Self-assembly of optical resonators with Casimir and electrostatic forces

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Vacuum fluctuations are a fundamental property of a quantized electromagnetic field. In a large number of macroscopic scenarios this vacuum state can be ignored. However, at the nanoscale the presence of a nontrivial vacuum state can play a decisive role. A telling example is the Casimir effect—an attraction between two electrically neutral mirrors in the absence of other interactions [1]. For most materials and geometries, the Casimir effect is strictly attractive. Only recently a structure with a *repulsive* vacuum potential was experiemntally demonstrated [2]. A clever combination of materials with dispersive refractive indices also allows engineering planar systems with stable equilibria between two metal films, leading to the regime of vacuum-induced *levitation* [3].
In this talk, I will summarize the fundamentals of the Casimir effect and discuss recent breakthroughs in this field. Our recent work [4] showed that the unavoidable vacuum attraction can be mitigated by the electrostatic repulsion produced by the formation of double electric layers, and a stable equilibrium between two metallic films in a solution of a salt can be reached. This interaction leads to *self-assembly* of Fabry-Perot optical cavities. These findings open possibilities for use of self-assembled microcavities as novel platforms in opto-mechanics, nanomachinery, and other cavity-induced applications.

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[3] Zhao R, Li L, Yang S, Bao W, Xia Y, Ashby P, Wang Y and Zhang X 2019 *Science* **364** 984–987
[4] Munkhbat B, Canales A, Küçüköz B, Baranov D G and Shegai T O 2021 *Nature* **597** 214–219