



Dynamics of 1D quantum Fluid: ^3He in MCM Nanochannels

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Introduction

In 1D strong correlations render all excitations collective and the dynamics is best described by the Tomonaga-Luttinger liquid (TLL) state [1-2]. The goal of this experiment was to search for TLL behavior for a 1D system of fermions created by adsorbing ^3He in the nanotubes of MCM-41. The advantages of this system are the ability to change the line density over a wide range, the intrinsic high purity of the 1D components, and the ability to measure the dynamics using high sensitivity NMR techniques.

Experimental

After calibration of the adsorption area of MCM-41, ^4He gas was added to complete a monolayer coating of the walls of the nanotubes. After plating with ^4He , ^3He was added to form a 1D fluid with line density of 0.10 \AA^{-1} . Pulsed NMR techniques were used to measure the nuclear spin relaxation times which depend on the dynamics of the ^3He atoms and thus test for Luttinger liquid behavior. The NMR probe was tuned cold and formed one side of an impedance matched hybrid tee circuit [3].

Results and Discussion

The temperature dependence shown in Fig. 1 exhibits the characteristic peak at $T = 2T_F$ as expected for a 1D Fermi fluid. T_F is the Fermi temperature. At low temperatures one expects a linear temperature dependence and above $2T_F$ the relaxation time falls as $T^{1/2}$. The solid red line in Fig. 1 shows the temperature dependence calculated by Polini *et al.* [4]

The inferred Fermi temperature of 98 mK is lower than expected and this is attributed to an appreciable fraction of the ^3He being adsorbed at sites other than the interior of the nanotubes and this has been observed by others [5].

Conclusions

The temperature dependence measured for the nuclear spin-lattice relaxation time is consistent with the prediction for a 1D fermi gas obeying Luttinger liquid dynamics.

Acknowledgements

This research was carried out at the National High Magnetic Field Laboratory's High B/T Facility which is supported by the National Science Foundation through NSF/DMR-1157490/1644779 and the State of Florida.

References

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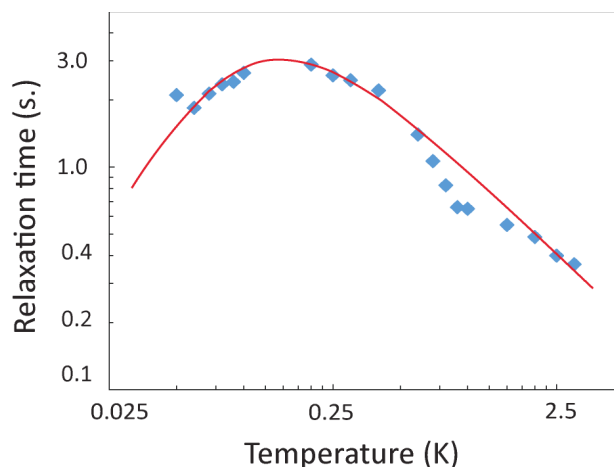


Fig.1 Observed temperature dependence of the nuclear spin-lattice relaxation time of ^3He in MCM-41 nanochannels.