Superfluid flow and dissipation of ^{4}He confined in a well-controlled nanopore array

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Superfluidity of liquid ^{4}He confined in nanopores with pore diameter of 3 nm is anomalously suppressed. The transition temperature approaches 0 K by pressurizing liquid, indicating a quantum phase transition between superfluid and nonsuperfluid states [1]. Since the suppression occurs at pore size much larger than the superfluid healing length $\xi \sim 0.3$nm, it opens possibility of developing novel superfluid weak links, i.e. superfluid Josephson junction working at wide temperature range, with nanopore fabrication technique. Here we report on measurements of superflow properties of ^{4}He in a regular array of nanopores made of porous alumina (PA). The pore size is controlled by Au film evaporated on and inside the nanopores. We employ the vibrating wire technique, in which the Au-evaporated PA is glued to a semicircular NbTi wire and is immersed in superfluid ^{4}He. Suppression of superfluid transition is successfully observed as an abrupt change in resonant frequency accompanying a dissipation peak. We find that, when the oscillation velocity of the wire increases, only the dissipation peak increases. The dissipation increases linearly with velocity at low temperature, while it saturates near the superfluid transition temperature inside the nanopores. We will discuss these behaviours in terms of phase slippages and turbulence by quantized vortices.

[1] K. Yamamoto *et al.*, Phys. Rev. Lett. **93**, 075302 (2004); K. Yamamoto *et al.*, Phys. Rev. Lett. **100**, 195301 (2008).

Section: LD - Low dimensional and confined systems

Keywords: superfluid ^{4}He, confined gyometry, quantum vortex