Towards many-body quantum dynamics based on fluctuations

Erik Schroedter, Michael Bonitz, and Jan-Philip Joost

Institute for Theoretical Physics and Astrophysics, Universiy Kiel, Germany, Leibnizstr. 15, 24098 Kiel, Germany

Many-body quantum dynamics is a hot topic in a broad range of fields, including systems as diverse as cold atoms in optical lattices, correlated condensed matter systems and dense quantum plasmas and warm dense matter. The goal is the computation of the nonlinear response of the system to a time-dependent external excitation and the subsequent relaxation, fully including quantum, spin and correlation effects. The standard approaches include reduced density operators (RDO) and Nonequilibrium Green functions (NEGF) that give rise to a hierarchy of coupled equations of motion for the reduced quantities, such as the BBGKY-hierarchy of RDO or the Martin-Schwinger hierarchy of NEGF, e.g. [1]. Recently a dramatic speedup of the numerical solutions of the quantum dynamics that include dynamical screening and strong coupling could be achieved [2,3] which will be demonstrated in the first part of the talk. In the second part, we explore an independent approach to the quantum dynamics that is based on the time evolution of correlation functions of quantum fluctuations. This is motivated by successful concepts in classical plasmas [4], in correlated quantum plasmas in equilibrium [5] and various phenomenological stochastic concepts in quantum systems, e.g. [6]. Here we present a rigorous derivation of the hierarchy of equations of fluctuations of the NEGF and compare it to the aforementioned approaches [7].

[1] M. Bonitz, „Quantum Kinetic Theory“, 2nd ed. Springer 2016

[2] N. Schlünzen, J.-P. Joost, Phys. Rev. Lett. 124, 076601 (2020)

[3] J.-P. Joost, N. Schlünzen, and M. Bonitz, Phys. Rev. B 101, 245101 (2020)

[4] Yu.L. Klimontovich, „Kinetic Theory of Nonideal Gases and Nonideal Plasmas“, Pergamon Press 1982

[5] T. Dornheim, S. Groth, J. Vorberger, and M. Bonitz, Phys. Rev. Lett. 121, 255001 (2018)

[6] D. Lacroix, S. Hermanns, C. Hinz, and M. Bonitz, Phys. Rev. B 90, 125112 (2014)

[7] E. Schroedter, J.-P. Joost, and M. Bonitz, to be published