Chiral-reversing vortex radiation at the exceptional point of a plasmonic nanocavity

Ren-Min Ma[1], Xing-Yuan Wang[1], Hua-Zhou Chen[1], Suo Wang[1], Li Ge[2], Shuang Zhang[3],

[1] *School of Physics, Peking University, Beijing 100871, China*

[2] *Department of Engineering Science and Physics, College of Staten Island, CUNY, NY 10314, USA*

[3] *School of Physics and Astronomy, University of Birmingham, Birmingham, B15 2TT, UK*

The radiation of an emitter does not depend only on its intrinsic properties but also on the surrounding photonic environment, the notion of which is essential in the developments of lasers, quantum optics and other light-matter interaction related fields. However, in conventional wisdom, an emitter radiates into photonic eigenstates in the weak coupling regime and does not alter the property of the latter. Here, we report a counterintuitive phenomenon where the radiation field of a dipole in a parity-time symmetric ring resonator displays the opposite handedness to the coalesced eigenstate of the system (Fig. 1) [1]. This finding, to the best of our knowledge, is the first time the wave function of a Jordan vector is revealed in a physical system. We employ this phenomenon to construct vortex radiation with controllable topological charge from a single quantum dot embedded plasmonic nanocavity, demonstrating an enhancement of the Purcell factor by three orders of magnitude. Our scheme enriches the intriguing physics of an exception point in the quantum region and may open a new paradigm for chiral quantum optics and vortex lasers at nanoscale.

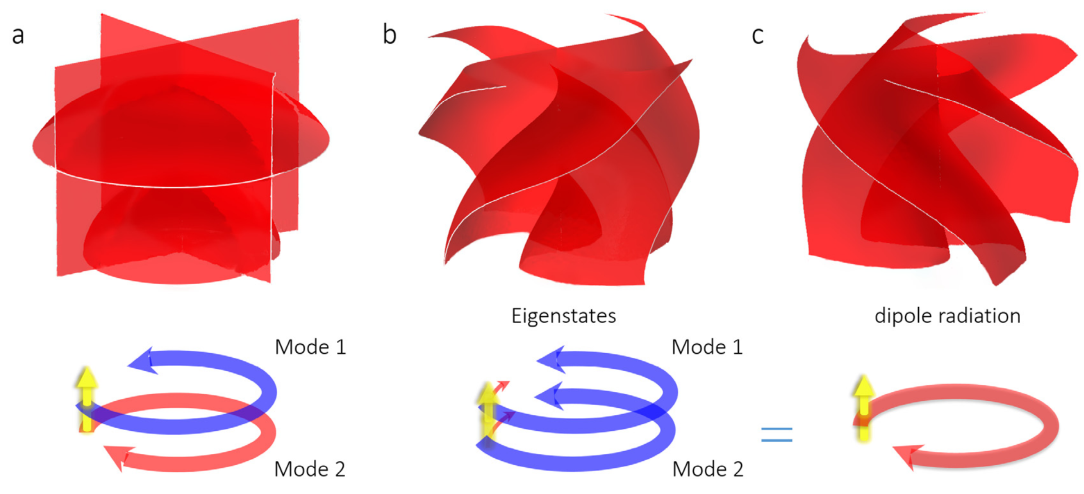

Fig. 1. Chiral-reversing dipole radiation by eigenstates phase locking. The radiation field pattern (isosurface of $E_\rho = 0$) of a **(a)** dipole emitter inside a normal ring cavity, of **(b)** the coalesced eigenstate of a ring cavity operating close to an exceptional point, and of **(c)** a dipole emitter inside a ring cavity operating close to an exceptional point.

[1] X. Y. Wang *et al.,* arXiv: [1707.01055] (2017).