All-optical dynamical Casimir effect in a 3D THz photonic band gap

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Abstract

We identify an architecture for the observation of all-optical dynamical Casimir effect in realistic experimental conditions. We suggest that by integrating quantum wells in a three-dimensional photonic band gap material made out of large-scale (~ 200µm) Germanium logs, it is possible to achieve an unprecedented ultra-strong light-matter coupling at terahertz frequencies for the cyclotron transition of a two-dimensional electron gas interacting with long-lived optical modes, in which vacuum Rabi splitting is comparable to the Landau level spacing. When a short, intense electromagnetic transient of duration ~ 250fs and carrying a peak magnetic field ~ 5T is applied to the structure, the cyclotron transition can be suddenly tuned on resonance with a desired photon mode, switching on the light-matter interaction and leading to a Casimir radiation emitted parallely to the quantum well plane, and which spectrum consists of sharp peaks with frequencies coinciding with engineered optical modes within the three-dimensional photonic band gap. We show that the characteristics of the radiation spectrum are extremely robust to the non-radiative damping which can be large in our system. Furthermore, the absence of continua with associated low-energy excitations for both electromagnetic and electronic quantum states can prevent the rapid absorption of the photon flux which is likely to occur in other proposals for all-optical dynamical Casimir effect.