortex Generation in Superfluid ^{3}He by a Vibrating Grid

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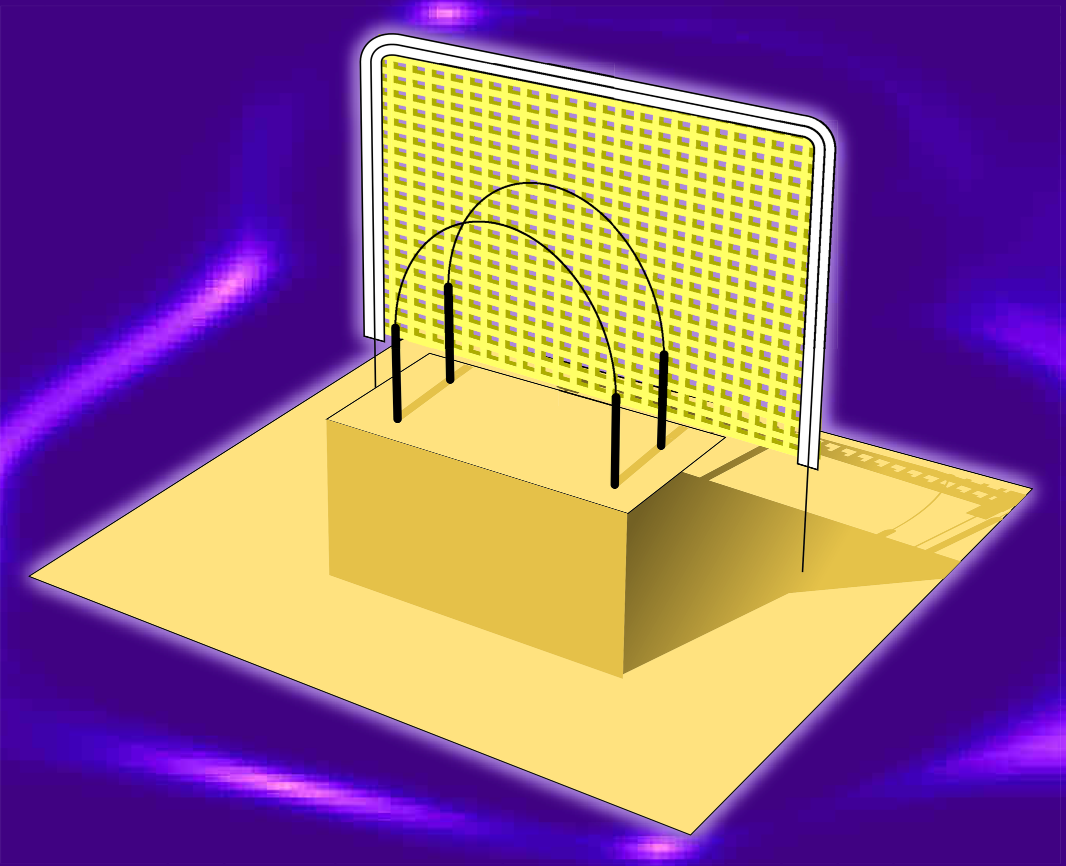
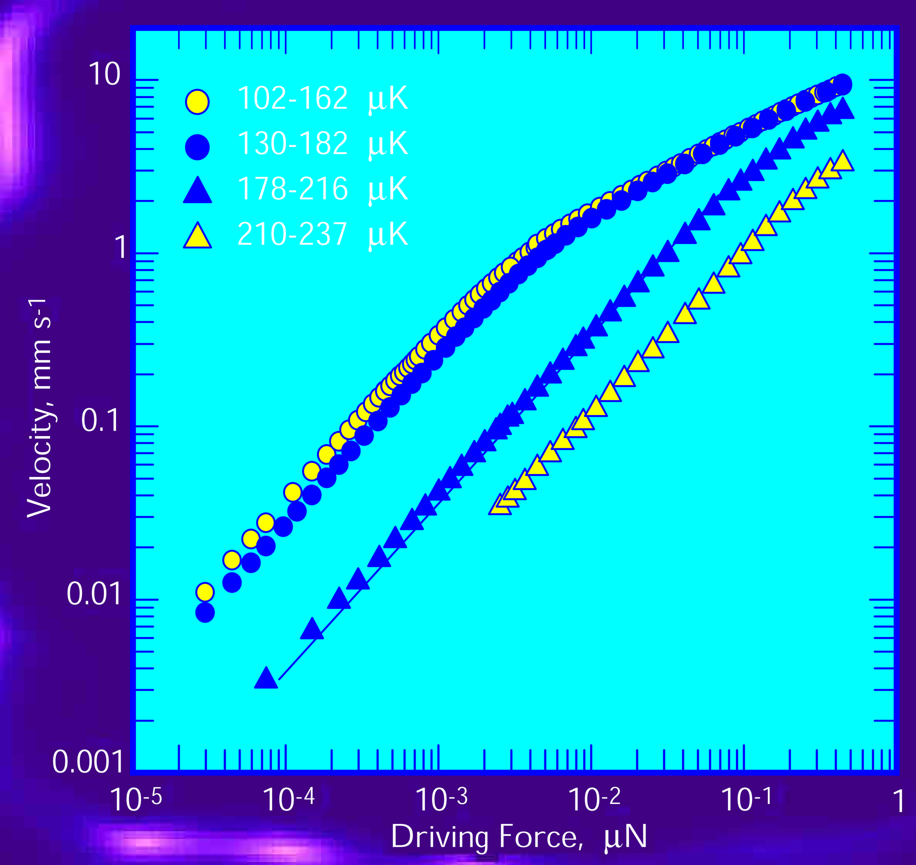
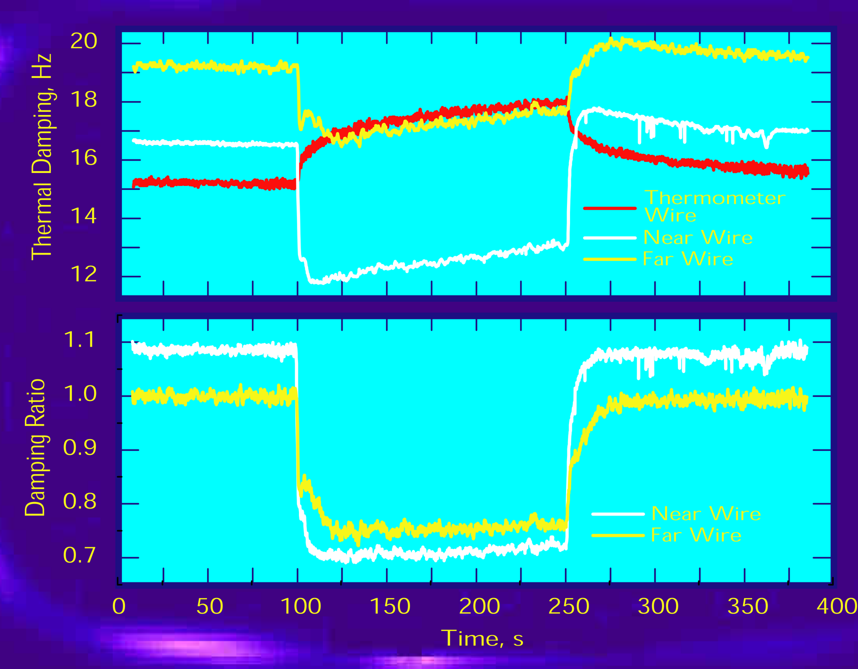
We describe the first measurements of superfluid turbulence generated by a vibrating grid in the B-phase of superfluid ^{3}He at very low temperatures. By measuring the decay of the observed vorticity after arresting the grid motion we find a dramatic change in the decay rate corresponding to a sharp transition between ballistic vortex ring production at low grid velocities to quantum turbulence at higher velocities.



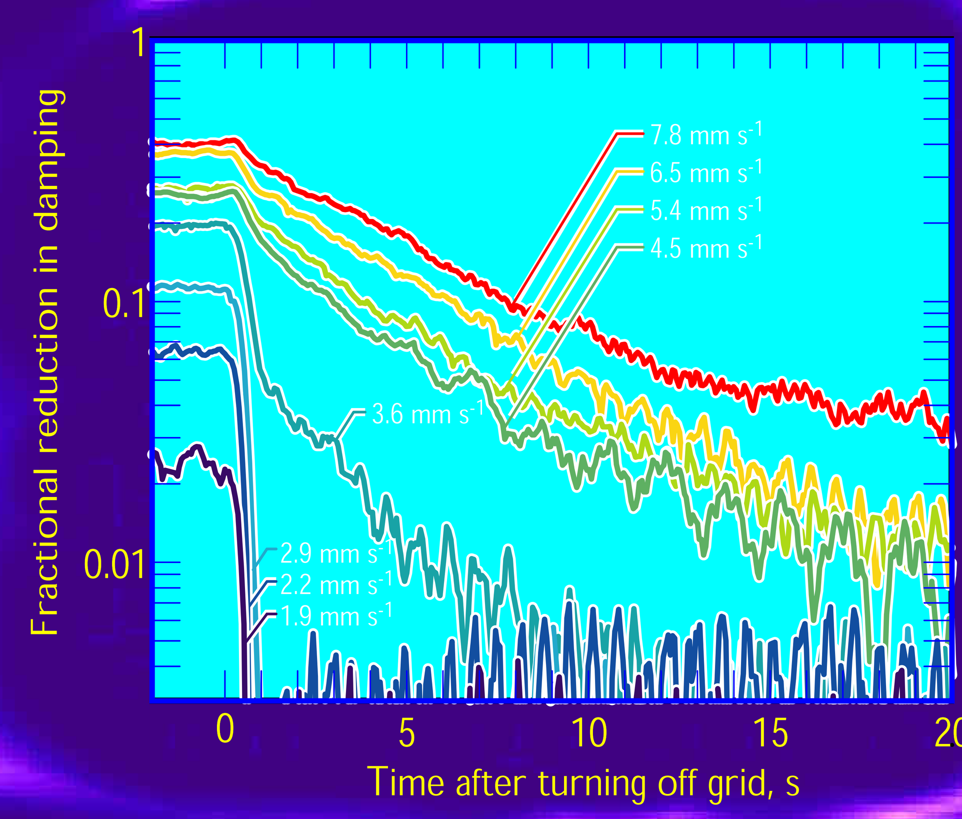
The grid resonator consists of a fine mesh of 11µm copper wires 50µm apart which is glued to a 5 mm square frame formed by 0.125 mm Ta wire. In front of the grid are two conventional 4.5µm NbTi vibrating wire resonators located approximately 1mm and 2mm from the grid as shown.



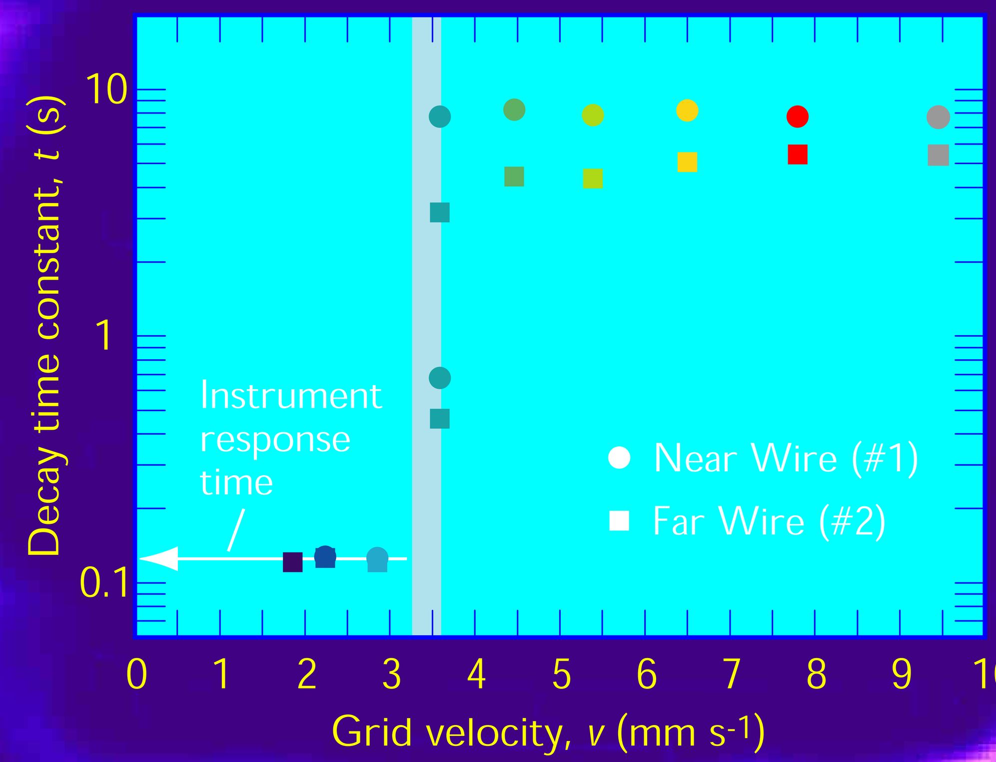
The response of the vibrating grid at various temperatures.



We measure the turbulence generated from the grid using the two wires in front of the grid and a thermometer wire. Quasiparticle excitations are Andreev reflected by turbulent flow resulting in a reduction of the thermal damping of the wires. The damping of the three wires is shown as a function of time while the grid is driven at 4.3mm/s. The lower plot shows the ratio of the damping of the two wires near the grid to the remote thermometer wire. The grid turbulence causes a reduction in damping relative to the thermometer wire.



The fractional reduction of the damping ratio provides a direct measure of the fraction of thermal quasiparticles Andreev-reflected by the surrounding vortex lines. The transient response of the fractional change in damping ratio for the wire closest to the grid as a function of time after stopping the grid motion for various initial grid velocities is shown above. The slow recovery at higher velocities corresponds to the decay/dispersion of quantum turbulence. At lower velocities a very rapid recovery is observed corresponding to ballistic vortex ring production by the grid.



With increasing grid velocity rings are emitted more frequently. Presumably, at some critical grid velocity the density of rings becomes sufficiently large that they intersect; reconnection brings more complex shapes and a cascade of further reconnections leading to a vortex tangle (quantum turbulence). While the gas of rings can travel rapidly, the vortex tangle is virtually static and decays or disperses on much longer time scales

Our studies of an oscillating grid in superfluid ^{3}He-B suggest that at low velocities the vorticity takes the unusual form of a gas of independent ballistic vortex rings. A developed vortex tangle only appears above a sharply defined grid velocity. We believe that this behaviour may well be general and that vortex rings provide the precursors for a wide range of systems generating quantum turbulence.