

Asymmetric and nonreciprocal control of light with dielectric metasurfaces

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Over just a few years we have seen a tremendous progress of dielectric metasurfaces from fundamental concepts [1] to mass-fabricated consumer products. Passive and linear dielectric metasurfaces have started replacing conventional bulky optical components. One of the new frontiers of both fundamental and applied metasurface research is in nonlinear light-matter interactions rendered by nanoscale engineering. Nonlinearity offers a solution to a vital but largely unaddressed problem of contemporary optics and photonics: *nonreciprocal optical response at the nanoscale*. The 21st century photonics might depend on nanoscale nonreciprocal metasurfaces as much as the 20th century electronics depended on nanoscale nonreciprocal semiconductor diodes. A nonreciprocal system exhibits different received-transmitted field ratios when their sources and detectors are exchanged [see Fig. 1]. Such response requires breaking the Lorentz reciprocity theorem. Nonlinearity is one of only few fundamentally possible pathways to such behavior [2].

The talk will cover our latest *experimental results* on nonreciprocal one-way transmission of light and optical isolation with dielectric metasurfaces. The presentation will extend to nonlinearity-induced asymmetries with regards to the exchange of sources and detectors to parametric generation of light, including asymmetric images *experimentally observed* via a third-harmonic generation process [3].

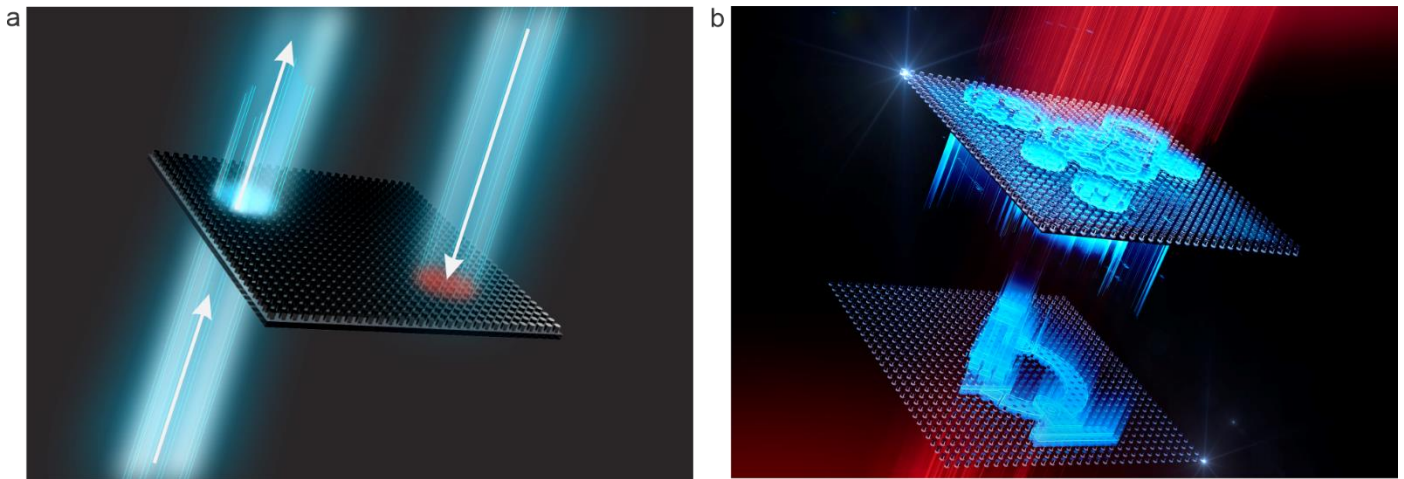


Figure 1. Nonreciprocal and asymmetric light-matter interactions with nonlinear dielectric metasurfaces. (a) Optical isolation with a metasurface allowing one-way light transmission. Experimentally observed nonreciprocal transmission is in the spectral range of optical fiber communication. (b) A metasurface generating two independent images in transmission for two opposite directions of illumination via a parametric process of third harmonic generation.

- [1] S. Kruk and Y. S. Kivshar, “Functional meta-optics and nanophotonics governed by Mie resonances,” *ACS Photon.*, 4, 2638 (2017).
- [2] C. Caloz et al., “Electromagnetic Nonreciprocity?” *Phys. Rev. Applied* 10, 047001 (2018).
- [3] S. Kruk et al., “Asymmetric parametric generation of images with nonlinear dielectric metasurfaces” *Nature Photon.* 16, 561–565 (2022).