Turbulent and Laminar Dynamics of Superfluid ^{3}He-B at Low Temperatures

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The dynamics of superfluids in applied flow was thought to be fully turbulent in the zero-temperature limit, when the density of the normal component vanishes and the associated mutual friction damping rapidly decreases. We have studied how the superfluid ^{3}He-B, contained in a cylinder, is put into rotation at temperatures below $0.2\,T_{\mathrm{c}}$ and how the rotation is stopped. Unexpectedly we have found that laminar dynamics, i.e. motion of approximately straight vortices without reconnections, plays an important role even at these low temperatures. In the experiment the motion of vortices is observed using nuclear magnetic resonance techniques and the dissipated energy is directly measured with a bolometer. A remarkable example of the non-trivial dynamics is the vortex front, which separates non-rotating vortex-free superfluid and rotating superfluid with vortices. The turbulent front propagates axially in a nearly steady-state configuration towards the vortex-free part, while the approach to equilibrium rotation behind the front is laminar. We compare the observations to numerical simulations of vortex dynamics and discuss potential links to novel phenomena like decoupling of the superfluid from the rotating reference frame in the zero-temperature limit and dissipation mechanisms which differ from the standard mutual friction.

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