Light-sound interaction and spontaneous emission control in dual photonic-phononic microcavities

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The modulation of the optical response of photonic structures in the presence of elastic vibrations is a field of extensive research from the point of view of photoelasticity, Raman and Brillouin spectroscopy, and acousto-optics (AO) in general. In a typical AO experiment, a piezoelectric transducer produces an acoustic wave that changes the optical response of the photonic device [1]. On the other hand, increased popularity gain pump-probe techniques, which employ an ultrafast laser to generate and detect very short strain pulses by monitoring the optical reflectivity of the sample in the time domain [2]. Elastic vibrations can also be used to efficiently manipulate light in structures that simultaneously sustain acoustic and optical resonances in the same volume and enhanced AO effects are expected if such dual resonant modes interact with each other.

In this study we report on appropriately designed microcavities that simultaneously localize light and acoustic waves [3]. We address the problem of the AO interaction in such structures and discuss the consequences of this simultaneous confinement. An extensive analysis is presented for multilayer stacks supporting resonances for both electromagnetic and acoustic fields, resulting in multi-phonon exchange processes and dynamical optical frequency shift. Furthermore, we investigate the influence of a dual photonic-phononic resonant excitation on the spontaneous light emission by active centers [4]. Our calculations are based on the classical approach for light emission, solving the problem of an oscillating point dipole inside the multilayer structure by multiple scattering Green's function techniques. Our results indicate that an acoustic wave can strongly modulate light emission through a resonant AO interaction.

References

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