Propagation of Vortex Rings Nucleated in Turbulent Layers of Superfluid ^{4}He

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Superfluid turbulence in boundary layers of superfluid ^{4}He has recently attracted research interest. In turbulent layers, vortex lines attached to boundaries are expected to unstably expand ,entangle, and reconnect themselves by a superfluid flow at a sufficiently high velocity. Consequently, many vortex rings are expected to nucleate in turbulent layers and propagate in a surrounding superfluid; however, direct detection of vortex rings has not been studied yet. Only indirect detections have been reported for superfluid ^{3}He so far [1]. In the present study, we report direct detection of vortex rings using two vibrating wires and discuss propagation of vortex rings generated in turbulent layers.

Two vibrating wires are located in a chamber as shown in a inset of Fig. 1. Both wires are formed into a semicircular shape: a vibrating wire A is oriented perpendicular to the face of the semicircular shape of a vibrating wire B, separated in a distance of 1.0 mm. At first we applied drive force to both vibrating wires, then increased drive force of the vibrating wire B, generating turbulence after sufficient applied force. We plot the velocities of both wires in Fig. 1 as a function of time. The velocity of the generator wire B suddenly drops at which turbulence occurs. After a while of the transition to turbulence, we detected a dissipation with the vibrating wire A. This result indicates that vortex rings are generated by the wire B, propagate and attached to the wire A, causing dissipation. Above a velocity of about 50 mm/s, the vibrating wire A enters a turbulent state; i.e. attached vortex rings would unstably expand and reconnect themselves, multiplying vortex rings. We measured a time Δt from the transition to the detection of dissipation as a function of velocity of the detector wire A, as shown in Fig. 2. The time Δt increases with decreasing velocity of the detector. This result suggests that the size of a vortex ring affect the dissipation of the detector wire A, because the propagation time of a vortex ring increases with decreasing its size.

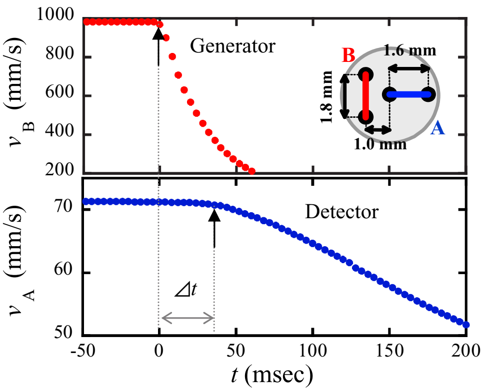

Fig. 1. Energy dissipation of wires.

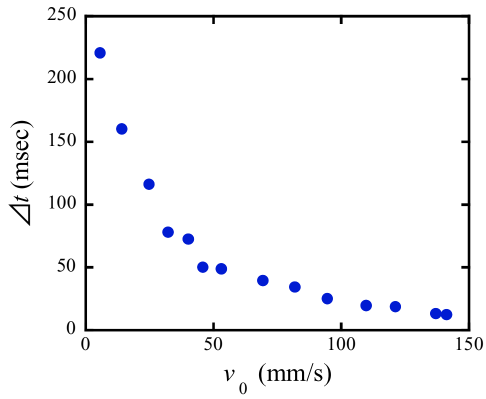

Fig. 2. Detector velocity dependence of delay time.

[1] S.N. Fisher, A.J. Hale, A.M. Guenault, and G.R. Pickett, Phys. Rev. Lett. **86**, 244 (2001).