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# Editorial: Editors' showcase: Metamaterials

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Editorial on the Research Topic
Editors' showcase: Metamaterials

The metamaterials/metasurfaces have become an important platform for exploring light-matter interactions and light field manipulations. In particular, the metasurfaces as a two-dimensional version of metamaterials have attracted great research interest recently since their optical response is engineered locally, addressing large degrees of freedom. The planar structures are compatible with mature microfabrication techniques. This Research Topic aimed to explore recent developments in this area with a focus on diffraction optics and topological photonics. The deep learning-driven reconfigurable metasurface is also highlighted.

A study by Quan et al. reexamines the famous Wood anomalies in metallic gratings from phase gradient metasurfaces (PGM). They show that due to the gauge invariance in PGM, that is, the diffraction law of PGM is independent of the choice of the initial value of abrupt phase shift, the well-studied subwavelength metallic grating can be regarded as a special case of PGM. Thereafter, their optical diffracting properties can be explained more deeply by the generalized grating diffraction equation. For example, they find that when the abrupt phase shift along the interface covers full $2\pi$ and satisfies the condition of PGM, the intensity of Wood anomalies becomes strongest. This work provides more insight into the design of diffraction components such as the retroreflector and wavefront control applications.

Another study by Li et al. experimentally demonstrates a new type-III nodal loop (NL) in an artificially designed bilayer metasurface. This type-III NL is created by the crossing between a resonant flat band and a positively dispersive band, which is different from the conventional NL in terms of the band slopes and the spatial dispersion of the crossing point. Here, the NL is protected by a mirror symmetry of the bilayer metasurface along the out-of-plane direction. By breaking the structural symmetries, the sequential topological transitions of band degeneracy from the NL *via* the Dirac point to the gapped phase are also observed. The bilayer design of high-structural tuning degrees of freedom allows for the exploration of rich physics in two-dimensional topological photonics.

Another study by Wang et al. demonstrates a frequency-diverse multiple-input-multiple-output (MIMO) metasurface antenna for computational imaging (CI). The frequency response of the metasurface antenna can be engineered by the metallic gap width. Basically, the imaging quality of CI depends on the orthogonal measurement modes. By adopting the aperture rotation technique (ART) in a passive frequency-diverse $2 \times 2$ MIMO, more radiation modes can be obtained and the imaging resolution performance can be significantly improved, although at the cost of imaging speed.

The past years have witnessed the fast development of deep learning in various research areas. Different from the traditional optimization algorithms requiring repeated iterative training for each computation, the data Research Topic and network training for deep learning are only a one-time cost. Hence, such data-driven models have shown great power for the on-demand design of photonic structures by using hierarchically structured layers. The study by Jiang et al. reports using a four-layer fully connected network to realize the far-field radar cross-section (RCS) prediction of programmable metasurfaces. This work has potential applications in future 6G communications.

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J-hC and HC were guest editors of the Research Topic and wrote the paper text.

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## 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.

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