Micro- and nano-optomechanics towards quantum state and hybrid devices

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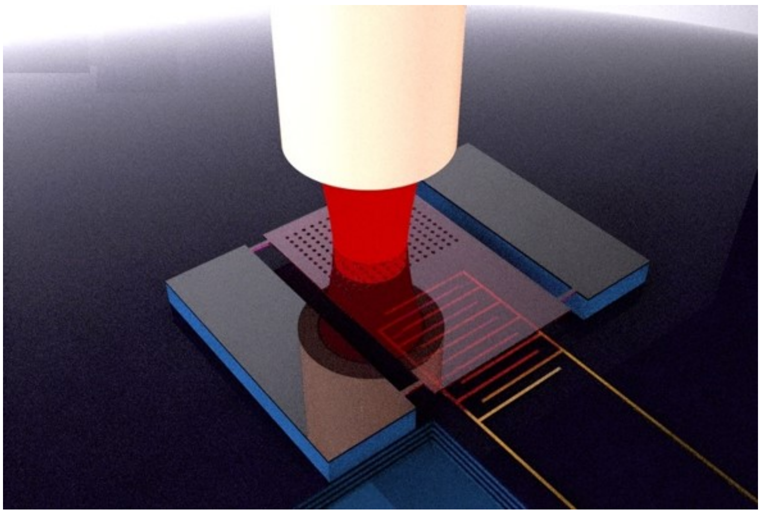
Reaching the quantum ground state of macroscopic and massive mechanical objects is a major experimental challenge at the origin of the rapid emergence of cavity optomechanics. Indeed, past years have witnessed the development of a new research field that studies the interaction between radiation pressure of light and nano- or micro-mechanical resonators. This field aims at studying basic concepts of quantum and measurement theories, such as the quantum nature of macroscopic objects or backaction effects in very sensitive measurements, with applications ranging from novel classical force sensors with unprecedented sensitivity to the understanding of quantum limits in interferometric measurements such as gravitational-wave interferometers. Fundamental tests of quantum theory are also of concern, with the possibility to study the entanglement and decoherence of macroscopic objects, or how radiation-pressure backaction can be circumvented in optical measurements.

Our team is developing new generations of optomechanical devices, either based on 1-mm long micropillars with very high mechanical quality factor or on photonic crystal suspended nanomembranes. Both are used in high finesse Fabry-Perot cavities leading to ultra-sensitive interferometric measurement of the resonator displacement. We expect to reach the ground state of such optomechanical resonators combining cryogenic radiation-pressure coolings. We already carried out a quantum-limited measurement of the micropillar thermal noise at low temperature, and a cold damping of the nanomembrane. We also investigate the possibility to develop a hybrid platform which may be very helpful for quantum engineering and quantum information processing, by coupling our suspended nanomembranes to cold atoms or to microwave circuits.



Example of a hybrid device coupling microwave and optical photons through their interaction with a suspended nanomembrane: its motion changes both the optical cavity length and the capacitance in the microwave circuit