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Reversed phase propagation for hyperbolic surface waves

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Magnetic properties can be used to control phase propagation in hyperbolic metamaterials. However, in the visible spectrum magnetic properties are difficult to obtain. We discuss hyperbolic surface waves allowing for a similar control over phase, achieved without magnetic properties.

Hyperbolic metamaterials (HMMs) are strongly anisotropic structures, exhibiting metallic properties on one direction while having dielectric properties in the other. This ability of HMMs to allow propagation of waves with short effective wavelengths (i.e. high-k waves) has sparked interest in HMM based devices for subwavelength imaging: hyperlenses [1]. However, broadening due to losses present in a realistic implementation of HMMs is an obstacle for imaging applications. We have recently shown that by employing magnetic properties, this broadening can be significantly reduced by adding a region with reversed phase propagation due to μ-negative HMMs [2].

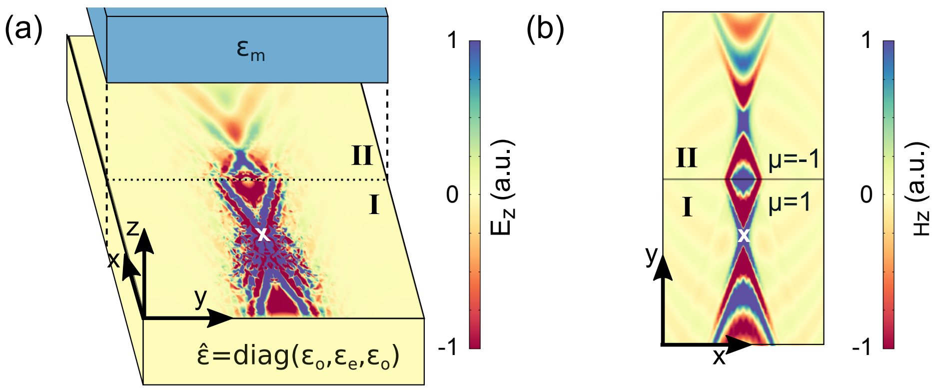

Fig. 1. (a) Geometry of the system, showing both two- and three-layer parts. A point dipole near the surface is used to excite the hyperbolic surface waves. (b) 2D simulation of an analogous case for bulk HMM, with a line source and μ-positive and -negative HMMs. Regions with normal (I) and reversed (II) phase propagation are marked, along with positions of point sources.

The required control over phase propagation can be achieved without magnetic properties in case of surface waves, by using two- and three-layer systems as a counterpart to μ-positive and -negative HMMs, respectively. We study a system composed of an anisotropic metal and a dielectric layer, which supports hyperbolic surface waves (with normal phase propagation). To have region with reversed phase propagation we use a three-layer system, with an additional isotropic metal layer. The system along with numerical simulations is shown in fig. 1. We see that in phase-reversed part the fields are restored towards the original point source. Note that due to lossy media the reconstruction is not perfect.

References

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