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Editorial: Non-hermitian and topological photonics

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Editorial on the Research Topic
Non-hermitian and topological photonics

Topological phases of matter, an interesting Research Topic in physics, have greatly improved the understanding of the classification of states in condensed matter physics [1, 2]. Inspired by the topological properties of electronic band structures, scientists have also designed their classical counterparts and observed the charming edge states in artificial photonic and acoustic structures [3, 4]. It is of great scientific significance to use topology to control the photonic edge states, that can overcome the scattering losses caused by structural defects and disorder and realize topologically protected photonic devices, such as unidirectional waveguides and single-mode lasers. Metamaterials, artificial materials composed of subwavelength unit cells, have enabled unprecedented capabilities in manipulating electromagnetic waves for many different applications [5]. Thus far, through artificially designed resonant units, metamaterials provide vast degrees of freedom for realizing various photonic topological states, e.g., the Weyl/Dirac point, nodal line, and Weyl surface in higher-dimensional synthetic spaces [6].

On the other hand, non-Hermitian topological photonics is a very interesting Research Topic in topological physics [7]. Advances in the field of non-Hermitian photonics based on parity-time symmetry [8] or anisotropic coupling distributions [9] have greatly improved the ability to design new photonic topological states in previously inaccessible ways. Overall, the non-Hermitian topological systems realized by the metamaterials provide an effective avenue for studying the intriguing properties of topological photonics involving exceptional points and novel skin effect, and also for developing new functional devices [10, 11].

This Research Topic aims to systematically reflect on the latest research progresses of the topological photonics with metamaterials and promote the development of non-Hermitian properties in new directions. The scope of the Research Topic includes the design, fabrication, and measurement of photonic topological and non-Hermitian structures as well as their applications.

This Research Topic includes five original research articles covering fundamental physics and device applications of topological and non-Hermitian photonics. Wang et al. reported a novel design of gradient valley photonic crystal with square lattices to realize topological rainbow trapping (Wang et al.). The behavior of rainbow trapping both in Hermitian and non-Hermitian systems cannot be destroyed by the introduction of defects, demonstrating the robustness of the topological protection. Wu et al. investigated the incident direction-dependent non-Hermitian skin effect in modulated photonic waveguide arrays. By utilizing periodic modulation of complex permittivity and the anisotropic coupling between symmetric and anti-symmetric modes in multimode waveguides, the non-Hermitian Su–Schrieffer–Heeger (SSH) lattice is constructed and the direction-dependent non-Hermitian skin effect is demonstrated (Wu et al.). By controlling the refractive index ellipsoid, Wang et al. exploited the dispersions of the guided modes in the continuous uniaxial crystal slab waveguide and proposed the nodal point and nodal line degeneracies of the guided modes. The characteristics of Dirac degeneration and their connections with the refractive index ellipsoid can be controlled through switching the propagation direction (Pan et al.). Yan et al. proposed the tunable perfect optical absorption in truncated asymmetrical photonic crystals with lossy defects. The number of absorption peaks can be modulated not only by tuning the thickness of the defect layer, but also by changing the number of defects. Moreover, for photonic crystals containing multiple defects, the distance between absorption wavelengths can be tuned by altering the distances among the defects. Gao et al. proposed an electromagnetic modulator, in which the switching transmission of meta-molecule is realized by loading PIN diodes in the structure. They experimentally verified the electromagnetic modulation in three narrow bands on the spontaneous-emission-cancellation-like (SEC-like) spectrum, and achieved a 52.1 dB peak modulation contrast on 2.59 GHz transmission through electrical biasing.

This Research Topic provides an exciting overview of the unique properties and rich physical phenomena of non-Hermitian and topological structures. From this Research Topic, these new results show recent progresses in non-Hermitian and topological photonics with metamaterials in both physical mechanisms and functional devices. It is expected that more and more non-Hermitian and topological structures 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 non-Hermitian and topological photonics.

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.

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References

1. Hasan MZ, Kane CL. Colloquium: Topological insulators. *Rev Mod Phys* (2010) 82(4):3045–67. doi:10.1103/RevModPhys.82.3045

2. Qi XL, Zhang SC. Topological insulators and superconductors. *Rev Mod Phys* (2011) 83(4):1057–110. doi:10.1103/RevModPhys.83.1057

3. Ozawa T, Price HM, Amo A, Goldman N, Hafezi M, Lu L, et al. Topological photonics. *Rev Mod Phys* (2019) 91(1):015006. doi:10.1103/RevModPhys.91.015006

4. Xue HR, Yang YH, Zhang BL. Topological acoustics. *Nat Rev Mater* (2022) 7(12): 974–90. doi:10.1038/s41578-022-00465-6

5. Zheludev NI, Kivshar YS. From metamaterials to metadevices. *Nat Mater* (2012) 11(11):917–24. doi:10.1038/nmat3431

6. Ma S, Yang B, Zhang S. Topological photonics in metamaterials. *Photon Insights* (2022) 1(1):R02. doi:10.3788/PI.2022.R02

7. Bergholtz EJ, Budich JC, Kunst FK. Exceptional topology of non-Hermitian systems. *Rev Mod Phys* (2021) 93(1):015005. doi:10.1103/RevModPhys.93.015005

8. Ding K, Fang C, Ma GC. Non-Hermitian topology and exceptional-point geometries. *Nat Rev Phys* (2022) 4(12):745–60. doi:10.1038/s42254-022-00516-5

9. Weidemann S, Kremer M, Helbig T, Hofmann T, Stegmaier A, Greiter M, et al. Topological funneling of light. *Science* (2020) 368(6488):311–4. doi:10.1126/science.aaz8727

10. Long Y, Xue HR, Zhang BL. Non-Hermitian topological systems with eigenvalues that are always real. *Phys Rev B* (2022) 105(10):L100102. doi:10.1103/PhysRevB.105.L100102

11. Qin CZ, Wang B, Wong ZJ, Longhi S, Lu PX. Discrete diffraction and Bloch oscillations in non-Hermitian frequency lattices induced by complex photonic gauge fields. *Phys Rev B* (2020) 101(6):064303. doi:10.1103/PhysRevB.101.064303