Possible Finite-Length 1D Superfluidity of ^{4}He Adsorbed in Nanochannels

T. Matsushita, Y. Nakanishi, Y. Nakashima, Y. Minato, M. Hieda, and N. Wada

Department of Physics, Nagoya University, Chikusa-ku, Nagoya 464-8602, Japan

Using straight nanochannels in silicates FSM, 1.5–4.7 nm in diameter and about 300 nm in length, the superfluid densities of ^{4}He adsorbed in 1D channels and the pore-size dependence have been measured systematically[1]. These studies show that superfluid fraction exists in channels wider than 1.8 nm and that there are qualitative differences between 2.2 and 2.8 nm in diameter. At present, we have examined the superfluid density and accompanying dissipation of ^{4}He adsorbed in 2.4 nm channels by the torsional oscillator method. At relatively high densities where ^{4}He adatoms do not form film, a large dissipation peak related to ^{4}He superfluid in nanochannels is observed at low temperatures, separately from a sharp peak at T_{KT} due to the Kosterlitz-Thouless transition of ^{4}He film on grain surface of FSM powder. Correspondingly, the superfluid density in channels grows gradually towards lower temperatures.
Recent theoretical studies show that in the 1D system with a finite length, the superfluidity does not vanish by phonon fluctuations, but phase-slip excitations play a major role[2]. The characteristic temperature T_{PS} depends on the 1D ^{4}He density and also the system length itself. The T_{PS} is comparable to T_{KT} for 300 nm length, depending on the pore size. The gradual increase of the superfluid density observed in these nanochannels qualitatively agrees with that expected for the finite-length 1D superfluid.

[1]H. Ikegami et al., Phys. Rev. B **76**, 144503 (2007).
[2]K. Yamashita and D. S. Hirashima, J. Low Temp. Phys. **162**, 617 (2011), and references therein.