The confinement of quantum fluids in nanotubes, including Helium-3 \(^{3}\text{He}\), Helium-4 \(^{4}\text{He}\), Hydrogen \((\text{H}_2)\), and Hydrogen-Deuterium \((\text{HD})\), for which the deBroglie wavelength and/or Fermi length become comparable to or larger than the channel size has been predicted to lead to emergent quantum behaviors. We have carried out experiments designed to search for these new quantum behaviors for \(^{3}\text{He}\) constrained to move in 1D channels.

The MagLab user program has developed special low temperature pulsed NMR techniques to determine the temperature dependence of the dynamics of \(^{3}\text{He}\) atoms confined to the interior of the hexagonal nanoscale channels of MCM-41. The typical nanochannel diameter in this material is only 1.5 nm, with lengths greater than 300nm.

A spin-echo radio-frequency (RF) pulse sequence is followed by an NMR spin-lattice relaxation that consists of two distinct relaxation components attributed, respectively, to the \(^{3}\text{He}\) atoms on the walls of the nanochannel (the shorter relaxation time) and atoms free to move in the center of the nanochannel (long time relaxation). The long time relaxation shown in Fig. 1 exhibits the characteristic \(T^{3/2}\) dependence (indicated by the solid black line in the Figure) that is expected for a Fermi gas confined to a one-dimensional space.

New NMR probes and techniques are being developed to extend the temperature range below the Fermi temperature (~80mK) to test for Luttinger liquid behavior in a system without electric charge.


Facility: Bay 2 of the MagLab’s High B/T Facility.