Abstract

In this talk, I will present new important analytical results on the dynamics of open quantum many-body systems, as described by a time-dependent quantum master equation. The first result is that the time evolution in this very generic setting can be simulated by a unitary quantum circuit of a size that scales polynomially with the system size and the time. An immediate consequence is that dissipative quantum computing is no more powerful than the unitary circuit model. It also follows that most quantum states cannot be prepared efficiently, i.e., that the enormous size of the state space is in a sense fictitious.

For the second result, I switch from the Schrödinger picture to the Heisenberg picture to address the evolution of operators in open systems with short-range interactions. Using a novel Lieb-Robinson bound on the propagation speed of information in such systems it can be shown that the dynamics is quasi-local. This means that the evolution of observables can be approximated by implementing the dynamics only in a vicinity of the observables' support. This can be exploited to simulate the evolution on classical computers with a cost that is independent of the system size. Providing error bounds for Trotter decompositions, it follows that the simulation on a quantum computer is additionally efficient in time. For experimental and theoretical investigations, the result can be used to bound finite-size effects.

[1] M. Kliesch, T. Barthel, C. Gogolin, M. Kastoryano, and J. Eisert "Dissipative Quantum Church-Turing Theorem", Phys. Rev. Lett. 107, 120501 (2011), also highlighted in D. Browne "Viewpoint: Quantum simulation hits the open road", Physics 4, 72 (2011)
[2] T. Barthel and M. Kliesch "Quasi-locality and efficient simulation of Markovian quantum dynamics", arXiv:1111.4210