Probing quantum turbulence using mechanical oscillators

A.M. Guènault, R.P. Haley, S. Kafanov, M.T. Noble, G.R. Pickett, M. Poole, V. Tsepelin, D.E. Zmeev, and T. Wilcox

Department of Physics, Lancaster University, LA1 4YB, United Kingdom

We present studies of quantum turbulence in superfluid ^{3}He-B and ^{4}He using mechanical oscillators. Quantum turbulence comprises single quantised vortices and is expected to differ from its classical counterpart. We use a wide range of high quality-factor resonators (superconducting wires, quartz tuning forks and nano-electromechanical beams) to generate and probe quantum turbulence. Measurements of their force-velocity characteristics allow one to probe the creation of vortices and other excitations in both superfluids. In superfluid ^{4}He the appearance of turbulence can be confirmed using the second sound attenuation in the two fluid regime or more sophisticated techniques at low temperatures. In superfluid ^{3}He, despite the stringent requirements to reach one ten-thousandth of a degree, turbulence imaging and visualisation is more straightforward since we do not need to add tracer particles and can instead exploit the properties of its inherent ballistic quasiparticles. Our measurements combined with numerical simulations of realistic 3D vortex tangles suggest that quantum turbulence produced by uni-directional injection of energy is polarised. We attribute the latter to the observed similarities between quantum and classical turbulence at ultra low temperatures. We propose experiments to create non-polarised tangles and discuss other finding.

Section: VT - Vortices and turbulence

Keywords: mechanical oscillators, quantum turbulence, Andreev reflection, superfluid He3, superfluid He4