Arnoldi-Lindblad time evolution: Faster-than-the-clock algorithm for the spectrum of (Floquet) open quantum systems

Fabrizio Minganti[1] and Dolf Huybrechts*[2]

[1]Institute of Physics, Ecole Polytechnique Fédérale de Lausanne (EPFL) – Switzerland
[2]Département de Physique [ENS Lyon] – École Normale Supérieure - Lyon – France

Abstract

The characterization of open quantum systems is a central and recurring problem for the development of quantum technologies. For time-independent systems, an (often unique) steady state describes the average physics once all the transient processes have faded out, but interesting quantum properties can emerge at intermediate timescales. Given a Lindblad master equation, these properties are encoded in the spectrum of the Liouvillian whose diagonalization, however, is a challenge even for small-size quantum systems. Here, we propose a new method to efficiently provide the Liouvillian spectral decomposition. We call this method an Arnoldi-Lindblad time evolution, because it exploits the algebraic properties of the Liouvillian superoperator to efficiently construct a basis for the Arnoldi iteration problem. The advantage of our method is double:
(i) It provides a faster-than-the-clock method to efficiently obtain the steady state, meaning that it produces the steady state through time evolution shorter than needed for the system to reach stationarity.
(ii) It retrieves the low-lying spectral properties of the Liouvillian with a minimal overhead, allowing to determine both which quantum properties emerge and for how long they can be observed in a system.
This method is general and model-independent, and lends itself to the study of large systems where the determination of the Liouvillian spectrum can be numerically demanding. Our results can be extended to time evolution with a time-dependent Liouvillian. In particular, our method works for Floquet (i.e., periodically driven) systems, where it allows not only to construct the Floquet map for the slow-decaying processes, but also to retrieve the stroboscopic steady state and the eigenspectrum of the Floquet map. We demonstrate the efficiency of our method on several examples of coupled bosonic systems.

*Speaker