# Coupling between waveguides and cavities in photonic crystals: the role of mode symmetry

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Light propagation in photonic crystals is attracting much attention since long ago. Photonic crystals consist in a periodic arrange of two dielectric materials with a given dielectric contrast ($\varepsilon_1/\varepsilon_2$). Such a structure allows a total control and manipulation of the propagation of light due to the presence of ranges of frequencies for which light propagation trough the material is forbidden. Spectacular examples are the fabrication of loss-less waveguide bends by modifying the crystal structure to give rise to a channel waveguide or high-Q cavities. In this work we investigate both waveguides and cavities and the coupling between them within a theoretical framework. In particular we focus on two-dimensional H2 cavities (see figure) and waveguides fabricated in the interior of a lattice of air holes (n=1) in a semiconductor matrix of index (n=3.2). This lattice exhibit a remarkable bandgap for TE modes (the H-field is parallel to the hole axis). By filling some air pores one can fabricate any structure that will produce new states in the band structure. Such states manifest themselves as straight lines (no dispersion) in the band structure and will be spatially localized. For a H2 cavity (see Fig,.1) the result is a great number of those so-called 'cavity modes'. The presence of such an amount of mode makes it possible to observe a variety of symmetries (in the figure we show some examples of monopole-like states (a), hexapoles (b) and more complicated ones (c) ). When we construct a H2 waveguide all the modes will have a dispersion relation in the direction of propagation. We show that it is possible to select the desired mode that will propagate through the waveguide by breaking the waveguide in two pieces and coupling them by a resonant cavity. The cavity has been engineered so that those modes not having the right symmetry will be filtered by the cavity and will not propagate through the entire waveguide.

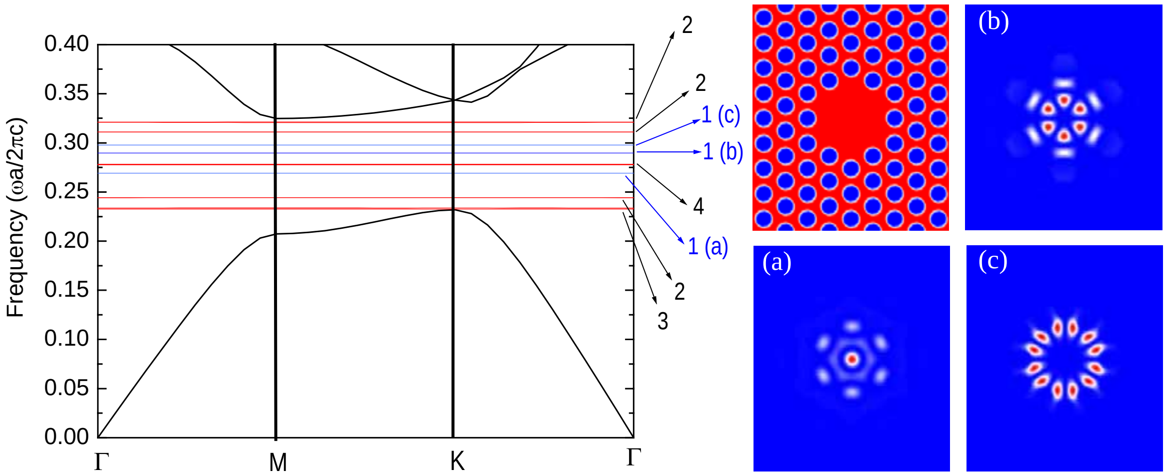


**Figure.1.** Left panel: Band structure (black lines) of the lattice whose parameters are given in the text, showing the different states of the H2 resonant cavity (straight lines). Right panel: Geometry of the H2 cavity and the square modulus of the H-field ( $|H(x,y)|^2$ ) associated to some selected modes of the cavity.