Appunti di Fisica '18
&
Dottorato di Ricerca in Fisica

5 aprile ore 15:00
Sala seminari, CNR-IPCF

Nonperturbative Dynamical Casimir Effect in Optomechanical Systems: How to convert mechanical energy into photon pairs

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I present very recent theoretical results on the dynamical Casimir effect:
https://journals.aps.org/prx/abstract/10.1103/PhysRevX.8.011031

According to quantum field theory, empty space is not empty but rather filled with virtual particles popping in and out of existence. These virtual particles can have real effects, such as the Casimir effect in which two plates placed nanometers apart are pulled toward each other. In the dynamical Casimir effect (DCE), a rapidly moving mirror can transform virtual photons into real ones. Recent experiments show evidence for the DCE, but these did not employ moving mechanical mirrors. Direct observations of a conversion from mechanical energy to pairs of photons would help clinch the case for DCE. However, previous theoretical descriptions indicated that such an observation would require mechanical oscillators with resonance frequencies exceeding currently available technology. Our improved theoretical analysis shows that this is not the case.

We analyzed the DCE in cavity optomechanical systems, using quantum-mechanical descriptions of both the cavity field and the vibrating mirror. Our fully quantum approach describes the DCE without introducing a time-dependent light-matter interaction; we show that the DCE can even be described without considering any time-dependent Hamiltonian. Vacuum emission can originate from the free evolution of an initial pure mechanical excited state, in analogy with the spontaneous emission from excited atoms.

Our analysis shows that optomechanical systems with coupling strengths in reach of current experiments, and with vibrating mirrors working in the gigahertz spectral range, can be used to observe light emission from mechanical motion. We also found that the oscillating mirror can evolve into a state that is entangled with the radiation emitted by the mirror itself.