Quantum turbulence and the free decay of grid oscillations in He II

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We have measured the decay of free oscillations of a circular grid in superfluid ^{4}He for pressure $P = 5\,\mathrm{bar}$, and temperatures $10 < T < 1500\,\mathrm{mK}$. In the $T \to 0$ limit, we observe three distinct decay regimes. At high grid velocities $v > v_{c2} \simeq 1\text{-}2\,\mathrm{cm/s}$, the oscillation amplitude decays very fast. For $v_{c2} > v > v_{c1}$, the decay is less fast but still non-exponential. When $v < v_{c1} \simeq 0.3\text{-}0.5\,\mathrm{mm/s}$ the decay is exponential with a decay constant $\tau \sim 80\,\mathrm{s}$ consistent with the small-amplitude grid quality factor ($Q \sim 2.5 \times 10^5$). We tentatively attribute the high-attenuation regime to the creation of quantum turbulence; the low-attenuation regime to pure "nuisance damping" due to nonidealities in the grid and possible internal friction, with no significant influence by the superfluid or pinned vortices; and we shall discuss possible interpretations of the intermediate regime. Other phenomena, including a switching regime during steady driving of the grid, and evidence for two distinct long-lived states of the system characterised by a relative frequency shift of $\sim 50\,\mathrm{mHz}$ and different free-decay characteristics in the intermediate regime, will also be discussed.