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PM2: Optomechanics: Exploring Physics from the macroscopic down to the nanometric scale

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Optomechanics is the field of Physics that studies the reciprocal interactions between light and mechanical motion.Originally introduced in the context of gravitational wave detection in the 1960's[1], this approach quickly became a template for the study of Quantum Measurement[2], with the outstanding perspective to investigate the fundamental principles of quantum mechanics at the macroscopic scale[3].

The extreme weakness of quantum optomechanical effects raises a number of technological challenges aiming at developingoptomechanical systems with enhanced light-motion interaction.In particular, the approach of cavity optomechanics[4]has proven to be remarkably efficient, enabling the first displacement measurement below the attometre level ($10^{-18}m$) [5] as well as the first radiation pressure cooling of a gram-scale object [6] in the late 1990's.

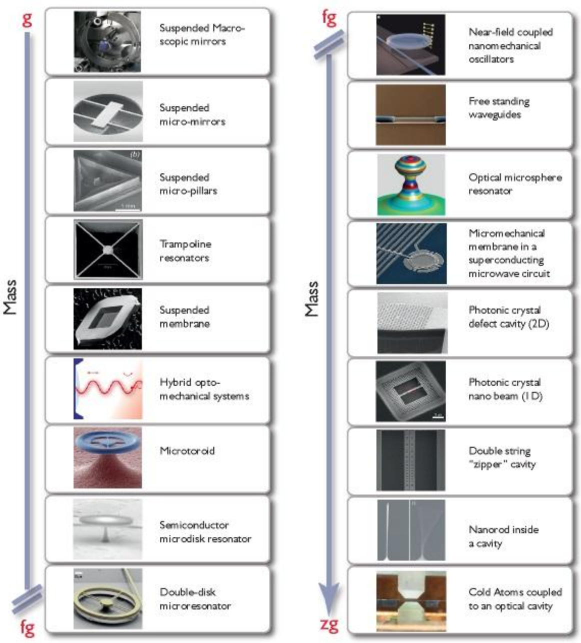

Figure 2 A gallery illustrating the variety of optomechanical devices, arranged according to mass [7].

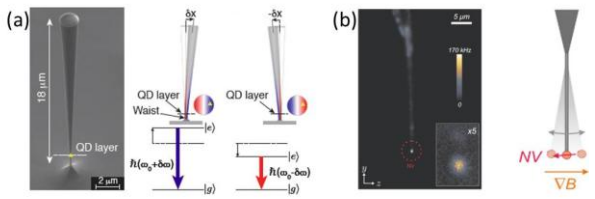

Figure 2 (a) Hybrid quantum dot nano-optomechanical system. Hybrid NV-centrenano-optomechanical system [12, 13].

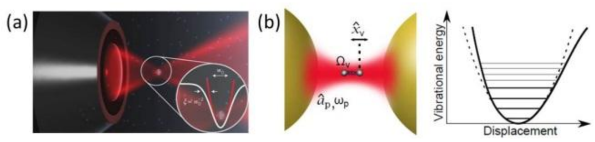

Figure 3 (a) Nano-optomechanics and thermodynamics with optically trapped particles [14]. (b) Optomechanics and molecular dynamics withplasmons and molecules [16].

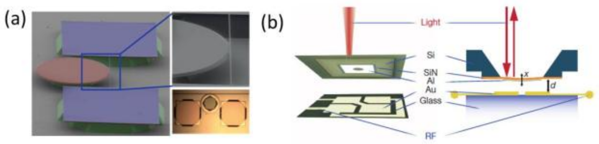

Figure 4(a) Nano-optomechanical system for ultra-sensitive integrated force detection [17]. (b) Hybrid Electro-optomechanical system for quantum-limited signal conversion [18].

Since then, optomechanics has considerably developed and improved in a plethora of unexpected and exciting ways, with the emergence of a variety of systems ranging from the centimetre down to the nanometre scale[7], see Fig. 1.Thereby,

within just 15 years of experimental research, optomechanics has been at the origin of such major achievements as the demonstration of macroscopic vibrational states close to the groundstate[8], the demonstration of the quantum backaction noise in interferometric measurements [9] or the generation of entangled optomechanical states [10].

At present, optomechanics is rapidly extending to a number of diverse physical topics, opening radically new perspectives both in fundamental and applied Science, such as the dynamical study of astrophysical phenomena[11], the coherent control of quantum information through novel hybrid optomechanical interactions[12, 13], the unprecedentedly sensitive measurement of nano-optical interactions and correspondingly novel, unexplored thermodynamics regimes[14, 15], the elucidation and control of molecular dynamics[16], the emergence of a new generation of versatile, highly integrated sensors[17] and quantum-limited converters[18].

Our mini-colloquium “Optomechanics: Exploring Physics from the macroscopic down to the nanometric scale” aims at reviewing the most recent advances in our rapidly growing field, with specific attention being devoted to highlighting its interdisciplinary potential.Contributions to this session should be given in English.

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