

Abstract

In this thesis we theoretically and numerically investigate localization phenomena in one dimensional non-Hermitian quasiperiodic lattices. Starting from the non-Hermitian generalized Aubry–André (nHGAA) model, we predict a reentrant delocalization transition, where the system successively transitions from a delocalized phase to a localized phase and then back to a delocalized phase as a function of the non-Hermiticity parameter in the quasiperiodic potential. The localized region is found to be topological in nature characterized by nonzero spectral winding number that vanishes in the delocalized phases, signifying a reentrant spectral topological transition. Intermediate regions hosting both localized and extended states exhibit nontrivial winding numbers distinct from those of the purely localized regime.

Extending this framework to a system with long-range hopping, we show that the localized and extended states are intermixed in the spectrum rather than being separated by a clear mobility edge. This spectral intermixing gives rise to an atypical intermediate phase where isolated extended states intermittently appear within the localized region and we denote this phenomena as the non-Hermitian comb effect. Such anomalous features can also be engineered in short-range hopping systems through suitable design of the onsite potential. Due to this effect, we uncover non-standard spectral structures in the complex energy plane where complex eigenenergies encircle real ones, revealing the intricate interplay between non-Hermiticity and quasiperiodic disorder.

Furthermore, we consider a coupled system of a non-Hermitian quasiperiodic chain and a clean chain and identify distinct transitions depending on the inter-chain coupling strength. For weak coupling, the system transitions from a delocalized to an intermediate phase with increase in non-Hermiticity, while strong coupling drives a sequence of delocalized–localized–intermediate

transition. The resulting intermediate regime exhibits a non-Hermitian comb effect (NHCE), characterized by the coexistence of localized and extended states without a sharp mobility edge.

Finally, in an extended Hatano–Nelson model with quasiperiodic potential, we demonstrate that the usual correspondence between delocalization-localization and real–complex spectral transitions breaks down in the presence of quasiperiodic potentials. Under open boundary conditions, the eigenstates exhibit a bidirectional non-Hermitian skin effect (NHSE). When a periodic onsite potential is introduced, we observe not only a bidirectional NHSE but also a complete direction reversal of the skin modes as a function of the potential strength.

The theoretical predictions presented in this thesis can be realized experimentally in controllable platforms such as photonic lattices, ultracold atoms, or electric circuit networks. Future studies may explore the dynamical aspects, higher-dimensional extensions, and interaction-induced effects to further deepen the understanding of non-Hermitian quasiperiodic systems.