Walther-Meißner-Seminar

Walther-Meißner-Institute, Seminar Room 143

Date: **Friday, December 5th 2025, 11:15 h**

Speaker: **Clara Wanjura**

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Title: **Non-Hermitian topology and directional amplification**

Zoom: **639 1624 8696 (passkey: 228294)**

Abstract:

Topology has been a major research theme in condensed matter physics and is associated with a number of remarkable phenomena such as robust edge states. A prominent example is the quantum Hall effect, in which the topological invariant is directly observable through the Hall resistance. More recently, topology started to be investigated in systems experiencing gain and loss sparking the field of non-Hermitian topology. However, for a long time, a clear observable signature of non-Hermitian topology had been lacking.

We recently closed this gap and showed that non-trivial, non-Hermitian topology is in one-to-one correspondence with the phenomenon of directional amplification [1-3] in one-dimensional bosonic systems, e.g., cavity arrays. Directional amplification allows to selectively amplify signals depending on their propagation direction and has attracted much attention as key resource for applications, such as quantum information processing. In collaboration with the group of Ewold Verhagen at AMOLF, Amsterdam, we experimentally demonstrated this connection between non-Hermitian topology and directional amplification in a cavity optomechanical system [4].

Building on these previous results, we recently developed a framework that naturally extends to systems of more than one band and more than one dimension [5]. Concretely, I will introduce a complex generalisation of the singular value decomposition, which we dub generalised singular spectrum (GSS). The GSS allows us to define physically meaningful bands related to the system's scattering behaviour and to define invariants for point gaps (non-Hermitian topology) and line gaps (Hermitian-like topology), respectively. For both invariants, we prove a bulk-boundary correspondence and show that they give rise to two different kinds of topological edge modes. I will illustrate our results with a 1D non-Hermitian Su-Schrieffer-Heeger (SSH) model and a 2D non-Hermitian model that features non-trivial higher-order topology which we link to corner-to-corner amplification.

Our work opens up new routes for the design of multimode robust directional amplifiers and novel topological sensors that can be integrated in scalable platforms such as superconducting circuits, cavity optomechanical systems, plasmonic waveguides and nanocavity arrays.

References

[1] Wanjura, Brunelli, Nunnenkamp. Nat Commun **11**, 3149 (2020).
[2] Wanjura, Brunelli, Nunnenkamp. Phys. Rev. Lett. **127**, 213601 (2021).
[3] Brunelli, Wanjura, Nunnenkamp. SciPost Phys **15**, 173 (2023).
[4] Slim, Wanjura, Brunelli, del Pino, Nunnenkamp, Verhagen. Nature **627**, 767–771 (2024).
[5] Wanjura, Nunnenkamp. Unifying framework for non-Hermitian and Hermitian topology in driven-dissipative systems. arXiv:2509.19433 (2025).