Observation of Higher-order Non-Hermitian Skin Effect

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Abstract— Hermitian theories play a major role in understanding the physics of most phenomena. It has been found only in the past decade that non-Hermiticity enables unprecedented effects such as exceptional points, spectral singularities and bulk Fermi arcs. Recent studies further show that non-Hermiticity can fundamentally change the topological band theory, leading to the non-Hermitian band topology and non-Hermitian skin effect, as confirmed in one-dimensional (1D) systems. However, in higher dimensions, these non-Hermitian effects remain unexplored in experiments. Here, we demonstrate the spin-polarized, higher-order non-Hermitian skin effect in two-dimensional (2D) acoustic metamaterials. Using a lattice of coupled whisper-gallery acoustic resonators, we realize a spinful 2D higher-order topological insulator (HOTI) where the spin degree of freedom is emulated by the anti-clockwise and clockwise resonant modes. We find that non-Hermiticity drives wave localizations toward opposite edge boundaries depending on the spin polarizations. More interestingly, for finite systems with both edge and corner boundaries, the higher-order non-Hermitian skin effect leads to wave localizations toward two opposite corner boundaries for all the bulk, edge and corner states in a spin-dependent manner. We further show that such a non-Hermitian skin effect enables rich wave manipulation by configuring the dissipation in each unit-cell. The discovered spin-dependent, higher-order non-Hermitian skin effect reveals the intriguing interplay between higher-order topology and non-Hermiticity, which is further enriched by the pseudospin degree of freedom. Our study unveils a new horizon in the study of non-Hermitian physics and the design of non-Hermitian metamaterials.