Kelvin Spectrum for a Harmonically Driven Vortex at Low Temperatures

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Currently one important interest in the quantum turbulence community is the dissipation and the decay of quantum turbulence in the zero temperature limit. As $T \to 0$ the coupling between vortices and normal fluid becomes negligibly small. Vortices in helium superfluids are quantized and therefore the traditional Kolmogorov energy cascade becomes impossible at scales smaller than the intervortex distance. To be able to dissipate, energy must be cascaded from the intervortex scales to scales of the order of the vortex core. This cascade is expected to occur via Kelvin wave excitations. Here we numerically determine the steady state spectrum for Kelvin waves on a superfluid ^{4}He vortex that is driven by shaking its endpoints and damped by mutual friction, a situation easily realized in vibrating wire/grid/fork experiments. The resulting spectrum depends weakly on temperature and, for small drives, is independent of the drive amplitude. Due to the spacially sharply peaked drive no high-k cutoff is observed, even when the mutual friction is large. At low drives, the accumulation (so-called bottleneck effect) of Kelvin waves in the region above the drive is absent. For higher drives the bottleneck effect is difficult to determine since the Fourier representation fails before a proper spectrum develops. We also determine the power dissipated due to mutual friction, as a function of the number of Kelvin modes present in the system, using different Kelvin spectra. Additionally, we show that the cascade is not totally absent in the Local Induction Approximation (LIA) provided that the Kelvin amplitudes are not small.