Spin impurity in interaction with multiple baths via non-commuting coupling operators: An analytic approach

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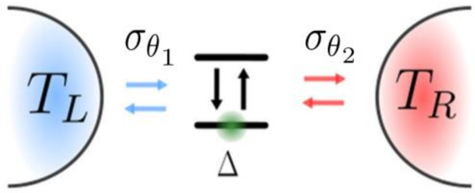
The Effective Hamiltonian theory [1] allows analytical studies of quantum dynamics and thermodynamics in the strong system-bath coupling limit. Here, we present an extension to the Effective Hamiltonian framework and tackle the problem of quantum systems coupled to *multiple* reservoirs through *non-commuting* system's operators. We report that this approach, which includes generalizing the mapping procedure, yields closed-form analytical expressions that expose the nontrivial impact of strong coupling effects on, e.g., spin magnetization at equilibrium and heat current in a nonequilibrium steady state. This tool will augment numerical studies based on quantum master equations and path integral approaches. Future prospects include extending this procedure to study dissipative spin chains. For example, coupling spin lattices to multiple environments could allow engineering their magnetic or topological order [2].



$$\sigma_{\theta_i} = \sigma_z \cos(\theta_i) + \sigma_x \sin(\theta_i)$$

Figure 1: Example of a two-level system, coupled to two bosonic bath of different temperature via coupling operators in the form of linear combinations of Pauli Matrices. This system can now be analytically described using the generalized effective Hamiltonian method described above. Figure based on [1].

References

[1] Nicholas Anto-Sztrikacs, Ahsan Nazir, Dvira Segal, PRX Quantum, 2023

[2] Brett Min, Nicholas Anto-Sztrikacs, Marlon Brenes, Dvira Segal, arXiv preprint, 2024