Simulation of quantum many-body dynamics using dynamical coarse graining: application to tunneling.

M. Khasin and R. Kosloff

Fritz Haber Research Center for Molecular Dynamics,

Hebrew University of Jerusalem, Jerusalem 91904, Israel

(Dated: October 13, 2008)

Abstract

Simulating the dynamics of a restricted set of observables of a many-body system is a very difficult problem. An efficient simulation is one that the computation resorces does not scale with the number of partcles. We present a method to carry out such simulations for a restricted set of many body observables. The set comprises the spectrum-generating algebra (SGA) of observables of the system. The technical development of the algorithm relies on the close connection between the algebra of observables and the set of states minimizing the generalized uncertainty with respect to these observables − the generalized coherent states (GCS). These states serve as dynamical basis functions for expanding the state of the system. The original unitary dynamics of the observables is simulated by a pertinent open-system dynamics, which can be interpreted as a weak measurement of the elements of the SGA, performed on the evolving system. The measurement leads to a coarse-graining of the evolving state in the corresponding phase-space. The coarse-grained mixed state can be represented as a mixture of pure states, localized in the phase-space. The evolution of the pure states is governed by the stochastic nonlinear Schrödinger equation (sNLSE), which can be simulated at dramatically lower computational cost using expansion of the localized solutions in the basis of the GCS. The algorithm is demonstrated in the simulation of the dynamics of a system of $2 * 10^4$ cold atoms in the double-well trap, described by the two-sites Bose-Hubbard model[1, 2].

[1] Michael Khasin and Ronnie Kosloff, Phys. Rev. A **78**, 012321 (2008).

[2] Michael Khasin and Ronnie Kosloff, J. Phys. A: Math. Gen. **41**, 365203 (2008).