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Editorial: Optical hyperbolic metamaterials

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Editorial on the Research Topic
Optical hyperbolic metamaterials

Optical metamaterials, artificial materials composed of engineered subwavelength structures, provide a powerful platform for manipulating light (Zheludev and Kivshar, 2012). The existence of negative refraction and superlensing beyond the diffraction limit was initially realized with left-handed metamaterials (Smith et al., 2004). Some other intriguing optical phenomena have been continuously discovered in various metamaterials, such as invisibility cloaking, optical tunneling, and light trapping (Engheta, 2007; Soukoulis and Wegener, 2010; Ni et al.; Lu et al.). As an important class of anisotropic metamaterials with a hyperbolic iso-frequency contour, hyperbolic metamaterials (HMMs) have attracted significant attention due to their unique ability to control the light-matter interaction. Tailoring the hyperbolic dispersion offers an enticing route to flexibly control the light propagation and to produce collimation, beam splitting, robust transmission, and enhanced Purcell effect (Poddubny et al., 2013). Thus far, miniaturization, integrability, and low loss are the main pursuits of anisotropic metamaterials. Hyperbolic metasurface, the 2D version of ultrathin hyperbolic metamaterials, has a planar structure that is easier to integrate and is featured with a smaller loss (High et al., 2015; Gomez-Diaz and Alu, 2016; Guo et al.). Especially since 2D materials can support the propagation of hyperbolic phonon-polaritons or surface plasmons with low loss, hyperbolic 2D materials can be exploited to facilitate the design of low-loss hyperbolic metasurfaces and thus greatly promotes the development of planar optics, namely to mold the flow of light in a plane (Lin et al., 2017; Ma et al., 2018). Very recently, with the emergence of twist-optics, the interlayer rotation of 2D materials/metasurfaces provides another feasible route to explore the topological phase transition of isofrequency contours and has gained significant interest because of its promising potential in the design of advanced active devices (Hu et al., 2020; Shen et al., 2020).

This Research Topic aims to systematically reflect on the latest research progress of the anisotropic metamaterials/metasurfaces and promotes the development of metamaterials in new directions. The scope of the Research Topic includes the design, fabrication, and measurement of photonic anisotropic metamaterials/metasurfaces, the topological transition of polaritonic isofrequency contours, and their applications.

This Research Topic includes five original research articles covering fundamental physics and device applications of anisotropic metamaterials/metasurfaces. From the theoretical side, Xu et al. reported a novel design of W-shaped resonators to realize broadband reflective linear and circular polarization conversions (doi: 10.3389/fmats.2022.850020). For cross-polarization conversion, the PCR for normal incidence is over 0.95 from 9.2 to 18.7 GHz, covering 68% of the central frequency. Guo et al. proposed the multiple linear-crossing dispersion in the hyperbolic topological transition (doi:10.3389/fmats.2022.1001233). The unique beam splitting and directional refraction of multiple linear-crossing dispersion at different frequencies have been demonstrated. Ran et al. employed a broadband dual-polarized Huygens' metasurface by constructing simultaneous electric and magnetic responses and realized the efficient anomalous refraction of terahertz wave (doi:10.3389/fmats.2022.899689). From the experimental perspective, Xue et al. exploited the configurations of a 1-bit dualpolar-sized Huygens' ultrathin lens antenna (doi:10.3389/fmats.2022.962798). The 1-bit Huygens' lens antenna achieved the refraction functions of 0°, 15°, and 30° radiated beams for dual polarizations. Wang et al. investigated the large-area subwavelength cavity antenna with artificial permeability-negative metamaterials (doi:10.3389/fmats.2022.962798). Compared with the traditional antenna, the cavity thickness of the antenna is only 1/5 of the resonant wavelength. Moreover, it has a high gain, large radiation aperture, and good directivity.

This Research Topic provides an exciting overview of the different anisotropic metamaterials and metasurfaces that incorporate reconfigurable mechanisms. From this Research Topic, these new results demonstrate recent progress in anisotropic metamaterials and their potential applications in various aspects, both experimentally and theoretically. Meanwhile, more engineering attempts emerge for applications, especially in the microwave community. We expect that more and more anisotropic metamaterials/metasurfaces will be demonstrated to control the fundamental light-matter interactions. To conclude this editorial, we sincerely appreciate all authors' contributions to this Research Topic and believe that it provides an overview of recent efforts by leading scientists in the field of hyperbolic metamaterials.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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