Graduate School Event

Thesis Defense: Universality in Random Matrices with Spatial Structure

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This thesis deals with eigenvalue and eigenvector universality results for random matrix ensembles equipped with non-trivial spatial structure. We consider both mean-field models with a general variance profile (Wigner-type matrices) and correlation structure (correlated matrices) among the entries, as well as non-mean-field random band matrices with bandwidth W >> N^(1/2). To extract the universal properties of random matrix spectra and eigenvectors, we obtain concentration estimates for their resolvent, the local laws, which generalize the celebrated Wigner semicircle law for a broad class of random matrices to much finer spectral scales. The local laws hold for both a single resolvent as well as for products of multiple resolvents, known as resolvent chains, and express the remarkable approximately-deterministic behavior of these objects down to the microscopic scale. Our primary tool for establishing the local laws is the dynamical Zigzag strategy, which we develop in the setting of spatially-inhomogeneous random matrices. Our proof method systematically addresses the challenges arising from non-trivial spatial structures and is robust to all types of singularities in the spectrum, as we demonstrate in the correlated setting. Furthermore, we incorporate the analysis of the deterministic resolvent chain approximations into the dynamical framework of the Zigzag strategy, synthesizing a unified toolkit for establishing multi-resolvent local laws. Using these methods, we prove complete eigenvector delocalization, the Eigenstate Thermalization Hypothesis, and Wigner-Dyson universality in the bulk for random band matrices down to the optimal bandwidth W >> N^(1/2). For mean-field ensembles, we establish universality of local eigenvalue statistics at the cups for random matrices with correlated entries, and the Eigenstate Thermalization Hypothesis for Wigner-type matrices in the bulk of the spectrum. Finally, this thesis also contains other applications of the multi-resolvent local laws to spatially-inhomogeneous random matrices, obtained prior to the development of the Zigzag strategy. In particular, we provide a complete analysis of mesoscopic linear-eigenvalue statistics of Wigner-type matrices in all spectral regimes, including the novel cusps, and rigorously establish the prethermalization phenomenon for deformed Wigner matrices.

Wednesday, October 22, 2025 04:00pm - 05:00pm

Central Bldg / O1 / Mondi 3 (I01.O1.010) and Zoom

This invitation is valid as a ticket for the ISTA Shuttle from and to Heiligenstadt Station. Please find a schedule of the ISTA Shuttle on our webpage: https://ista.ac.at/en/campus/how-to-get-here/ The ISTA Shuttle bus is marked ISTA Shuttle (#142) and has the Institute Logo printed on the side.