Graduate School Event

Thesis Defense: Modeling complex quantum systems - Random matrices, BCS theory, and quantum lattice systems

Joscha Henheik (Erdös Group)
Erdös Group

Host: Johann Danzl

This thesis deals with several different models for complex quantum mechanical systems and is structured in three main parts. In Part I, we study mean field random matrices as models for quantum Hamiltonians. Our focus lies on proving concentration estimates for resolvents of random matrices, so-called local laws, mostly in the setting of multiple resolvents. These estimates have profound consequences for eigenvector overlaps and thermalization problems. More concretely, we obtain, e.g., the optimal eigenstate thermalization hypothesis (ETH) uniformly in the spectrum for Wigner matrices, an optimal lower bound on non-Hermitian eigenvector overlaps, and prethermalization for deformed Wigner matrices. In order to prove our novel multi-resolvent local laws, we develop and devise two main methods, the static Psi-method and the dynamical Zigzag strategy. In Part II, we study Bardeen-Cooper-Schrieffer (BCS) theory, the standard mean field microscopic theory of superconductivity. We focus on asymptotic formulas for the characteristic critical temperature and energy gap of a superconductor and prove universality of their ratio in various physical regimes. Additionally, we investigate multi-band superconductors and show that inter-band coupling effects can only enhance the critical temperature. In Part III, we study quantum lattice systems. On the one hand, we show a strong version of the local-perturbations-perturb-locally (LPPL) principle for the ground state weakly interacting quantum spin systems with a uniform on-site gap. On the other hand, we introduce a notion of a local gap and rigorously justify response theory and the Kubo formula under the weakened assumption of a local gap. Additionally, we discuss two classes of problems which do not fit into the three main parts of the thesis. These are deformational rigidity of Liouville metrics on the torus and relativistic toy models of particle creation via interior-boundary-conditions (IBCs).

Thursday, April 3, 2025 10:00am - 11:00am

Office Bldg West / Ground floor / Heinzel Seminar Room (I21.EG.101) 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.