Title: Quantum nuclear dynamics beyond the independent particle picture

Abstract:

The dynamics of nuclear systems quickly becomes more and more difficult to describe accurately with increasing particle number because of the exponential growth of the size of the associated Hilbert space. This constitutes a great challenge since nuclear systems can contain up to several hundreds of particles.

A simplified approach of the problem is to suppose that some degrees of freedom (DoFs) contain more information than other. One usual approximation in Nuclear Physics is to take interest in the one-body DoFs only. The dynamics is approximated using nucleons that are freely moving inside a Mean-Field potential [1,2]. In this approach, the system is described as a Slater determinant at all times. Although it lead to an understanding of several key properties of the nuclear medium, the Mean-Field approach is not able to describe several important phenomenons, such as collision effects at finite temperature.

The possibility to apply phase-space methods to many-body interacting systems, however, might provide accurate descriptions of correlations with a reduced numerical cost. For instance, the so-called stochastic mean-field phase-space approach [3,4], where the complex dynamics of interacting fermions is replaced by a statistical average of mean-field like trajectories is able to grasp some correlations beyond the mean-field. We explore the possibility to use alternative equations of motion in the phase-space approach. Guided by the BBGKY hierarchy [5], equations of motion that already incorporate part of the correlations beyond mean-field are employed along each trajectory. The method is called Hybrid Phase-Space (HPS) [6] as it mixes phase-space techniques and the time-dependent reduced density matrix approach. The novel approach is applied to the one-dimensional Fermi-Hubbard model. We show that the predictive power is improved compared to the original stochastic mean-field method. In particular, in the weak-coupling regime, the results of the HPS theory can hardly be distinguished from the exact solution even for long time.

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