Experimentally Probing Non-Hermitian Spectral Transition and Eigenstate Skewness

Jia-Xin Zhong (Jiaxin.Zhong@psu.edu),[1] **Jeewoo Kim**,[1] **Kai Chen**,[2,4] **Jing Lu**,[2,4] **Kun Ding**,[3] **Yun Jing**[1]

[1]Graduate Program in Acoustics, Penn State University
[2]Key Laboratory of Modern Acoustics, Nanjing University
[3]Department of Physics, Fudan University
[4]NJU-Horizon Intelligent Audio Lab, Horizon Robotics

PennState College of Engineering

NSF No. 2039463 195122

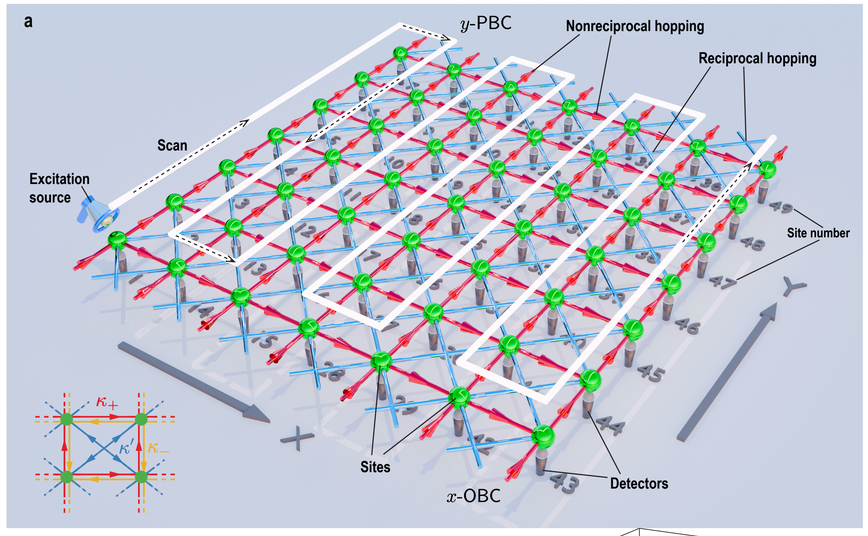
Scan for full paper

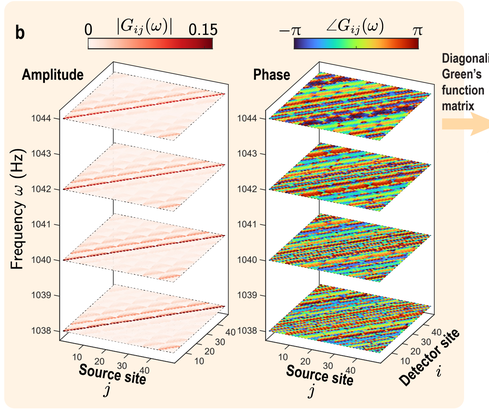
Introduction

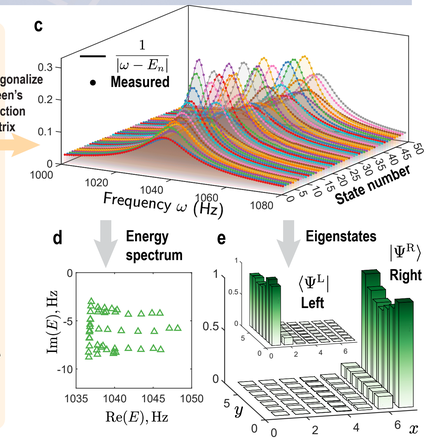
Complex-valued energy spectra and biorthogonal eigenstates constitute fundamental characteristics of non-Hermitian (NH) systems, manifesting unique phenomena unparalleled in Hermitian physics–most notably the NH skin effect and ultra spectral sensitivity. Despite their fundamental significance, **direct experimental measurement** of these intrinsic quantities has remained elusive due to limitations in traditional probing methodologies. To bridge this gap, we present a Green's function formalism combined with active acoustic lattices, achieving the **first experimental observation** of both spectral topology transitions and eigenstate skewness. Our approach is inherently universal, establishing a new paradigm for probing non-Hermitian physics across wave-based systems.

Green's function-based probing method

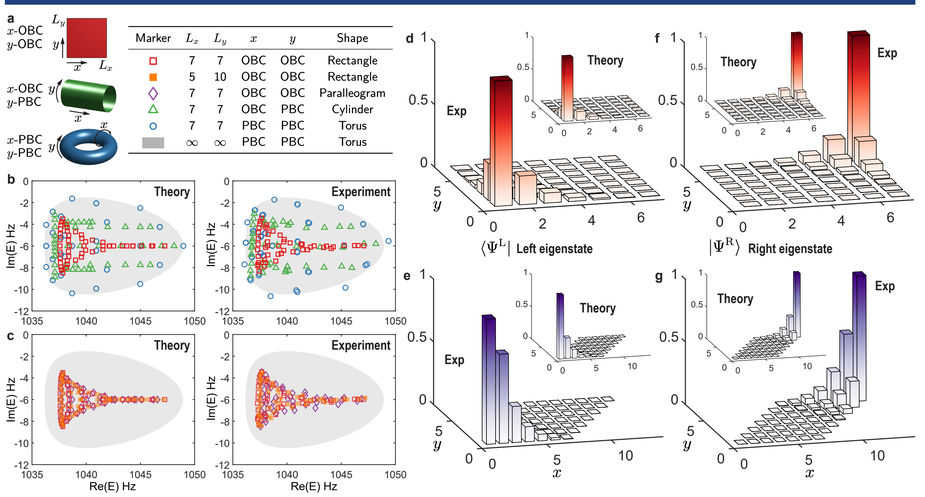
- Experimentally measure the complete Green's function matrix including both magnitude and phase responses



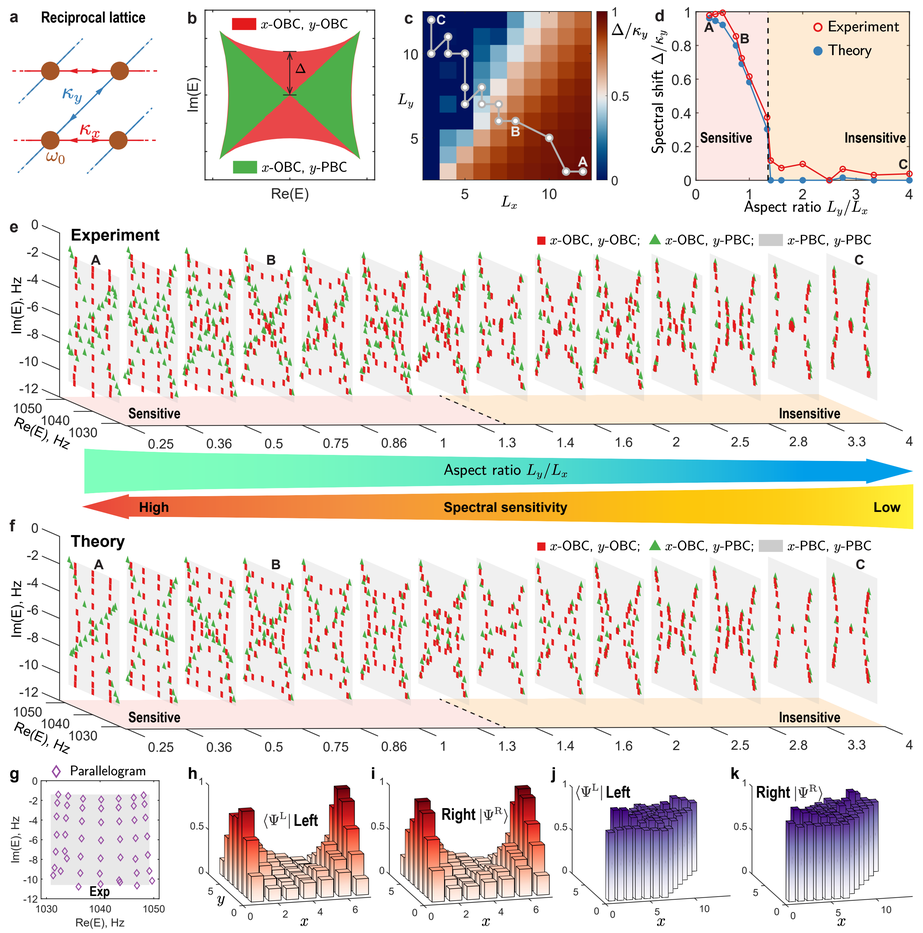




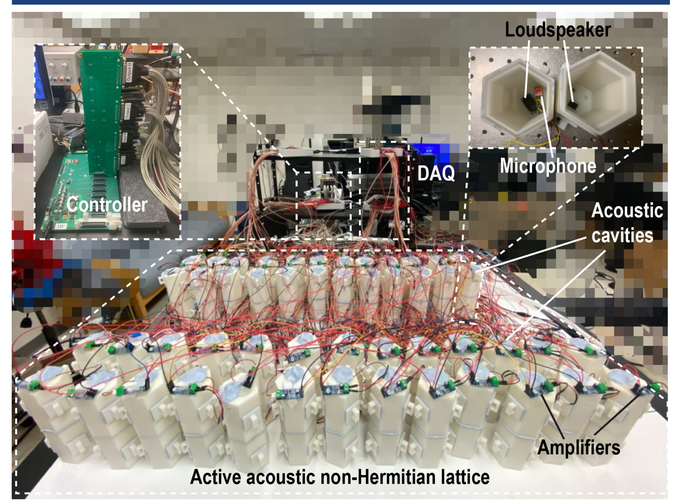
Observation of nonreciprocal NH lattices



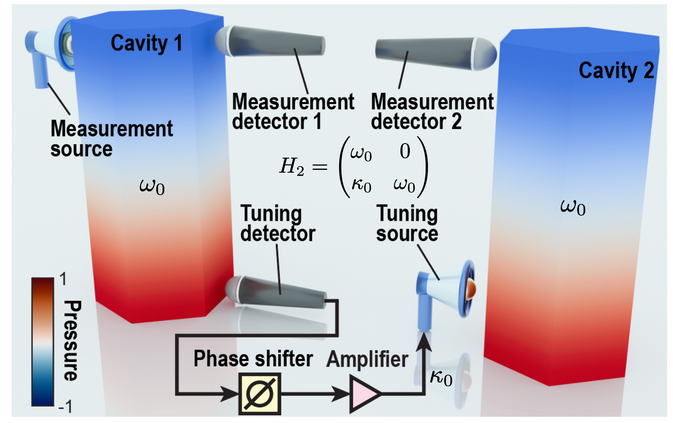
Observation of reciprocal NH lattices



Active acoustic lattices



Implementation of hoppings



Highlights

For the first time, we observed:

- Energy spectra of both nonreciprocal and reciprocal NH lattices under varied conditions and geometries.
- Hierarchical spectral relationship in nonreciprocal NH lattices, where the OBC spectrum is contained within the PBC spectrum.
- Sensitive spectral transition in reciprocal NH lattices induced by macroscopic geometries.
- Extremely skewed left and right eigenstates in nonreciprocal NH lattices.
- Nearly identical left and right eigenstates in reciprocal NH lattices.