Photonic band-related minima in transmission spectra of opal-based photonic crystals

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Experimental investigation of high-order photonic bandgaps (PBGs) in 3D photonic crystals (PhCs) remains a challenging task owing to high requirements towards the crystallinity of the PhC lattices. This can be fully applied to high-order bands in opal-based PhCs. Realization of thin opal films brought well-ordered opals, the lattices of which produce distinct diffraction pattern.

Transmission spectra of thin opal films demonstrate a number of minima. Plotted as a function of the angle of propagation, the central frequencies of these minima follow closely the dispersion of PhC eigenmodes (Fig.). High order transmission minima appear at slightly lower frequencies comparing to calculated bands due to, probably, the frequency dependence of the refractive index. Despite the latter fact, the empiric conclusion can be drawn that transmission minima appears in between two bands, which demonstrate nearly the same dispersion.

In the s-polarized light the lowest frequency transmission minimum appears due to the directional bandgap between 1st and 4th bands. In appealing controversy to this correspondence, there are no PBGs between 5th and 6th as well as between others pairs of bands, if the projection from the center of the Brillouin zone is taken into account. Thus these minima do not respect bandgaps, but follow bands at the boundary of the Brillouin zone.

Numerical modeling of 2D PhC with triangular lattice revealed the similar feature. The model explaining this behavior is based on the orthogonality of modes, which belong to pairs of bands, if these bands experienced degeneracy at some point of PBG diagram.

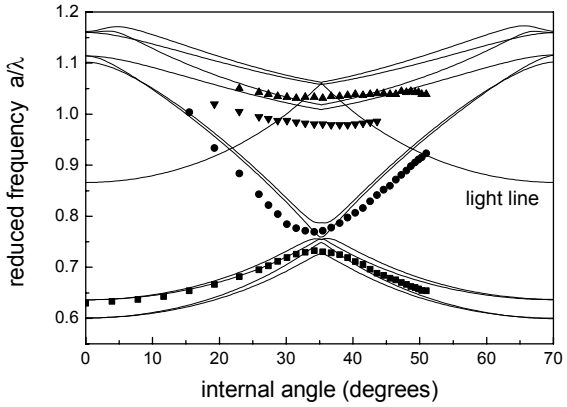

Fig. Central frequencies of transmission minima in s-polarized light as a function of internal angle of propagation in comparison with LKL' segment of the opal PBG diagram.