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Harnessing vacuum forces for quantum sensing of graphene motion CHRISTINE MUSCHIK, SIMON MOULIERAS, ADRIAN BACHTOLD, FRANK KOPPENS, MACIEJ LEWENSTEIN, DARRICK CHANG, ICFO - The Institute of Photonic Sciences — Vacuum forces are one of the most spectacular predictions of quantum physics and have gained great importance in modern nanotechnology, due to their large magnitude at nanoscale distances. We present a novel method to exploit the strength of vacuum forces associated with single quantum emitters. We show that vacuum fluctuations map small displacements of a nanomechanical oscillator onto large shifts in the transition frequency of a proximal emitter. This optically detectable shift consequently provides a mechanism for ultra-precise position measurements. This new technique works for a wide class of materials, as opposed to conventional methods based on optical forces. Optical forces are typically weak and cannot be applied to important materials such as graphene. Graphene is an excellent resonator with very low mass and high quality factor, which raises intriguing technological possibilities such as mass detection at the single-atom level. Current read-out techniques require averaging over many cycles of the mechanical motion. In contrast, our Casimir-based sensing scheme enables the monitoring of graphene motion at the quantum level in real time, which is not feasible using any other method. Our work constitutes the first example where Casimir potentials are utilized as a valuable resource for practical applications, which can already be realized with current technologies. This work merges the fields of graphene and quantum optics, and will open new avenues for strong-light matter interactions.

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