DC SQUID NMR Study of Very Dilute ^{3}He-^{4}He Mixture Films in Nanopores

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We have used DC SQUID NMR and vapour pressure measurements to study very dilute ^{3}He-^{4}He mixture films adsorbed in the mesopores of MCM-41, down to 1.7 K. The substrate is a powder of grain size ∼300 nm which consists of a hexagonal array of straight 2.3 nm diameter pores. The pores were initially preplated with 1.12 monolayers of ^{4}He before adding 0.01 monolayer of ^{3}He. At such low ^{3}He coverages this system is expected to exhibit a crossover to a quasi-1D state at temperatures sufficiently below 700 mK. Evidence for such a crossover has been observed on a similar substrate, using heat capacity measurements.[1] In order to get sufficient signal sensitivity at this low ^{3}He coverage, we developed a broadband NMR spectrometer based on a SQUID with additional positive feedback (APF), which has an overall coupled energy sensitivity of 30 h with the SQUID at 1.7 K, where h is Planck's constant. NMR relaxation times T_1 and T_2^* were measured as a function of temperature at frequencies from 80 to 240 kHz. T_1 and T_2^* were found to be independent of ^{3}He coverage at very low densities, suggesting that the relaxation times are dominated by single particle effects. These data were consistent with 2D diffusive motion in mangetic field gradients. Changes in the observed relaxation times measured as a function of ^{4}He density were found to follow changes in the isothermal compressibility of the film.

[1]J. Taniguchi *et al.*, Phys. Rev. Lett. *94*, 065301 (2005).