

HARNESSING QUANTUM FLUCTUATIONS: DESIGN, PHYSICS, AND NANOTECHNOLOGY OF CASIMIR FORCES AND QED TORQUES*

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The Casimir/Lifshitz force is the attraction between uncharged metallic or dielectric surfaces due to quantum mechanical fluctuations of the EM field. We will discuss high precision measurements of the Casimir force between metallic surfaces via MicroElectroMechanicalSystems (MEMS) and its use in actuators and in nonlinear oscillators.^{1,2} Experiments on tuning the Casimir force using hydrogen switchable mirrors and the skin-depth effect will be discussed.^{3,4} Recent results on the first unambiguous observation of the Casimir effect in fluids (measurement of the attractive force between gold and gold (sphere-plate geometry) in ethanol) will be presented⁵. Geometries aimed at the detection of *repulsive* Casimir-Lifshitz forces between solids separated by a liquid, and the predicted vacuum torque between suitable birefringent materials will also be discussed⁶. The critical role of these repulsive forces in QED torque experiments and their possible use virtually on frictionless bearings and other nanodevices will be examined. The talk will conclude with a discussion of new directions including parametric generation of light out of vacuum via Casimir interactions between uncharged oscillating high-Q cavity walls (the so called dynamic Casimir effect) and via London-Van der Waals forces between a neutral beam of molecules and a grating.⁷ For recent reviews of my group's work see references 8 and 9.

* Work in collaboration with: J. Munday, D. Iannuzzi, H.B. Chan, M. Lisanti, Y. Barash, M. Romanowsky, V.A. Aksyuk, R. N. Kleiman, D.J. Bishop

1. H.B. Chan, V.A. Aksyuk, R. N. Kleiman, D.J. Bishop, F. Capasso, *Phys. Rev. Lett.* **87**, 211801 (2001)
2. H.B. Chan, V.A. Aksyuk, R. N. Kleiman, D.J. Bishop, F. Capasso, *Science*, **291**, 1941 (2001).
3. D. Iannuzzi, M. Lisanti, F. Capasso, *Proc. Nat. Acad. Sci.* **101**, 4019 (2004)
4. M. Lisanti, D. Iannuzzi, F. Capasso, *Proc. Nat. Acad. Sci.* **102**, 11989 (2005)
5. J. Munday and F. Capasso, *Phys. Rev. A Rapid Comm.* **75**, 60102 (2007)
6. J. Munday, D. Iannuzzi, Y. Barash, F. Capasso, *Phys. Rev. A* **71**, 042102 (2005)
7. A. Belyanin, V. Kocharovsky, V. Kocharovsky, and F. Capasso, *Phys. Rev. Lett.*, **88**, 053602 (2002).
8. D. Iannuzzi, M. Lisanti, J. Munday, F. Capasso, *Solid-State Comm.* **135**, 618 (2005)
9. F. Capasso, J. Munday, D. Iannuzzi, H.B. Chan, *IEEE J. Select. Topics Quantum Electron.*, Special issue on Optical Micro-and-Nano-systems, **13**, 400 (2007)