Optomechanical resonators for cryogenic operation

P.-F. Cohadon, A. Kuhn, C. Molinelli, T. Antoni, J. Teissier, T. Briant, and A. Heidmann

Laboratoire Kastler Brossel, ENS-UPMC-CNRS, Paris, France

Reaching the quantum ground state of a macroscopic mechanical object appears as a major challenge, at the origin of the rapid emergence of the cavity optomechanics research field. Many groups have been targeting this objective for a decade, using a wide range of resonators oscillating at frequencies from a few Hz to the GHz-band, and different techniques of displacement sensing. The development of a very sensitive position sensor combined with a mechanical resonator working in its quantum regime would have very important consequences, both for fundamental aspects in quantum physics such as entanglement and decoherence of mechanical resonators, and for applications such as the detection of very weak forces.

To demonstrate the mechanical ground state, the thermal energy has to be small with respect to the zero-point quantum energy: $k_\mathrm{B} T_\mathrm{c} \ll h\nu_\mathrm{m}$. For a resonator oscillating at a frequency $\nu_\mathrm{m} = 4\,\mathrm{MHz}$, the resulting temperature T_c is in the sub-mK range and cannot be reached by conventional cryogenic cooling. It has therefore to be combined with a novel mechanism such as cavity cooling.

We present a new generation of high-Q high-frequency optomechanical resonators, designed for dilution fridge operation at 100 mK and optical cooling using a small-waist Fabry-Perot cavity.