An exactly solvable model for two-dimensional non-Hermitian quasicrystals

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The phenomenon Anderson localization explains the metal-insulator transition in a material with the increase of disorder and its electrons' transport change from diffusive into localized. The study of the Anderson localization has been extended to many fields of physics, including the quasiperiodic or incommensurate systems. According to the single-parameter scaling theory, an arbitrarily small on-site random disorder induces all states being localized in one and two dimensions, with no mobility edges to separate extended states from the localized ones. However, such a scaling theory is invalid to the quasiperiodic systems, for which lower-dimensional quasicrystals may exhibit a metal-insulator transition. For example, a few generalized Aubry-André (AA) models with exact mobility edges have been proposed, which provide significant help to understand the localization in one-dimensional (1D) systems. Unfortunately, a two-dimensional (2D) generalization of the quasiperiodic AA model is not exactly solvable.

Recently, a family of models with quasiperiodic on-site modulation has been experimentally realized to host an exact mobility edge using synthetic lattices of laser-coupled atomic momentum modes [1], and a 2D eightfold symmetric quasicrystalline optical lattice has been experimentally and numerically revealed to exhibit a finite localization transition [2]. For 2D cases, the localization transition emerges when the system presents the spin-orbit scattering, the strong interactions, and the magnetic field [3], which has caused a lot

of head-scratching among theorists and experimenters. Hence, an exactly solvable 2D disordered model is urgent for understanding the underlying mechanism and providing an accurate theoretical prediction of the metal-insulator transition in the 2D case.

In ref. [4], the authors disclose an exactly solvable model for 2D non-Hermitian quasicrystals with parity-time (PT) symmetry exhibiting exact mobility edges by using the Sarnak method [5]. One of the metal-insulator transition points is of topological nature characterized by a hidden winding number defined in the dual space. Such a 2D model can be realized experimentally with photonic crystals, electronic circuits, or ultracold atoms, and its localization features can be detected by excitation dynamics.

Because direct measurement of the mobility edges in the experiment is still quite challenging for a 2D disordered system, an exactly solved 2D model becomes especially crucial. The present work is timely and is expected to stimulate the study of Anderson localization in 2D non-Hermitian disordered systems.

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