WWTF Project MA14-002

Adaptive Time-Splitting for Many-Body Quantum Propagation

Abstract

Understanding non-equilibrium quantum many-body systems is one of the grand challenges in current physics. The ability to describe time-dependent extended systems on a quantitative level promises to open up new technological developments such as laser control of chemical reactions, femtosecond lightfield electronics, and material design for sustainable energy. Most experimental probes of quantum many-body systems rely on so-called pump-probe schemes. The system is driven out of equilibrium and the ensuing dynamics is studied. While for weak pump and probe fields the dynamics can be understood within linear response theory where essentially equilibrium (or near ground state) properties enter, stronger pumping requires a full time-dependent propagation beyond the perturbative limit. While the high-dimensional many-particle Schrödinger equation is too complex to be solved for more than a few particles in three dimensions, practically all approximations to it give rise to coupled nonlinear partial differential equations in space and time in reduced dimensions. Still, propagation of these equations constitutes a major challenge. In this proposal we aim for the development and implementation of highly efficient and accurate high-order adaptive time-splitting methods for the propagation of quantum many-body systems that are presently out of reach. We will investigate the efficiency, error, and speed-up of these methods and apply them to both fermionic and bosonic systems of current interest.

Scientific disciplines:
101014 - Numerical mathematics (50%) | 103025 - Quantum mechanics (50%)

Keywords:
Quantum many-body dynamics; Numerical methods; Splitting methods

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Further links about the involved persons and regarding the project you can find at
https://archiv.wwtf.at/programmes/mathematics/MA14-002