

Validating a quantum simulator for the Hubbard model: do ultra-cold atomic gases live up to their promise?

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Ultracold atomic gases in optical lattices provide controllable, tunable and clean implementation of strongly interacting quantum many-body systems. They offer the possibility of an almost verbatim realization of prototypical models in condensed matter physics, realizing Feynman's idea of a quantum simulator. They have the potential for solving many open problems in condensed matter physics, from strongly correlated fermion systems to non-equilibrium effects. However, an essential precondition before they can be used as quantum simulators is their quantitative validation for a representative benchmark problem, to check whether they live up to their promise. In this talk I will present a the first ab-initio comparison validation of an experiment on ultracold atomic gases by quantum Monte Carlo simulations. Our benchmark problem is the suppression of the superfluid transition temperature in a strongly interacting Bose gas as a Mott insulator is approached. Accounting for all experimental details, including effects that were considered unimportant before, we find excellent agreement between theory and experiment, thus demonstrating the feasibility of an optical lattice quantum analog computer. However, there are still substantial challenges to be overcome before such quantum simulators can be used to solve interesting open problems in condensed matter physics.