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Quantum Phase Transition of ^{4}He Confined in a Nanoporous Material

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Confinement of ^{4}He in porous medium such as Vycor glass results in suppressions of freezing and superfluidity. The suppressions can be enhanced as the pore size decreases to nanometer scale. From torsional oscillator [1] and pressure studies we have revealed the $P-T$ phase diagram of ^{4}He confined in a porous Gelsil glass which has nanopores of 2.5 nm in diameter. We have found that the superfluid transition temperature approaches 0 K at 3.4 MPa, and the freezing pressure shifts from the bulk one to 3.5 MPa. The solid - nonsuperfluid phase boundary is independent of temperature below 1 K, suggesting that the nonsuperfluid phase has low entropy as well as solid. The features indicate that the confined ^{4}He undergoes a superfluid - nonsuperfluid - solid quantum phase transition at 0 K. The low - entropy nonsuperfluid phase may be a localized Bose - condensed state, in which global phase coherence is destroyed by strong correlation between ^{4}He atoms or by random potential. [1] K. Yamamoto, H. Nakashima, Y. Shibayama, K. Shirahama, Phys. Rev. Lett. 93, 075302 (2004).