TITLES AND ABSTRACTS

April Workshop at

Institut Mittag-Leffler

Program

"Spectral Methods in Mathematical Physics"

Jeffrey Schenker

Title: Localization (and resonant delocalization?) for a disordered polaron

Abstract: Polaron models describe the motion of a tracer particle interacting with a quantum field. The Holstein Hamiltonian describes a tight binding particle interacting with a field of harmonic oscillators. We will consider the Holstein Hamiltonian with the addition of on-site disorder in the tracer particle potential. Provided the hopping amplitude for the particle is small, we are able to prove localization for matrix elements of the resolvent, in particle position and in the field Fock space. These bounds imply a form of dynamical localization for the particle position that leaves open the possibility of resonant tunneling in Fock space between equivalent field configurations. Some related deformations of the Anderson model in which we can prove the existence of resonant tunneling will be presented, but the exact nature of the dynamics for the disordered Holstein model remains open. (Joint work with Rajinder Mavi and Rodrigo Matos)

Vieri Mastropietro

Title: Persistence of gaps in the interacting anisotropic Hofstadter model

Abstract: We consider an interacting version of the Hofstadter model, which in absence of interactions has a spectrum given by a Cantor set. In the anisotropic situation where the hopping in one direction is smaller than in the other, we rigorously prove that the n-th gap persists in presence of interaction, even for interactions much stronger than the gap. We assume a Diophantine property and a smallness condition weakly dependent on n.

Adrian Dietlein

Title: Poisson local eigenvalue statistics for continuum random Schrödinger operators

Abstract: Poissonian local eigenvalue statistics are believed to be a characteristic feature of spectrally localized quantum mechanical systems. For localized random Schrödinger operators Poissonian level statistics have however only been proven for the lattice Anderson model and close relatives: The proof of a key ingredient, the Minami estimate, crucially relied on the rank-1 character of the single-site potential. We present a more flexible approach towards Minamis estimate, which for instance works at the bottom of the spectrum of a continuum random Schrödinger operator with sufficiently regular single-site distributions. The talk is based on joint work with Alex Elgart.

Christophe Sabot

Title: The Edge reinforced random walk, its non-reversible counterpart, and random Schrödinger operators
Abstract: I will review some recent developments on two self-interacting processes: the Edge-Reinforced Random Walk (ERRW) and the Vertex Reinforced Random Walk (VRJP), and explain their relation with some random Schrödinger operators. I will also give a glimpse of a non-reversible generalization. (Based on joint works or work in progress with P. Tarrès, X. Zeng, S. Baccalado)

Sven Bachmann

Title: Quantized charge transport in a many-body setting

Abstract: I will present an index describing the expected change transported by a unitary in a many-body state. I will show that, under appropriate assumptions, it takes only integer values and is therefore stable under perturbation. As applications, we recover (a versions of) the Lieb-Schultz-Mattis theorem and the quantization of the Hall conductance. This is joint work with Alex Bols, Wojciech De Roeck and Martin Fraas.

Alexander Sodin

Title: Some applications of the change of variables $t \mapsto \sqrt t$

Abstract: The change of variables $t \mapsto \sqrt t$ (conjugated by Fourier transform) will be used to give relatively simple proofs of several results on quasianalyticity (no preliminary knowledge of which will be assumed). There will be at least one application in spectral theory: following old work of Pavlov and a very recent one of Borichev, Frank and Volberg, we shall discuss the number of complex eigenvalues of a non-selfadjoint Schrödinger operator with decaying (complex) potential.

Peter Müller

Title: How much delocalisation is needed for an enhanced area law of the entanglement entropy?

Abstract: We consider the random dimer model in one space dimension with Bernoulli disorder. For sufficiently small disorder, we show that the entanglement entropy exhibits at least a logarithmically enhanced area law if the Fermi energy coincides with a critical energy of the model where the localisation length diverges.

John Imbrie

Title: Smoothing of eigenvalue distributions for quantum systems with discrete disorder

Abstract: Degeneracies (or near-degeneracies) create difficulties in understanding the behavior of quantum systems. In the case of disordered quantum systems such as the Anderson model, degeneracies provide avenues for long-range tunneling, and hence are a barrier to localization. To handle these effects in the case of discrete disorder distributions, one needs to build up smoothness of the density of states in a multi-scale procedure. I will give some details on the key elements of a procedure that can be used to prove localization and eigenvalue separation in this context.

Gian Michele Graf

Title: Indirect Measurements of a Harmonic Oscillator

Abstract: The measurement of a quantum system becomes itself a quantum-mechanical process once the apparatus is internalized. That shift of perspective may result in different physical predictions about measurement outcomes for a variety of reasons. In fact, whereas the ideal measurement, as described by Born's rule, is instantaneous, the apparatus produces anoutcome over time. In contrast to the often purported view that perfect measurement emerges in the long-time limit, because decoherence supposedly improves with time, it is found that the operation may be of transient character. Following an initial time interval, during which the system under observation and the apparatus remain uncorrelated, there is a ``window of opportunity'' during which suitable observables of the two systems are witnesses to each other. After that time window however, the apparatus is dominated by noise, making it useless. These conclusions are drawn from a model describing both system and apparatus and consisting of a harmonic oscillator coupled to a field. The equation of motion is a quantum stochastic differential equation. By solving it we establish different time scales relevant to the measurement process, including a classical and noisy large-time limit. (Joint work with Martin Fraas and Lisa Hänggli.)

Günter Stolz

TItle: Area laws for the disordered Ising and XXZ spin chains: Beyond the droplet spectrum

Abstract: Recent works by Beaud/Warzel and Elgart/Klein/Stolz have established localization properties of the disordered XXZ spin chain in the droplet regime of its spectrum. An interesting problem is to understand the extend to which these localization properties persist for energies above the droplet regime. Here we will report on current work with Houssam Abdul-Rahman and Christoph Fischbacher which investigates this question in terms of bounds on the entanglement entropy, where the droplet regime has been settled by Beaud and Warzel.

Daniel Ueltschi

Title: Extremal states decomposition in quantum spin systems

Abstract: In equilibrium statistical physics, the set of infintie-volume Gibbs states has the structure of a Choquet simplex, that is, each state can be written as a convex combination of extremal states. This is known very generally and abstractly. The challenge is to identify the extremal states in given models. Following a suggestion by Tom Spencer, we consider a sort of Laplace transform of the measure on extremal states. We can calculate it for spin 1/2 Heisenberg models and for the quantum interchange model on the complete graph. Joint work with Jakob Björnberg and Juerg Fröhlich.

Hermann Schulz-Baldes

Title: Spectral flow of monopole insertion in topological insulators

Abstract: Inserting a magnetic flux into a two-dimensional one-particle Hamiltonian leads to a spectral flow through a given gap which is equal to the Chern number of the associated Fermi projection. This paper establishes a generalization to higher even dimension by inserting non-abelian monopoles of the Wu-Yang type. The associated spectral flow is then equal to a higher Chern number. For the study of odd spacial dimensions, a new so-called `chirality flow' is introduced which, for the insertion of a monopole, is then linked to higher winding numbers. This latter fact follows from a new index theorem for the spectral flow between two unitaries which are conjugates of each other by a self-adjoint unitary. (Joint work with Alan Carey)

Bruno Nachtergaele

Title: Slow propagation in some disordered spin chains

Abstract: We study the effect of dilute random perturbations on the dynamics of many-body localized spin chains. Using a notion of transmission time for propagation in quantum lattice systems we show slow propagation by proving a lower bound for the transmission time. This result can be interpreted as a stability property of slow transport in one dimension. (Joint work with Jake Reschke)

Alain Joye

Title: Lower Bounds on the Localisation Length of Balanced Random Quantum Walks

Abstract: We consider the dynamical properties of Quantum Walks defined on the d-dimensional cubic lattice, or the homogeneous tree of coordination number 2d, with site dependent random phases. Our focus is on Quantum Walks further characterised by transition probabilities between neighbouring sites all equal to $1/(2d)$. We show that the localisation length for these Balanced Random Quantum Walks can be expressed as a combinatorial expression involving sums over weighted paths on the considered graph. This expression provides lower bounds on the localisation length by restriction to paths with weight 1, which allows us to prove the localisation length diverges on the tree as d^2. On the cubic lattice, the method yields the lower bound $1/\ln(2)$ for all d, and allows us to bound the localisation length from below by the correlation length of self-avoiding walks computed at $1/(2d)$. This is joint work with J. Asch.

Kevin Schnelli

Title: Local laws for additive random matrix models

Abstract: Describing the eigenvalue distribution of the sum of two general Hermitian matrices is basic question going back to Weyl. If the matrices have high dimensionality and are in general position in the sense that one of them is conjugated by a random Haar unitary matrix, the eigenvalue distribution of the sum is given by the free additive convolution of the respective spectral distributions. This result was obtained by Voiculescu on the macroscopic scale. In this talk, I show that it holds on the microscopic scale all the way down to the eigenvalue spacing in the bulk and at the regular edges. This shows a remarkable rigidity phenomenon for the eigenvalues. Joint work with Z.G. Bao and L. Erdös.

Antti Knowles

Title: Mesoscopic eigenvalue correlations of Wigner matrices

Abstract: Ever since the pioneering works of Wigner, Gaudin, Dyson, and Mehta, the correlations of eigenvalues of large random matrices on short scales have been a central topic in random matrix theory. On the microscopic spectral scale, comparable with the typical eigenvalue spacing, these correlations are now well understood for Wigner matrices thanks to the recent solution of the Wigner-Gaudin-Dyson-Mehta universality conjecture. In this talk I focus on eigenvalue density-density correlations between eigenvalues whose separation is much larger than the microscopic spectral scale; here the correlations are much weaker than on the microscopic scale. I discuss to what extent the Wigner-Gaudin-Dyson-Mehta universality remains valid on such larger scales.

Maurice Duits

Title: Global fluctuations for (time-dependent) polynomial ensembles

Abstract: Recent years have seen an increasing activity around logarithmically correlated Gaussian fields in random matrix theory. They manifest as Central Limit Theorems for linear statistics with sufficiently smooth test functions. In this talk, I will discuss a method for deriving such Central Limit Theorems in the case of polynomial ensembles. This is a wide class of determinantal point processes that involve polynomials satisfying orthogonality relations. I will discuss a principle that proves such Central Limit Theorems when the right limit of the recurrence matrix (e.g. the Jacobi matrix in case of orthogonal polynomial on the real line) satisfies a certain commutation relation. In the time-dependent setting, like Dyson's brownian motion, this can be used to prove the massless two-dimensional Gaussian Free Field describing the global fluctuations.

Kurt Johansson

Title: Intermediate random matrix ensembles

Abstract: A central theme in random matrix theory is the universality of natural scaling limits of the spectrum as the size of the matrix grows. It is also of interest to consider random matrix ensembles that interpolate between these limits. It cannot be expected that these models, which have intermediate statistics, are universal but in some cases they nevertheless lead to nice models. I will give an overview of some models that I have worked on.

Christoph Fischbacher

Title: Entanglement entropy for the higher spin XXZ model

Abstract: Recently, Beaud and Warzel considered so called droplet states from the lowest energy band of the spin-1/2 XXZ chain and showed that the entanglement entropy for such states satisfies a log-corrected area law in the deterministic case and a true area in the disordered case. In this talk, we consider the XXZ chain for higher spins. We will discuss how it is still possible to write the Hamiltonian as a direct sum of Schroedinger-type operators on rather complicated graphs, where - under suitable assumptions on the anisotropy parameter - the potential controls the kinetic term. This fact can be used to prove suitable Combes-Thomas estimates and bounds on spectral projections similar to those previously shown for the spin-1/2 case. We then finish by presenting first results on entanglement entropy for states from the lowest energy regime. This is joint work with G. Stolz (UAB).

Per von Soosten

TItle: Localization and delocalization for ultrametric random matrices

Abstract: We consider a Dyson-hierarchical analogue of power-law random band matrices with Gaussian entries. The model can be constructed recursively by alternating between averaging independent copies of the matrix and running Dyson Brownian motion. We use this observation to map out the localized regime and a large part of the delocalized regime in terms of local statistics and eigenfunction decay. Our method extends to a part of the delocalized regime in which the model has a well-defined infinite-volume limit with Hölder-continuous spectral measures. This talk is based on joint work with Simone Warzel.