Spectrum and histogram of vorticity in a superfluid grid experiment

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A turbulent superfluid can be viewed as a dense tangle of vortex lines wiggling around. Strikingly, the collective behaviour of this tangle mimics classical turbulence at inertial scales, at least according to existing velocity measurements. This allows to envision superfluids as model fluids to explore the inertial-range properties of classical turbulence, in particular those difficult to resolve with classical fluids such as vorticity and enstrophy.

Along this line, we report times series of the vorticity measured in a grid experiment (at 10M) using superfluid ^{4}He at 1.65 K. The measurements are made with specially-designed micro-fabricated probes that are able to resolve the velocity and the density of vortex line at a scale around one millimeter[1]. These probes are based on an open second-sound cavity forced at resonance (see photo).

As expected, the velocity histogram is quasi-gaussian and the velocity spectrum evidences a scaling behaviour along more than one decade of inertial range, slightly less steep than -5/3 due to proximity to the grid (see plot). In contrast, the vorticity time series are strongly skewed -as expected- and the vorticity spectrum doesn't evidence any scaling range[2]. Implications are discussed.

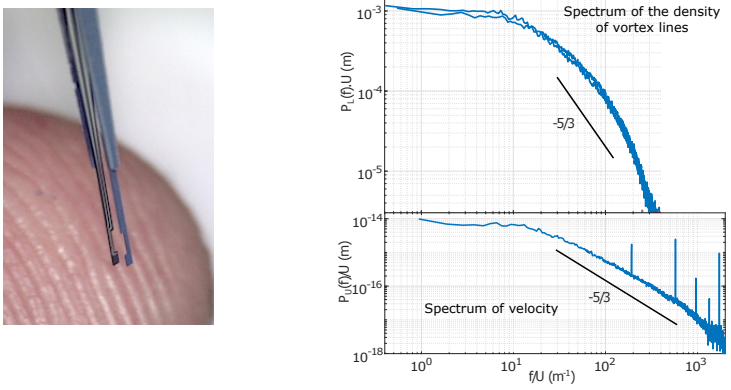

Figure 1: [left] Three-quarter view of the sensitive part of the vortex line density probe. [right] Vorticity (top) and velocity (bottom) spectra in the near field of a grid in superfluid helium. The largest values of the wave-vector f/U correspond to the probe resolution.

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[1]Woillez, Valentin and Roche, *hal* **03927919** (2023).
[2]Woillez, Valentin and Roche, *EPL*, **134** 46002 (2021).