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**Description of correlations in the dynamics of interacting Fermi systems**

Abstract :

The dynamics of a quantum system of interacting particles rapidly becomes impossible to describe exactly when the number of particles increases. This is one of the main difficulties in the description of atomic nuclei, which may contain several hundred of nucleons. A simplified approach to the problem is to assume that some degrees of freedom contain more information than others. A classical approximation is to focus on one-body degrees of freedom: the dynamics of the system can be approximately described by a set of particles propagating in an effective mean-field. While the mean-field approximation has allowed many advances in the theoretical understanding of the properties of nuclei, it is still unable to describe certain of their properties, for example the effects of direct collisions between nucleons or the quantum fluctuations of one-body observables. The objective of the thesis is to account for these correlations beyond the mean-field approximation in order to improve the dynamical description of quantum correlated systems.

One component of the thesis has been to study methods to treat collisions between particles by including the Born term beyond the mean-field. This term is particularly complex because of non-local effects in time, the so-called non-Markovian effects. Possible simplifications of this term have been studied for future applications. Two simplifying approaches have been proposed, one allowing to treat the collision term with master equations, the other allowing to get rid of time integrals while keeping the non-locality in time. The second part of the thesis was devoted to the improvement of the mean-field approximation in order to describe the quantum fluctuations. Based on existing phase space methods, a new method, called "Hybrid Phase Space Method" (HPS) has been proposed. This method is a combination of the mean-field theory with initial fluctuations and a theory where the two-body degrees of freedom are propagated explicitly. This new approach has been successfully tested for the description of an ensemble of fermions on a lattice, i.e. the Fermi-Hubbard model, and has given much better results than the phase-space approaches previously used to describe correlated systems, in particular in a weak coupling case. If this new approximation gives interesting results, it remains numerically rather heavy and empirical. This led to a detailed study of the Wigner-Weyl and Bohm formalisms in order to explore phase-space methods in a more systematic way. The notion of trajectory in quantum mechanics has been systematically investigated. The conclusion of this study, where illustrations have been made on the tunneling effect, is that it is necessary that the trajectories interfere with each other in the course of time to reproduce the quantum effects.