Quantum flexible quasi-molecular chains in optical lattice

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We consider dipolar molecules in layered optical lattice with N layers (which can be 2d planes or 1d "cigars") and the polarization perpendicular to the layers[1,2]. First-principle quantum Monte Carlo canonical simulations of N molecules arranged one per layer in the absence of inter-layer tunneling find formation of a single N-molecular chain for strong enough dipole interaction V (in units of the intra-layer band width t). Such flexible quantum chains are analogous to classical chains found in magnetic and electric dipolar colloids[3]. Single chain formation is seen by columnar imaging of the density distribution map: For small V such map shows mostly single molecules distributed independently in each layer. Above some critical value $V_c \approx 0.75$ configurations where all molecules are atop of each other dominate the density map. Gyration radius exhibts log-growth with number of layers in a narrow range of V (up to ~ 1.25 in 2d), which indicates quantum rough state of single chain. At higher V this chain exhibits KT transition into autolocalized stiff (smooth) chain. The question of the nature of multi-chain state is addressed by J-current model simulations[2]. Superfluid phase of chains for fixed N is found, with the range of its existence shrinking as N increases.

This work is supported by NSF grant PHY-0653135.

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