Ultrasound Measurement of Confined ^{4}He near the Quantum Critical Point

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In a previous torsional oscillator study[1], we discovered a quantum phase transition (QPT for short) in ^{4}He confined in a nanoporous Gelsil glass (pore size: 2.5 nm). The superfluid - nonsuperfluid transition occurs when the pressure is swept around 3.4 MPa (critical pressure P_c) near 0 K. Theories with a classical analogue of QPT[2] predict that the characteristic time scales that dominate the quantum fluctuations diverge at the quantum critical point (QCP for short), same as other classical dynamic critical phenomena. If the time scales characterizing superfluidity diverge at QCP, some quantities, such as superfluid density, will become strongly frequency dependent near P_c.

We study the possible frequency effect on superfluid properties by the ultrasound technique, which provides information on the superfluid density and dissipation at frequencies from 1 to 100 MHz, which are from 3 to 5 orders of magnitude higher than that of the torsional oscillator method. We employ a Gelsil sample with the same pore size as the previous torsional oscillator study. A preliminary result shows that the temperature dependence of sound velocity depends on frequency.

[1]K. Yamamoto, Y. Shibayama, and K. Shirahama, Phys. Rev. Lett. **93**, 075302 (2004); K. Yamamoto, H. Nakashima, Y. Shibayama, and K. Shirahama, Phys. Rev. Lett. **100**, 195301 (2008).
[2]S. L. Sondhi, S. M. Girvin, J. P. Carini, and D. Shahar, Rev. Mod. Phys. **69**,315 (1997).