Physikalisches Institut
Fakultät für Mathematik und Physik
Albert-Ludwigs-Universität Freiburg

IRTG-Seminar

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"Tailoring Casimir-Polder interactions in nanophotonic systems"

Fluctuation forces arising between neutral objects due to the quantum fluctuations of the vacuum electromagnetic field are a remarkable feature of quantum electrodynamics. When considering atom-surface interactions at nanoscales, such short-ranged fluctuation forces, or Casimir-Polder forces become an imperative element of consideration in understanding and designing nanophotonic systems. It is therefore an interesting question to explore whether and how these forces can be engineered in a way to achieve better control and coherence of quantum systems interacting at nanoscales.

In this talk, I would like to motivate and introduce a series of works wherein we study a few possible ways to tailor fluctuation-induced phenomena in nanophotonic systems, particularly focusing on collective effects as a means to modify Casimir-Polder forces. In this specific work, we analyze cooperative phenomena in the fluctuation-induced forces between a surface and a system of neutral two-level quantum emitters prepared in a coherent collective state, showing that the total Casimir-Polder force on the emitters can be modified via their mutual correlations. Particularly, we find that a collection of emitters prepared in a super- or subradiant state experiences an enhanced or suppressed collective vacuum-induced force, respectively. The collective nature of dispersion forces can be understood as resulting from the interference between the different processes contributing to the surface-modified resonant dipole-dipole interaction. Such cooperative fluctuation forces depend singularly on the surface response at the resonance frequency of the emitters, thus being easily maneuverable. Our results demonstrate the potential of collective phenomena as a new tool to selectively tailor vacuum forces.

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