ATELIER SUR L'INFORMATION QUANTIQUE ET LA PHYSIQUE STATISTIQUE
18–21 OCTOBRE 2011

WORKSHOP ON QUANTUM INFORMATION IN QUANTUM MANY-BODY PHYSICS
OCTOBER 18–21, 2011

Time-dependent variational principle for quantum many-body systems

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We discuss the time-dependent variational principle in relation to the variational wave functions for quantum many body systems that have originated from quantum information perspectives in recent years. The time dependent variational principle was formulated by Dirac in the 1930s and can be applied to any variational manifold, resulting in e.g. the time-dependent Hartree-Fock equations or the Gross-Pitaevskii equations for mean field theory. An application to tensor network states had until recently not been attempted.

In this presentation, we explain how the time-dependent variational principle can efficiently be applied to both matrix product states and continuous matrix product states in order to describe real and imaginary time evolution. For the case of matrix product states, a powerful alternative to approaches based on the time evolving block decimation is obtained, which is globally optimal and better suited to respect symmetries. In combination with continuous matrix product states, where the time-evolving block decimation is not applicable, the time-dependent variational principle results in a very powerful approach to study both ground states and real time dynamics. If time permits, we also show how the time-dependent variational principle naturally results in a new ansatz to study low-lying excited states of quantum lattices and quantum fields.

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