Local Polaritons and Optical Properties of Mixed Polar Crystals

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The concept of local polaritons was introduced several years ago independently in Ref. [1] and Ref. [2]. The term refers to defect-induced local states that can arise in the Restrahlen region of polar crystals between TO and LO phonons, and are coupled to retarded electromagnetic field. Since the dielectric function within the Restrahlen is negative, electromagnetic field turns out to be localized around the defect. Unlike regular local vibrational modes, which arise in the gap between acoustic and optical phonons, or above all optical modes of the crystal, local polaritons arise in the region, which was never previously considered as a gap for phonons. It is, however, a gap for electromagnetic waves, and discussing experimental data for the density of states of various materials we conclude that in many of them Restrahlen is, in fact, the gap also for phonons. We show, further, that even if this region is filled with LO phonons, their density of states can be small enough for TO based local vibrations to survive and form local polaritons. We argue, therefore, that the local polaritons offer a novel and useful basis for discussion of optical properties of impure and mixed crystals. Applying the concept of local polaritons to optical properties of mixed crystals in the frequency region of their Restrahlen band, we show that this concept allows for a physically transparent explanation of the presence of weak features in the spectra of one-mode and one-two mode crystals. Unlike previous models, which were able to explain these features only with the use of many fitting parameters, our model provides qualitative explanation without any fitting at all. We also show that local polaritons can develop into a new band of impurity-induced polariton modes within the Restrahlen of the host crystals, which opens a new transmission channel for electromagnetic waves. We study carefully properties of these new excitations, and find, for example, that their group velocity is proportional to the impurity concentration and can be orders of magnitude smaller then the speed of light in vacuum.

[1] L.I. Deych and A.A. Lisyansky, Bull. Amer. Phys. Soc. **42**, 203 (1997); Phys. Lett. A, **240**, 329 (1998); V.S. Podolsky, L.I. Deych, and A.A. Lisyansky, Phys. Rev. B, **57**, 5168 (1998).
[2] V.I. Rupasov and M. Singh, Phys. Rev. A, **54**, 3614 (1996); Phys. Rev. A **56**, 898 (1997).