Title: Quantum Study of Optical and Geometrical Nonlinearities in Fabry-Pérot Optomechanical Cavity

Abstract:

Cooling a mechanical nano-structure towards its quantum ground state is in the heart of both fundamental science and technology nowadays. This enables the suppression of undesirable effects of the decoherence on quantum applications such as quantum sharing information and quantum computation through the generation of robust quantum states.

Considering the technological advances, phonon number less than unity have been achieved (n_{eff}<1) during these five last years. However, reaching the Standard Quantum Limit (n_{eff}= 0) remains an experimental challenge which seems to be explained in nonlinear terms. To give a satisfactory explanation to this problem, we focused our thesis works on the nonlinear phononics study at the single-phonon level in optomechanical systems. We have shown that:

- Softening geometrical nonlinearity allows a classical control of the nanoresonator.

The nonlinear term, through a semiclassical study, gives results which agree well with the quantum ones;

- Geometrical nonlinearity as the quantum decoherence, adds some of amount of phonons on the lowest result, and then limits the quantum ground state achievement. This allows us to show how very finesse structures (m_1) could be used to reduce the nonlinear effects and therefore suppress the quantum decoherence;

- Both at the mechanical and optical resonances where the geometrical and optical nonlinearities reach their maximum value, the squeezing is limited;
- At the blue detuning sideband, geometrical nonlinearity enhances the generation of robust CV entanglement against thermal decoherence.

The relevant fact of these results is that nonlinear effects not only contribute to the advance of the fundamental science but also appear as pillar elements for an improvement of quantum applications.

Keywords: Optomechanical oscillator, geometrical nonlinearity, optical nonlinearity, quantum ground state cooling, squeezing, entanglement.

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