Ultrastrong Coupling in an Optomechanical System

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The ultrastrong coupling regime, where the coherent coupling rate approaches the transition energy of the system, is a rarely studied area of physics despite its vast array of novel physics such as two-mode squeezing [1], the dynamical Casimir effect [2] and non-gaussian ground states [3]. Only a handful of experiments have been recently developed to probe this regime due to the large technologically challenges associated with engineering such a system [4].

Here, we implement a simple scheme for reaching the ultrastrong coupling regime in an optomechanical system which can be dynamically tuned to implement a wide range of quantum control protocols. We achieve this by coupling a levitated nanoparticle to an optical cavity through coherent scattering. Together with the ability to cool the system to its motional ground state [5], this result opens up quantum experiments in the ultrastrong regime to simple table-top systems. Lastly, we outline how to extend this to the deep strong coupling regime and its potential for future applications.

References

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