DYNAMICS OF HD ADSORBED ON MCM-41: NMR STUDIES

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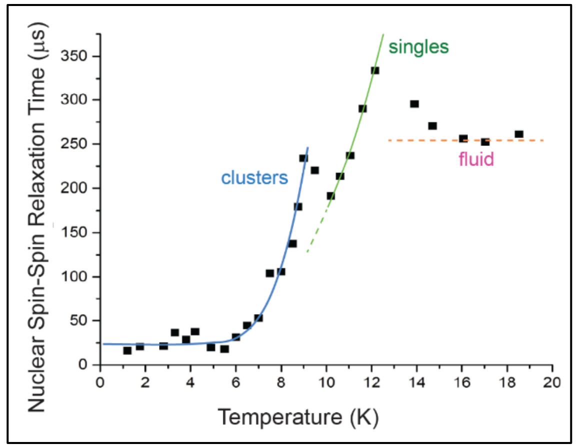

Interesting new properties are predicted [1], [2] for quantum fluids and solids confined to nanopores when the physical dimensions are smaller than the de Broglie wavelength, the Fermi length or the thermal phonon wavelength. In particular quantum clusters can form when the de Broglie wavelength of the atoms overlap in a mesocopic cage. Heat capacity studies [3] have revealed 2D-1D crossover behavior but little is known about the dynamics in such systems. Understanding the dynamics of atoms and molecules confined to nanoscale structures is needed to develop these materials for applications such as CO_2 sequestration, hydrogen storage, and molecular sieving in the petroleum industry.

We have measured the temperature dependence of the nuclear spin-spin and spin-lattice relaxation times of HD molecules adsorbed on the mesoporous molecular sieve MCM-41. These relaxation times provide quantitative values for the local diffusion in the confining structure and the thermal activation of the diffusion. At low temperatures we observe two distinct temperature dependences (Fig. 1). This behavior is consistent with the formation of quantum clusters of the molecules as proposed by Wada and Cole [1] but further measurements are needed to confirm this interpretation.

[1] N. Wada and M. Cole, J. Phys. Soc. Jpn **77**, 111012 (2008).
[2] N. Wada, T. Matsushita, M. Heda and R. Toda, J. Low Temp. Phys. **157**, 324 (2009).
[3] T. Matsushita, R. Toda, M. Heda and N. Wada, J. Phys. Conf. Ser. **150**, 032055 (2009).
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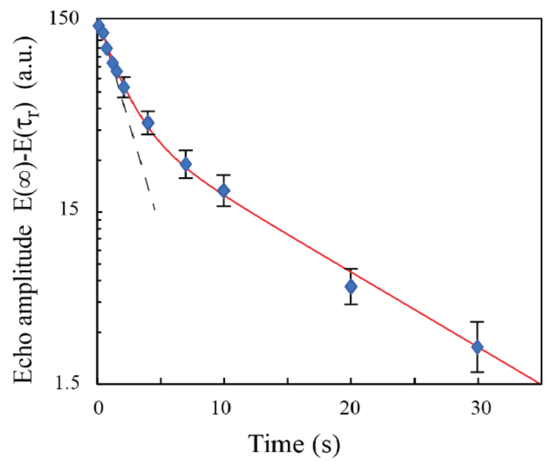

Figure 1. Time dependence of relaxation showing NMR echo recovery is a two stage process.

NMR STUDIES AT VERY LOW TEMPERATURES AND HIGH MAGNETIC FIELDS.

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NMR techniques can provide a very useful probe of the microscopic dynamics of materials at very low temperatures because the relaxation times depend on the motions of the atoms and molecules that constitute the materials. The motion modulates the nuclear spin-spin interactions and the Fourier transforms of these fluctuations can induce transitions between the spin states and thus the relaxation of nuclear magnetization.[1]

The Fourier transforms of the spin-spin correlation functions are known as the spectral densities. The spectral densities at the nuclear Larmor frequencies, or twice the Larmor frequency, determine the nuclear spin-lattice relaxation. The spectral densities at zero frequency determine the nuclear spin-spin relaxation times. Experimental values of these relaxations times can therefore be used to determine both fast and very slow motions.

Some theoretical knowledge of the nature of the motion is important for a proper analysis of the motion as the correlation functions are not always simple exponentials as often assumed in the simplest cases.[2]

[1] N. Bloembergen, E. M. Purcell and R. V. Pound, Phys. Rev. **76**, 679 (1948).
[2] A. B. Careful, *et al*., Nature Physics, in press.

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