Vortex Dynamics in the Turbulent Flow of Superfluid ^{4}He Generated by a Vibrating Wire

H. Yano, N. Hashimoto, A. Handa, R. Goto, K. Obara, O. Ishikawa, and T. Hata

Graduate School of Science, Osaka City University, Japan.

We have studied the flow of superfluid ^{4}He generated by a vibrating wire. As increasing drive force, a laminar flow around the wire develops into turbulence due to unstable expansion of vortex strings attached to the wire. Flow regimes are clearly separated at a critical velocity with both increasing and decreasing drive force. This dependence suggests that the vortex strings are confined in a finite size, even in turbulence. Since it is quite conceivable that an expanding vortex easily entangles and reconnects itself, this reconnection process should confine the vortex strings. We also measured the resonance frequency of the vibrating wire and found that the wire in superfluid ^{4}He gains in mass due to vortex strings attached to it and the extra mass of the wire varies with velocity: it increases gradually in the laminar flow and decreases steeply in the turbulent flow with increasing velocity. Entanglement and reconnection of the vortex strings are likely to reduce the extra mass in the turbulent flow, although expansion of the vortex strings must gain the mass. At the turbulence transition, the flow around the wire switches intermittently back and forth between both flow regimes. We found that a switching rate depends on temperature and resonance frequency of the vibrating wire. The switching phenomena likely occur by the chaotic motion of the vortex strings, although the vortex dynamics are not clear at the moment.