Usage Report for Fiscal Year 2021

Project Title:

Rabi-Raman scattering in Ultrastrong coupling regime

Name:

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1. Background and purpose of the project, relationship of the project with other projects

The prototypical system constituted by a two-level atom interacting with a quantized single-mode electromagnetic field is described by the quantum Rabi model (QRM). The QRM is potentially valid at any light-matter interaction regime, ranging from the weak to the deep strong coupling . However, when reaching the ultrastrong coupling regime, several theoretical issues may prevent the correct description of the observable dynamics of such a system. We study the photon flux emission rate of this system under the incoherent excitation of the two-level atom for any light-matter interaction strength, and consider different effective temperatures.

2. Specific usage status of the system and calculation method

Julia, Python, QuTiP, to simulate dissipative dynamics with Lindblad master equation and quantum Monte Carlo approach.

3. Result

We calculate numerically cavity and qubit emission rates and spectra versus the normalized light-matter coupling strength and for different incoherent qubit excitation strengths (effective temperature).

4. Conclusion

The obtained results are gauge independent. The theoretical framework allows us to investigate the light-matter decoupling and the fate of the Purcell effect in the QRM when the normalized coupling strength is significantly larger than one. In this case, we found that the cavity and qubit emission rates are affected both by light-matter decoupling and qubit-reservoir decoupling.

5. Schedule and prospect for the future

We want to study the emission rate of the Rabi model under the coherent excitation of the two-level atom for Ultra-light-matter interaction strength, and considering different effective temperatures. The dependence of the emission spectra on the coupling strength is the result of the interplay between energy levels, matrix elements of the observables, and the density of states of the reservoirs. The obtained results are gauge invariant and differ significantly from those obtained ignoring gauge issues.

6. If no job was executed, specify the reason.