Abstract

The dynamics of a quantum system that is not isolated are generally hard to obtain, either numerically or analytically. Usually, many approximations need to be employed. The most popular set of approximations leads to what is known as the Gorini-Kossakowski-Lindblad-Sudarshan (GKLS) equation, a Markovian master equation that is the cornerstone of open quantum systems theory. It is the most popular method despite of its known limitations, it is not a good approximation of transient dynamics, and if the coupling is not weak enough, it does not describe the steady state correctly either. Other popular methods are numerically exact, however, they rely on enlarging the Hilbert space of the system, which makes the simulation un feasible for many-body systems.

In this thesis, we provide an overview of the most common techniques to simulate open systems beyond the Markovian regime, with special emphasis on Non Markovian master equations such as the cumulant equation and the time-convolutionless equation. We provide a novel way to simulate them faster by approximating the environment in a way analogous to that used in numerically exact techniques. We show the potential of these equations and their superiority to the GKLS equation in several examples, showing that Non-Markovian equations are needed for a good description of finite-time thermodynamics.

Keywords:OpenQuantumsystems,Non-Markovianity, HEOM,Pseudomodes, Heat Transport