Explore Exceptional Points in Optical Microresonators: Fundamentals and Applications

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Exceptional points (EPs) are non-Hermitian degeneracies featured by the coalescence of eigenvalues and corresponding eigenstates when the parameters of a dissipative system are tuned appropriately. EPs universally occur in all open physical systems and have a significant impact on their behavior, leading to counterintuitive phenomena such as loss-induced lasing, unidirectional invisibility, and enhanced sensors. We have adopted whispering-gallery-mode (WGM) resonators as a platform to showcase the impact of non-Hermitian physics and EPs on physical systems and devices. High-Q WGM microresonators have a superior capability to trap light in a highly confined volume, enabling strong light-matter interactions, which can be utilized to investigate various interesting phenomena and applications, such as lasing, nonlinear optics, optomechanics, and sensing, etc. We will review our recent study in non-Hermitian physics and EPs that have unraveled innovative strategies to achieve a new generation of optical systems enabling unconventional control of light flow, such as loss engineering in a lasing system, directional lasing emission, and EPs enhanced sensing. We will also present a new finding regarding EP-enhanced sensing that can expand this approach to a wide range of optical sensor systems. Our research discoveries provide a glimpse of the potential of EPs in photonic resonators. There are many exciting opportunities to be explored in various physical systems by leveraging the interesting features associated with EPs.