Quantum Coherence and Decoherence in Cavity Optomechanics

From 2013-12-01 to 2015-11-30, closed project

Objective

Rapid progress in the field of optomechanics has undergone a paradigm shift in the last two years. It is now possible to use light to prepare and sense the quantum ground state of a nanomechanical oscillator. Alongside parallel developments in electromechanics, this success marks the emergence of a third wave of quantum technology based on mechanical systems, following in the footsteps of atomic physics in the 1970s and solid state spin ca. 10 years ago. The new field of quantum optomechanics faces key challenges on several fronts, including execution of protocols for preparation and readout of nontrivial quantum states, mitigation of fundamental sources of mechanical decoherence, and the search for robust and field-distributable architectures. The following proposal takes aim at this new threshold, exploring fundamental and practical aspects of coherence in a mechanical system optomechanically-cooled to near the quantum ground state. We build upon the capabilities of a state-of-the-art optomechanical system developed by the host group of T. J. Kippenberg at EPFL, consisting of a cryogenically-cooled silica microcavity with strongly coupled, high-Q optical and mechanical resonances. Using the recent development of quantum-coherent optomechanical coupling, we propose to demonstrate, for the first time, quantum-coherent state transfer of a nanomechanical resonator onto an optical field. Second, exploiting the tools of cryogenic optomechanics, we seek to observe and control resonant coupling of a micromechanical resonator to a two-level-fluctuator for the first time. Third, building upon developments in the integration of ultr-high-Q SiN nanobeams and Silica micro-disk resonators, we propose to realize a robust chipscale optomechanical system suitable for ground-state cooling using a simple table-top cryocooler.

(The applicant was trained at Caltech in the quantum optics group of J. Kimble, and brings significant cross-disciplinary expertise to the project.)

Related information

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Report Summaries
Final Report Summary - QCDOM (Quantum Coherence and Decoherence in Cavity Optomechanics)
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Subjects
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