Exceptional points and where to find them

Murray Batchelor
Australian National University
Murray T. Batchelor
Mathematical Sciences Institute, Australian National University, Canberra ACT 2601, Australia

Particularly interesting features in various non-Hermitian models involve exceptional points (EPs), which are isolated points (or manifolds) in a model's parameter space where two of the model Hamiltonian's eigenvalues and their corresponding eigenvectors coalesce. This does not happen in Hermitian systems. EPs have many interesting physical properties such as geometric phases and enhanced sensitivity, and can be observed in various experiments.

In this talk I will outline recent work on locating EPs in well known model systems which are exactly solved via free fermions. These models include the non-Hermitian extensions of the quantum Ising model, the XY model and more generally Z(N) free parafermions. It is seen for example, that rings of exceptional points can form in the complex valued parameter space, with implications for the critical properties of the model.

Key references:

[1] R.A. Henry and M.T. Batchelor, Exceptional points in the Baxter-Fendley free parafermion model, SciPost Physics 15, 016 (2023)

[2] D.C. Liu and M.T. Batchelor, Characterizing phase transitions and criticality in non-Hermitian extensions of the XY model, Phys. Rev. B 112, 014422 (2025)

[3] R.A. Henry, D.C. Liu and M.T. Batchelor, Exceptional point rings and PT-symmetry in the non-Hermitian XY model, arXiv:2507.04558

Neural Dynamics for Perception, Cognition, and Navigation

Dongping Yang
Zhejiang Lab

Brains exhibit complex and variable internal activity yet produce reliable, adaptive responses to external inputs. A central open question is how neural networks achieve stable representations under such variability. We show that neural heterogeneity plays a key role by disrupting rigid activity patterns, making neuronal dynamics more independent and flexible, with heterogeneous firing that enhances sensitivity to external signals. Under stimulation, this sensitivity yields stable, input-aligned transient patterns that support robust representation. Moreover, cognition requires mapping sensory inputs onto low-dimensional manifolds within high-dimensional activity. We find that such manifold mappings enable representation transfer and cognitive generalization. Finally, in spatial navigation, hippocampal theta oscillations and their coupling with movement balance reward prediction with threat vigilance during navigation.