Title: Possibilities and Device Applications of Degenerate Optical Microcavities

Funding Agency: Science and Engineering Research Board (SERB)

Completion date: 07.05.2021

Project PI: Dr Somanth Ghosh

Brief description:

In this project, exotic optical effects in the presence of exceptional points (EPs) are being explored in specialty gain-loss assisted optical microcavity and waveguide structures. The presence of multiple EPs and the interplay between them along an exclusively proposed exceptional line have been explored in a Fabry-Parot type microcavity, where the coupling phenomena between the resonances is entirely controlled by system topology. The specific chiral topological behavior of an EP will be explored in adiabatic-state-exchange mechanisms following a closed parametric encirclement around single or multiple EPs. In this context, the time or analogous length-scale dependent dynamical parametric encirclement will be studied in an optical waveguide; where owing to the contrast between the effect of EP and the adiabatic theorem, we will explore an exclusive route to achieve optical mode conversion, mode switching, optical isolation, etc. on-chip.

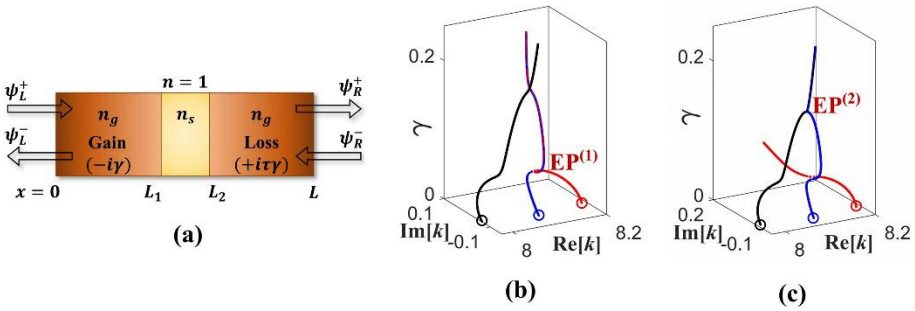

FIG. 1: (a) Schematic of a gain-loss assisted optical microcavity. (b) Coalescence of state-1 and state-2 at EP(1), unaffecting state-3. (c) Unaffecting state-1, the coalescence of state-2 and state-3 at EP(2).

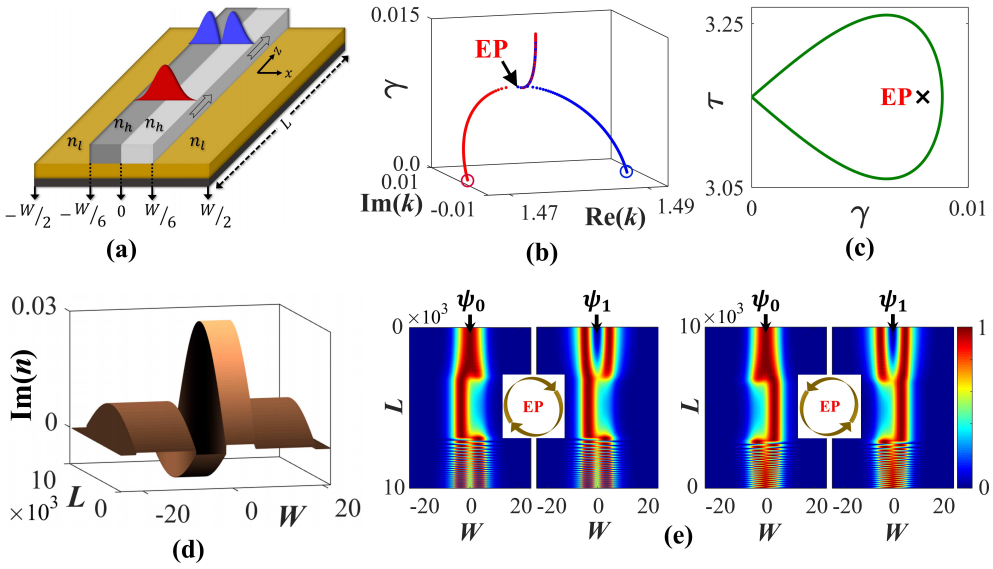

FIG. 2: (a) Schematic of a dual-mode planar optical waveguide. (b) Coalescence of β-values (propagation constants) of the supported modes at an EP. (c) Parametric encirclement scheme with a closed variation of gain-loss around the identified EP. (d) Associated length-dependent gain-loss distribution to encircle the identified EP dynamically. (e) Chirality-driven asymmetric mode conversion following the dynamical EP-encirclement scheme;

Publications:

1. A. Laha, A. Biswas and S. Ghosh, "Nonadiabatic Modal Dynamics Around Exceptional Points in an All-Lossy Dual-Mode Optical Waveguide: Toward Chirality-Driven Asymmetric Mode Conversion," Physical Review Applied **10**, 054008, (2018).

2. A. Laha, A. Biswas and S. Ghosh, "Minimally asymmetric state conversion around exceptional singularities in a specialty optical microcavity," Journal of Optics (IOP) **21**, 025201 (2019).

3. S. Bhattacherjee, H. K. Gandhi, A. Laha, and S. Ghosh, "Higher-order topological degeneracies and progress towards unique successive state switching in a four-level open system," Physical Review A **100**, 062124 (2019).

4. H. K. Gandhi, A. Laha, S. Dey, and S. Ghosh, "Chirality breakdown in the presence of multiple exceptional points and specific mode excitation," Optics Letters **45**, 1439 (2020).

5. A. Laha, S. Dey, H. K. Gandhi, A. Biswas, and S. Ghosh, “Exceptional point and toward mode-selective optical isolation,” ACS Photonics 7, 967-974 (2020)

6. S. Dey, A. Laha, and S. Ghosh, “Nonlinearity induced anomalous mode collapsing and non-chiral asymmetric mode switching around multiple exceptional points,” Physical Review B 101, 125432 (2020).