Quantum control of ultracold atoms: a serious game

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Progress in the field of quantum technology is hampered by daunting technical and theoretical challenges. Here I present an alternative approach to solving these by enlisting the aid of computer players around the world. In the online computer game Quantum Moves [1], we have encapsulated the time-dependent Schrödinger equation for various problems in a graphical user interface allowing for easy user input. The game has so far been played nearly 300,000 times and preliminary analyses suggest that players are more efficient at solving many problems than state-of-the-art optimization algorithms.

Extensions of the approach to Gross-Pitaevskii and Bose-Hubbard modelsare currently under development with the ultimate goal of developing a graphical simulation tool that can be used to enhance the innovative process of theoretical and experimental physicists in the field of ultra-cold atoms.

In the second half of my talk, I will focus on our efforts towards the non-destructive probing of ultra-cold atoms in optical lattices. We have recently [2] demonstrated non-destructive probing of an ultra-cold atomic cloud up to 2,000 times using the Faraday interaction of light and matter and applied the approach to speed up the characterization of various experimental parameters such as atom number, magnetic field, and trap frequency. Theoretically we explore the rich dynamics generated by combining the intrinsic tunneling dynamics in optical lattices with a sequence of measurements of the population of even lattice sites. We demonstrate quantum state preparation of e.g. Schrödinger cat states using appropriately timed projective measurements and investigate the result of a continuous weak probing of the lattice ground state at various values of U/J. In the latter, we identify a regime in which the probing induces larger next-neighbor correlations than nearest-neighbor reminiscent of a supersolid state.

[1] http://www.scienceathome.org

[2] Gajdacz et al, Rev. Sci. Instr. 84, 083105 (2013)