^{3}He Monolayers on Graphite in Ferromagnetic Regime: Cluster Size Effect

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The second solid ^{3}He monolayer on graphite provides an excellent example of a nearly perfect 1/2 - spin nuclear magnet on a triangular lattice. As the total coverage increases, the exchange J in the second layer evaluates from antiferromagnetic ($J > 0$) up to ferromagnetic ($J < 0$) with maximum of susceptibility just at third layer completion. The experiments on magnetization show that ^{3}He layers behave like a complex of magnetic nanoclusters whose average size varies with total coverage of the ^{3}He multilayered system. We investigate the magnetization of 2D ^{3}He monolayer theoretically within a ferromagnetic Heisenberg model (HFM) in an external magnetic field. We employ an analytical approach based on a second-order two-time Green function formalism with a new decoupling scheme that describes properly the HFM thermodynamics for both infinite and finite-sized spin systems in the whole temperature range at arbitrary fields h. In particular, the proposed method improves significantly the description of the 2D HFM at $h < T < J$ (J is an exchange constant) and ultralow magnetic fields $h/J \ll 1$, where the measurements for solid ^{3}He monolayers are usually made. The obtained results are used to give a consistent interpretation to a great number of known from literature experimental data on magnetization of the second solid ^{3}He monolayer in the ferromagnetic regime. It is proved that at dense coverages $\rho \geq 0.22\text{Å}^{-2}$ the pure Heisenberg behavior of 2D solid ^{3}He occurs, and the theory is in excellent agreement with the experimental data at all temperatures. The coverage dependences of the exchange constant, saturation magnetization M_{sat}, and average cluster size N are analyzed in detail. The exchange constant is found to display nonmonotonic behavior with increase in coverage, whereas M_{sat} as well as N continuously grow tending to their limiting values. Magnetization of 2D ^{3}He-^{4}He solid solutions has been also discussed.

Section: LD - Low dimensional and confined systems

Keywords: ^{3}He monolayers, magnetization, ferromagnetic Heisenberg model