Dynamics of a small quantum system open to a bath with thermostat

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We investigate dynamics of a small quantum system open to a bath with thermostat. We introduce another bath, called super bath, weakly coupled with the bath to provide it with thermostat, which has either the Lindblad or Redfield type. We treat the interaction between the system and bath via a rigorous perturbation theory. Due to the thermostat, the bath behaves dissipative and stochastic, for which the usual Born-Markov assumption is not needed. We consider a specific example of a harmonic oscillator system, and a photonic bath in a large container, and a super bath of the Caldeira-Legget oscillators distributed on the inner surface of the container. We use the *P*-representation for the total harmonic system. We derive the reduced time-evolution equation for the system by explicitly finding the correlation between the system and bath beyond the product state, that was not obtainable in the previous theory for the system and bath isolated from environment, and marginalizing bath degrees of freedom. Remarkably, the associated dynamic equation for the system density matrix is of the same form as the Redfield master equation with different coefficients depending on thermostat used. We find steady state does not depend on thermostat, but time-dependent state does, that agrees with common expectation. We expect to apply our theory to general systems. Unlike the usual quantum master equations, our reduced dynamics allows investigation for time-dependent protocols and non-equilibrium quantum stochastic dynamics will be investigated in future.

[1] C. Kwon and J-Y Gyhm, arXiv:2404.15568