Chirality is the property of an object that cannot be superimposed onto its mirror image. In optics, it can be a property of electromagnetic fields or materials that rotate their polarization. It has been used in photonic waveguides to create guided modes with particular features, as well as for applications to chirality sensing in chemistry and biology. We utilize advanced photonic concepts in numerical simulations to add to existing research on chirality in photonic waveguides, focusing on the creation and alteration of exceptional points (EPs).

First, we introduce a chiral dipole source between two parity-time-symmetric (PT) coupled waveguides. Using eigenmode expansion theory, we tailor the dipole polarization to directionally excite guided modes. Then, we model PT-symmetric coupled waveguides separated by a chiral material using the finite element method (FEM) and assess the impact of chirality on their mode dispersion. Various avoided crossings appear in the mode dispersion depending on their coupling, elucidated by a system of coupled-mode equations, providing a way to alter the position of EPs. Additionally, we characterize the effect of material chirality on the mode dispersion of cylindrical core-shell waveguides, with the aim to assess their suitability to sensing applications. Both 2D and 3D FEM simulations are carried out and compared for more thorough results. Furthermore, we implement extreme material chirality in waveguides simulated by FEM and show that they allow for forward and backward modes that couple to form EPs. The mode coupling mechanism is characterized using a theory that accounts for extreme values of chirality. Lastly, we introduce extreme chirality in the material between PT-symmetric waveguides, showing how avoided crossings and EPs evolve in the parametric space of chirality and gain-loss parameters

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Modeling of photonic waveguides with chirality and exceptional points

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PhD thesis

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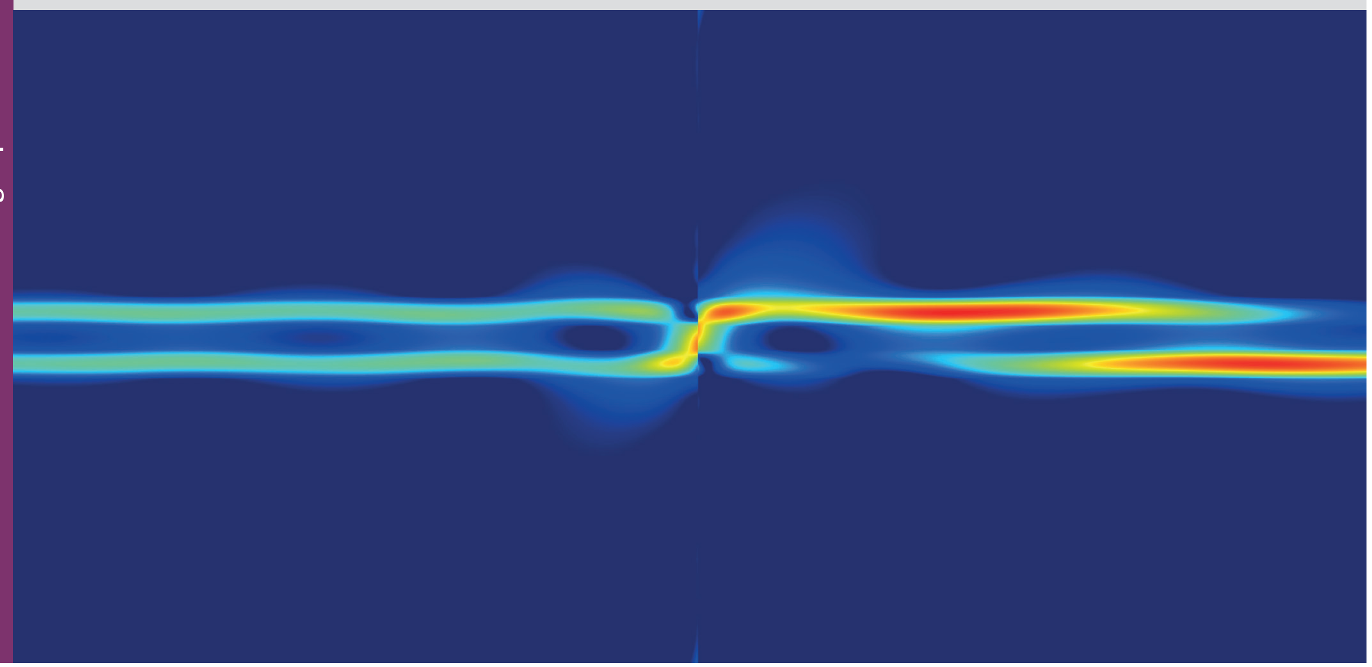

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