Superfluidity of flexible chains of dipolar molecules in layered optical lattices

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We study properties of quantum chains in a gas of polar bosonic molecules formed in a stack of N identical one- and two- dimensional optical lattices, with molecular dipole moments aligned perpendicularly to the layers. Quantum Monte Carlo simulations of a single chain (formed by a single molecule on each layer) reveal its quantum roughening transition. The case of in-layer finite density of the molecules is studied within the framework of the J-current model approximation, and it is found that N-layered molecular superfluid can undergo a quantum phase transition to a rough chain superfluid. A theorem is proven that no superfluidity of chains with length shorter than N is possible. The scheme for detecting chain formation is proposed [1]. In the case of 1d "cigar"-type layers at $T = 0$, the transition is a multi-layered version of the Berezinskii-Kostrelitz-Thouless transition. The bosonization-type approach similar to Refs.[2] captures its main features. In the case of 2d layers the transition becomes of strongly first-order which agrees well with the mean-field description.

[1]B. Capogrosso-Sansone and A.B. Kuklov, arXiv:1101.1901.
[2]A. Vishwanath & D. Carpentier, Phys. Rev. Lett. **86**, 676(2001); A. Hu,*et al.*, Phys. Rev. **A 80**, 023619 (2009)