Abstract Submitted
for the DAMOP20 Meeting of
The American Physical Society

Designing Quantum Phases at the interface of Atomic and Two-Dimensional Dirac Quantum Matter[1] VALERI KOTOV, ADRIAN DEL MAESTRO, JIANGYONG YU, TARAS LAKOBA, Univ of Vermont — Novel two-dimensional (2D), atomically flat materials, such as graphene and transition-metal dichalcogenides, exhibit unconventional Dirac electronic spectra, and we propose that their interactions with cold atoms can be effectively quantum engineered, leading to a synergy between complex electronic and atomic collective quantum phases and phenomena. In particular we discuss theoretically how to manipulate the Casimir / van der Waals (vdW) force between atoms and graphene monolayer through the application of strain, electronic doping, etc., which can lead to selective adsorption and also change the interactions between individual atoms. This allows us to influence fundamental phenomena such as Quantum Reflection, and also analyze manifestations of such 2D effects for many atoms forming a confined Bose-Einstein condensate (BEC) placed near 2D materials, which in turn makes the BEC frequency sensitive to the material presence. Finally we discuss the exciting possibility of a novel 2D anisotropic superfluid state formed by helium on strained graphene. This is based on preliminary large-scale ab initio quantum Monte Carlo simulations combined with a mapping of the problem to an effective Bose-Hubbard model.

[1]This work received support under NASA grant number 80NSSC19M0143.

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Date submitted: 30 Jan 2020 Electronic form version 1.4