Wave Propagation in Hyperbolic Metasurfaces

J. S. Gomez-Diaz and A. Alù
Department of Electrical and Computer Engineering, The University of Texas at Austin
juan-sebastian.gomez@utexas.edu, alu@mail.utexas.edu

The unique combination of reduced dimensionality and unusual electromagnetic response in metasurfaces [see N. Yu and F. Capasso, Nat. Mater. **13**, 139 (2014)] have recently led to the development of exciting applications, such as lenses able to control the direction of incoming beams [see F. Monticone, et al, Phys. Rev. Lett. **110**, 203903 (2013)], 2D waveguides supporting surface plasmons (SPPs) [see M. Jablan, et al, *Phys. Rev. B*., **80**, 245435 (2009)], or ultrathin reconfigurable antennas [see J. S. Gómez-Díaz, et al, *Opt. Express,* **21**, 24856 (2013)]. In a related context, bulk hyperbolic media [see V. P. Drachev, et al, *Phys. Rev. B*., **21**, 1699 (2013)] are well-known for combining dielectric and metallic properties in a single structure, thus providing interesting phenomena such as the increase of the local density of states of a dipole located in their vicinity or negative refraction.

Here, we explore the concept of hyperbolic and conductivity-near zero metasurfaces. Thanks to their reduced dimensionality, these structures can be rigorously described using a uniaxial conductivity tensor. The characteristics of different SPPs supported by hyperbolic metasurfaces are investigated, analytically revealing that the propagating energy can i) be confined along extremely narrow directions (1D) within the surface and ii) be easily manipulated by modifying the components of the conductivity tensor. Finally, several practical implementations of hyperbolic metasurfaces are analyzed and potential applications, such developing reconfigurable 1D waveguides within 2D metasurfaces or the dramatic increase of the power radiated by dipole located nearby, are presented and discussed.