Editorial

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Editorial: Transformation optics and its frontier branches

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Editorial on the Research Topic
Transformation optics and its frontier branches

Since transformation optics was first proposed to design invisibility cloaking in 2006, it has gradually emerged as a novel optical design method and has been widely applied in various fields. In recent years, in order to realize novel optical devices designed by transformation optics, various artificial materials such as metamaterials/metasurfaces and photonic crystals have also rapidly developed. Up to the present, the theoretical design methods of coordinate transformation have extended from the initial electromagnetic/optical domain to encompass other physical fields such as temperature fields, acoustic fields, quantum fields, and even the simultaneous control of multiple physical fields. This Research Topic covers the latest developments in the application of transformation optics and research on new materials. In this Research Topic, the latest research on transformation optics primarily involves the following aspects:

- One of the main application areas of transformation optics is for achieving various optical illusions, such as invisibility, deformation, and shrinking. Sadeghi has designed an electromagnetic expander, which can directly “amplify” the electromagnetic field distribution inside a scatter without disturbing the external scattering field (Sadeghi).
- Another major application of transformation optics is the ability to change the shape and size of optical devices while keeping their functionality unchanged, such as reshaping the focal surface of a lens and modifying the shape of electromagnetic antenna/cavity. Eskandari uses transformation optics to design an elliptical half Maxwell fish-eye lens, which can perform as a collimator for dual-polarized electromagnetic waves (Eskandari). Zang et al. use transformation optics to design a bi-dimensional compressed Luneburg lens, which can be applied to wide-angle beam steering (Zang et al.). Compared to uncompressed Maxwell fish-eye lens and Luneburg lens, the compressed lenses proposed in these two works can maintain the functionality of Maxwell fish-eye lens and Luneburg lens while obtaining a flattened, compact geometric structure, making them more suitable for on-chip integration.
- A future branch of development in transformation optics is the simultaneous control of multiple physical fields using coordinate transformation methods. Wu et al. propose the double-physical-field null medium by a metal plate array to achieve a double-

physical-field focusing lens, which can focus electromagnetic waves and acoustic waves simultaneously (Wu et al.).

In this Research Topic, the latest research on artificial materials primarily involves the following aspects:

- Micro-nanostructures, such as metal nanowires, nanorods, and nanospheres, are a common type of metamaterial in the optical range. They can be used for enhanced Raman spectroscopy, super-resolution imaging, optical illusions, and so on. In recent years, the fabrication techniques and synthesis processes of micro-nanostructures have been continuously improved. Link et al. conduct research on antimony telluride nanoplates by leveraging screw dislocation-driven growth, which can be used as a viable chemical route to realize spiral-type nanplate (Link et al.). Usman et al. propose a method to achieve large-scale ordered assembly of gold nanorods by controlling the droplet evaporation mode on hydrophobic substrates (Usman et al.).
- Metasurfaces were initially used to create specific phase gradients at interfaces, thereby verifying the general Snell's law. In recent years, metasurfaces have gradually evolved towards multi-functionality and intelligence. Li et al. have integrated many distinct functions within a single metasurface unit, which enables simultaneous color control and phase manipulation for pseudo-color nanoprinting and holographic image display (Li et al.). Additionally, Zhu et al. propose an intelligent tunable metasurface optimized by a generic algorithm, which can generate false electromagnetic targets in different scenarios (Zhu et al.).
- One direction of metamaterial development is to move from metallic metamaterials to all-dielectric metamaterials with low loss and large bandwidth. Cai et al. propose dielectric metamaterials based on ceramic cuboid units and apply them to achieve broadband extraordinary electromagnetic transmission (Cai et al.). Nonlinear metamaterials are also a branch of metamaterial research that can be used for frequency conversion devices. Shao et al. Propose a modified high-sensitivity optical nonlinear measurement method to characterize weak nonlinear refractive indices by a wide-band phase object (Shao et al.).

In summary, after more than 15 years of development, the applications of transformation optics are constantly expanding, and in the future it will be cross-developed with other theories and techniques, which may breed new branches including: multi-physical-field metamaterials and artificial intelligence transformation optics design. Its application domains will be further expanded from single function and single physical field to multi-functional and multi-physical field.

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Conflict of interest

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