Usage Report for Fiscal Year 2022

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. In particular, intriguing effect can be observed in ultrastrong coupling (USC) regime, for instance, Raman scattering of incident radiation in USC-cavity-QED systems without external enhancement or coupling to any vibrational degree of freedom. Raman scattering processes can be evidenced as resonances in the emission spectrum, which become clearly visible as the cavity-QED system approaches the USC regime.

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 provide a quantum mechanical description of the effect, and show that USC regime is a necessary condition for the observation of Raman scattering. We study quantum correlations in Raman photons.

4. Conclusion

We have demonstrated that spontaneous scattering of Raman photons from coherently driven cavity-QED systems can be visible in the USC regime without involving any vibrational degree of freedom. This result introduces new fingerprints of strong light-matter interaction that will allow us to leverage the potential of Raman spectroscopy for system characterization in the field of cavity-QED. The findings that we describe should be readily observable in superconducting circuits platforms.

5. Schedule and prospect for the future

The study of quantum correlations in Raman photonst, and its strong sensitivity to the system parameters, opens new avenues for the characterization of cavity-QED setups and the generation of quantum states of light.

6. If no job was executed, specify the reason

[Paper accepted by a journal]

Phys. Rev. Lett. 129, 273602 – Published 29 December 2022

https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.129.273602