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Non-Markovian dynamics of fermionic and bosonic systems coupled to several heat-baths

Employing the fermionic and bosonic Hamiltonians for the collective oscillator linearly FC-coupled with several heat-baths, the analytical expressions for the collective occupation number are derived within the non-Markovian quantum Langevin approach. The master-equations for the occupation number of collective subsystem are derived and discussed. In the case of Ohmic dissipation with Lorenzian cutoffs, the possibility of reduction of the system with several heat-baths to the system with one heat-bath is analytically demonstrated. For the fermionic and bosonic systems, a comparative analysis is performed between the collective subsystem coupled to two heat baths with the reference case of the subsystem coupled to one bath.

Summary

The non-Markovian quantum Langevin equation was derived under the physical hypotheses that at the initial time the heat baths are in the thermal equilibrium in the absence of the collective subsystem. For the collective bosonic or fermionic oscillator and several internal bosonic or fermionic heat-baths coupled linearly, the analytical expression for the collective occupation number was derived with the non-Markovian quantum Langevin approach. The asymptotes of the fermionic and bosonic occupation numbers were found.

In bosonic and fermionic cases, the statistics of particle in the effective bath differs from the original ones and can not be taken anymore as either bosonic or fermionic. In the Marokovian limit, the coupling to several bosonic baths is reduced to the coupling to one bosonic bath in which the effective temperature is a weighted average of the temperature of the original baths. As well as for fermionic case, the inverse temperature is the weighted average of the inverse temperatures of different original baths.

For the fermionic and bosonic systems with two baths (in the case of Ohmic dissipation with Lorenzian cutoffs), the results of illustrative numerical calculations of diffusion and friction coefficients and level populations were presented. The values of the time-dependent occupation number and decay rate in the bosonic system oscillate with larger amplitude than those in the fermionic system. However, the relaxation time is almost independent of the statistical nature of the baths. The relaxation times of the systems with two baths and with one bath are almost identical if there is no large difference in the bandwidths of the baths. For both statistics, the values of occupation numbers of the systems with two baths are in between the values of the occupation numbers of the corresponding systems with one bath. Two independent non-Markovian baths modify in non-additive manner the dynamics of a collective subsystem.

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