Merging of Exceptional Points in Classical Waves

Kun Ding, Guancong Ma, Meng Xiao, Z.Q. Zhang, and C.T. Chan⋆*
Department of Physics and Institute for Advanced Study,
The Hong Kong University of Science and Technology, Hong Kong

**Email of Presenting Author: kun@ust.hk*

Non-Hermitian systems, such as open systems and systems with asymmetric losses, are ubiquitous in nature and have drawn a lot of attentions for a long time. The exceptional points (EPs) that can exist in such systems when two eigenstates coalesce is the origin of a wide range of novel phenomena in different branches of physics such as level repulsion, superradiance, coherent perfect absorption, rings of EPs and loss-induced revival of lasing. Most of these can be understood by considering a simple 2x2 non-Hermitian matrix. At a higher dimension, more complex EP physics not found in two-state systems arises.

By recognizing this, we investigate the multi-state non-Hermitian system in both acoustics and photonic crystals. For acoustics systems, we consider the emergence and interaction of multiple EPs in a four-state system theoretically and the system is realized experimentally using four coupled acoustic cavities with asymmetric losses. We found that multiple EPs can emerge and as the system parameters vary, these EPs can collide and merge, leading to higher order singularities and topological characteristics much richer in physics than those seen in two-state systems. For photonic crystals, we study the complex band structures of one-dimensional *PT* symmetric photonic crystals by setting up a model Hamiltonian, and two types of *PT* phase diagram are found. Furthermore, by calculating non-Abelian Zak phases, we showed that the standard concept of band inversion in a Hermitian photonic crystal can be extended to non-Hermitian case before the *PT*-exact phase is broken.