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Process Tensor Networks for non-Markovian Many-Body Open Quantum Systems

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There is a range of interesting physical scenarios that include both many-body quantum systems *and* strongly coupled structured environments that lead to a non-Markovian evolution. However, almost all methods for the study of many-body systems only consider closed or Markovian dynamics, while methods for the study of non-Markovian open quantum systems are generally restricted to small system sizes. I will introduce a general numerical method to compute dynamics and multi-time correlations of chains of quantum systems, where each system may couple strongly to a structured environment [1,2]. The method combines the process tensor formalism for general (possibly non-Markovian) open quantum systems with time evolving block decimation (TEBD) for 1D chains. It systematically reduces the numerical complexity originating from system-environment correlations before integrating them into the full many-body problem, making a wide range of applications numerically feasible. Furthermore, on a more conceptional side, I will discuss fundamental connections among the concept of Markovianity, multi-time correlations, and the dynamics of a many-body open quantum system [3]. These connections not only have far reaching consequences in, for example, the field of strong coupling quantum thermodynamics, but also in many-body scenarios that are usually considered to be Markovian in the literature.

[1] G. E. Fux, D. Kilda, B. W. Lovett, and J. Keeling, *Thermalization of a spin chain strongly coupled to its environment*, arXiv:2201.05529 (2022).
[2] The TEMPO Collaboration, *OQuPy: A Python 3 package to efficiently compute non-Markovian open quantum systems*, ReadTheDocs (2020).
[3] G. E. Fux, *Operationally accessible information backflow in CP-divisible processes*, in preperation.

Abstract category

Numerical Methods

Primary author: FUX, Gerald E. (International Center for Theoretical Physics)

Co-authors: Dr KILDA, Dainius (Max-Planck-Institut für Quantenoptik); Prof. LOVETT, Brendon W. (University of St Andrews); Dr KEELING, Jonathan (University of St Andrews)

Presenter: FUX, Gerald E. (International Center for Theoretical Physics)