Photon momentum and optical forces in cavities

During the past century, the electromagnetic field momentum in material media has been under debate in the Abraham-Minkowski controversy as convincing arguments have been advanced in favor of both the Abraham and Minkowski forms of photon momentum. Here we study the photon momentum and optical forces in cavity structures in the cases of dynamical and steady-state fields. In the description of the single-photon transmission process, we use a field-kinetic one-photon theory. Our model suggests that in the medium photons couple with the induced atomic dipoles forming polariton quasiparticles with the Minkowski form momentum. The Abraham momentum can be associated to the electromagnetic field part of the coupled polariton state. The polariton with the Minkowski momentum is shown to obey the uniform center of mass of energy motion that has previously been interpreted to support only the Abraham momentum. When describing the steady-state nonequilibrium field distributions we use the recently developed quantized fluctuational electrodynamics (QFED) formalism. While allowing detailed studies of light propagation and quantum field fluctuations in interfering structures, our methods also provide practical tools for modeling optical energy transfer and the formation of thermal balance in nanodevices as well as studying electromagnetic forces in optomechanical devices.

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