Orthogonal Anisotropy in 2D PBG Structures and Metamaterials

Christophe Caloz, I-Hsiang Lin and Tatsuo Itoh

Electrical Engineering Department, University of California, Los Angeles, CA 90095, *caloz@ee.ucla.edu*

Orthogonal anisotropy in 2D PBG structures and metamaterials is explored. Orthogonal anisotropy represents a particular case of anisotropy of a periodic architecture characterized by distinct electromagnetic behaviors along orthogonal directions *x* and *y*. An example of an orthogonally anisotropic structure is the anisotropic UC-PBG microstrip ground plane consisting of an array of slots with filtering and propagating properties along *x* and *y*, respectively (C. Caloz, C.-C. Chang, and T. Itoh, "A Novel Anisotropic Uniplanar Compact Photonic Band-Gap (UC-PBG) Ground Plane", European Microwave Conference, vol. 2, pp. 185-187, London, United Kingdom, September 2001).

In this contribution, we focus on anisotropy in *effective periodic structures*, where the lattice constant *a* is much smaller than wavelength ($a \ll \lambda$), in contrast to typical PBG structures ($a \cong \lambda/2$). In particular, we investigate the existence of an anisotropic structure possessing a "horse saddle" type spectral distribution, as shown in Fig. 1. Such a mode is *propagating forward* (RH) *only in the x direction at frequencies lower than* the center point of the saddle ω_0, and is *propagating backward* (LH) *only in the y direction at frequencies higher than* ω_0. At the Γ point, which is the point of "perfect effectiveness" (medium perfectly homogeneous) because the guided wavelength is infinite ($a/\lambda_g = 0$), the group velocity is zero and therefore no propagation occurs. But just above and below ω_0, quasi-effective propagation can occur, with the interesting frequency/spatial anisotropy explained.

2D orthogonally anisotropic structures are demonstrated in lumped-element and distributed configurations

A structure exhibiting a mode of the type shown in Fig.1 could be used in anisotropic waveguide (ω outside the radiation cone) or antenna/reflector (ω inside the radiation cone) applications, respectively.
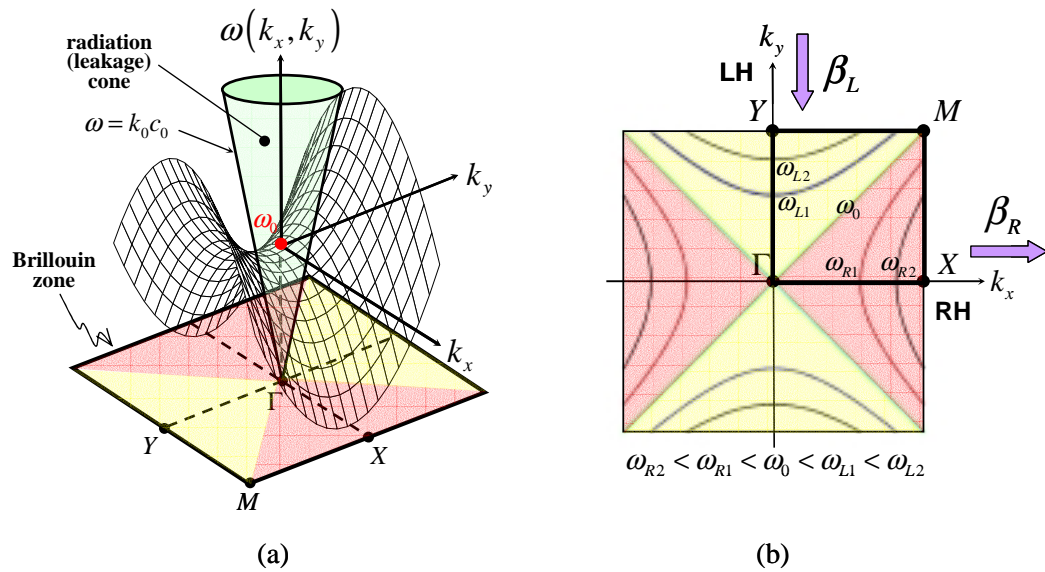

Figure 1 Spectral distribution for a possible mode $\omega(k_x, k_y)$ in an orthogonally anisotropic 2D periodic structure, characterized by right-handedness along *x* and left-handedness along *y*. (a) 3D "horse saddle" type configuration of the mode. (b) 2D projection of the mode for different frequencies represented by different contours.