The ISF Research Workshop on Random Matrices, Integrability and Complex Systems

Yad Hashmona, Judean Hills, Israel
October 03—08, 2018

Abstracts

I. Talks

The high temperature crossover for general 2D Coulomb gases

Gernot Akemann Universität Bielefeld, Germany
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We consider N particles in the plane influenced by a general external potential that are subject to the Coulomb interaction in two dimensions at inverse temperature β. At large temperature, when scaling $\beta = 2c/N$ with some fixed constant $c > 0$, in the large-N limit we observe a crossover from Ginibre's circular law or its generalization to the density of non-interacting particles at $\beta = 0$. Using several different methods we derive a partial differential equation of generalized Liouville type for the crossover density. For radially symmetric potentials we present some asymptotic results and give examples for the numerical solution of the crossover density. These findings generalise previous results when the interacting particles are confined to the real line. In that situation we derive an integral equation for the resolvent valid for a general potential and present the analytic solution for the density in case of a Gaussian plus logarithmic potential.

Distribution of eigenvectors in certain random matrix ensembles

Eugene Bogomolny Université Paris Sud, France
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I plan to discuss eigenvector distribution in certain RM ensembles.

A transfer matrix approach to scaled limits of Christoffel-Darboux kernels

Jonathan Breuer Hebrew University of Jerusalem, Israel
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We present an approach to computing the scaling limits of Christoffel-Darboux kernels using transfer matrix evolution.

Operator-valued zeta functions

Dorje Brody University of Surrey, United Kingdom
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Oct 05 – Fri – 08:40

The so-called Hilbert-Pólya programme aims at (a) finding an operator whose eigenvalues correspond to the nontrivial zeros of the zeta function, and (b) demonstrating that the operator is selfadjoint on a Hilbert space. In this talk I will show an example in which both objectives are achieved, and yet one learns little about the locations of the nontrivial zeros; thus casting a doubt on the feasibility of the Hilbert-Pólya programme. I will then propose an alternative approach by studying instead properties of operator-valued zeta functions. As an illustration I will show how some of the elementary properties of the zeta function can be inferred by such an approach. The talk is based on joint work with Carl Bender.

Random Lindblad dynamics

Tankut Can CUNY – New York, United States
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Oct 04 – Thu – 18:00

In this talk, I will discuss the spectral properties of the Lindblad equation governing the dynamics of an open quantum system coupled to a Markovian bath. Generic features of the non-equilibrium dynamics emerge when the Hamiltonian and jump operators appearing in the Lindblad equation are drawn from a random matrix ensemble. Our primary concern is to characterize the spectral gap (aka dissipative gap) which determines the asymptotic dynamics at long times. We find that the spectral gap is finite in the limit of infinite system size, and related to the symmetry class of the random matrix ensembles. We will present analytical and numerical evidence supporting this claim, and discuss its implications for the dynamics of complex open systems.

k-invariance, symmetry, and late-time chaos

Jordan Cotler Stanford University, United States
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Oct 05 – Fri – 12:20

Traditional quantum chaos focuses on the energy level statistics of ensembles of Hamiltonians. More recently, there are new tools to diagnose quantum chaos in many-body systems using local correlation functions. How do we relate the older and newer diagnostics of quantum chaos? Here we develop k-invariance, which enables us to relate late-time properties of many-body correlation functions with Hamiltonian level statistics. Symmetries of the Hamiltonian ensemble play a key role, and we explore in detail various symmetry classes as well as algebras of conserved charges. The locality of the many-body Hamiltonians comprising the ensemble is also important – we examine geometrically local Hamiltonians, q-local Hamiltonians, and non-local Hamiltonians. We find that late-time properties of out-of-time-ordered correlators and operator scrambling are intimately related to spectral form factors.

Eigenvector correlations for the Ginibre ensemble

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Oct 08 – Mon – 08:40

The complex Ginibre ensemble is an $N \times N$ non-Hermitian random matrix over $\mathbb{C}$ with i.i.d. complex Gaussian entries normalized to have mean zero and variance $1/N$. Unlike the Gaussian unitary ensemble, for which the eigenvectors are distributed according to Haar measure on the compact group $U(N)$, independently of the eigenvalues, the geometry of the eigenbases of the Ginibre ensemble are not particularly well understood. In this talk I will explain recent work with Ron Rosenthal in which we systematically study properties of eigenvector correlations in this matrix ensemble. We uncover an extended algebraic structure which describes their asymptotic behavior (as N goes to infinity). Our work extends previous results of Chalker and Mehlig, in which the correlation for pairs of eigenvectors was computed.

Eigenvectors of non-Hermitian random matrices

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Oct 08 – Mon – 09:20

Eigenvectors of non-hermitian matrices are non-orthogonal, and their distance to a unitary basis can be quantified through the matrix of overlaps. These variables quantify the stability of the spectrum, and characterize the joint eigenvalues increments under Dyson-type dynamics. They first appeared in the physics literature; well known work by Chalker and Mehlig calculated the expectation of these overlaps for complex Ginibre matrices. For the same model, we extend their results by deriving the distribution of the overlaps and their correlations. Joint work with P. Bourgade.

Random tilings, non-intersecting paths and matrix orthogonal polynomials

Maurice Duits KTH – Stockholm, Sweden
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Oct 04 – Thu – 10:50

In this talk I will I report on recent progress on the solvability of certain tiling models with periodic weightings, such as the two periodic Aztec diamond, that can be represented as ensembles of non-intersecting path models with block Toeplitz transition matrices. The heart of the approach is a connection to matrix orthogonal polynomials, which allows us to derive a formula for the correlation kernel that we believe to be a good starting point for an asymptotic analysis. In general, such an analysis still requires a further effort, for instance a steepest descent analysis for the Riemann-Hilbert problem for the matrix orthogonal polynomials. In special cases, however, a more straightforward analysis of the Riemann-Hilbert problem leads to explicit double integral formula that can be analyzed directly. This happens for various interesting models, including the two periodic Aztec diamond.

Density of eigenvalues in a quasi-Hermitian random matrix model: The case of indefinite metric

Joshua Feinberg University of Haifa, Israel
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Oct 08 – Mon – 11:00

We discuss a model of random matrices which are quasi-hermitian with respect to a fixed deterministic metric B. This ensemble is comprised of $N \times N$ matrices $H = AB$, where A is a complex-Hermitian matrix drawn from a $U(N)$-invariant probability distribution (e.g., the GUE ensemble). For positive-definite B (corresponding to the model introduced by Joglekar and Karr several years ago in [Phys. Rev. E 83, 031122 (2011)], the resulting spectrum is real, because H is similar to a Hermitian matrix. In this talk we shall discuss the average spectrum of this ensemble for indefinite-metric (analogous to the broken PT-symmetry phase), in which case H is no-longer similar to a Hermitian matrix, and therefore its spectrum becomes complex. We will present analytical and numerical results for this spectrum in the complex plane in the large-N limit, and explain its behavior as the number of negative eigenvalues (a finite fraction of N) of the metric B increases.

Corrections to scaled limits in random matrix theory

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Oct 05 – Fri – 10:00

Analysis of Odlyko's data for the Riemann zeros draws attention to the asymptotic expansion in N of quantities in random matrix theory. At the soft edge, there is evidence of a weak universality: calculations show that the optimal leading correction is proportional to $N^{-2/3}$ for a variety of model systems, whereas the corresponding functional form is ensemble dependent.

Random matrices, black holes and the Sachdev-Ye-Kitaev model

Antonio M. Garcia-Garcia Shanghai Jiao Tong University, China
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Oct 07 – Sun – 14:30

N fermions with k-body infinite-range interactions, originally introduced in the context of quantum chaos, and recently re-labelled Sachdev-Ye-Kitaev (SYK) models, are attracting a great deal of attention in both high energy and condensed matter physics. I show that its thermodynamic and long time dynamical properties are consistent with the existence of gravity dual and that spectral correlations are well described by random matrix theory. This suggests that random matrix theory is a universal feature of both quantum black holes and strongly-coupled metals. I also discuss the robustness of these features in generalized SYK model which undergo chaotic-integrable and metal-insulator transitions.

What drives transient behaviour in complex systems?

Jacek Grela Université Paris-Saclay, France
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Oct 04 – Thu – 16:10

Transient (growth) behaviour is a robust phenomenon present in complex systems with non-symmetric interactions between components. This study is motivated by applications in ecology and neural networks where complexity necessitates the use of a random matrix approach however similar features are believed to be found also in other contexts. We study this problem in the framework of a general set of non-linear ODE's which we linearize around a generic stable point. We introduce a seminal May-Wigner model by substituting a completely random Jacobian to the linear model. Besides known stable and unstable regimes we focus on the indicators of transient phenomena. When taken into account, two novel sub-regimes in the stable area are identified - where transient phenomena are either present or absent. We further compute average abundances of both trajectories. We obtain Gaussian and Tracy-Widom distributions (known in extreme value statistics) from which we conclude that inside the transient regime the trajectories are present although quite rare. This reflects the fact that although extreme trajectories are found, they are not numerous when sampled randomly. This leads to a natural question - what matrix characteristic produces transient trajectories altogether and maybe how to tweak it? It turns out to be intimately connected with the eigenvectors and their non-orthogonal nature (and not in the eigenvalues themselves!). To test that, we modify the May-Wigner model by fixing only the eigenvector information (and keeping the eigenvalues intact) which indeed produces transient behaviour as we vary appropriate parameters. Thus, with this simple model we produce typical transient trajectories. The talk is based on [Phys. Rev. E 96, 022316 (2017)].

Collective and incoherent single-particle motion in interacting many-body systems

Thomas Guhr Universität Duisburg-Essen, Germany
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Oct 07 – Sun – 09:00

The field of quantum chaos originated in the study of spectral statistics for interacting many-body systems, but this heritage was almost forgotten when single-particle systems moved into the focus. In recent years new interest emerged in many-body aspects of quantum chaos. I will start by presenting our work on spreading, i.e. the conversion of energy and momentum in collective to single-particle degrees of freedom in a closed and finite system. This is related to but different from thermalization. I then turn to our recent results on a chain of interacting, kicked spins. We carry out a full-scale semiclassical analysis that is capable of identifying all kinds of genuine many-body periodic orbits. We show that the collective many-body periodic orbits can fully dominate the spectra in certain cases.

Quantum chaos versus quantum complexity

Boris Gutkin Holon Institute of Technology, Israel
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Oct 07 – Sun – 09:40

It is usually assumed that integrable systems posses simple dynamics, while their energy levels are uncorrelated and follow Poissonian statistics. I will discuss how many-body nature of model changes this perception. In spite of seemingly simple dynamical equations, the set of periodic orbits/tori of many-body integrable systems can be quite complex. I will present a class of integrable spin chains where all periodic orbits are in one-to-one correspondence with periodic orbits of fully chaotic Arnold's cat map and posses non-trivial correlations. As a result, the long range spectral statistics of the corresponding quantum spin chains turn out to be intrinsically connected with the one of chaotic quantum maps.

Lattice models with discrete randomness

Haomichi Hatano University of Tokyo, Japan
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Oct 03 – Wed – 18:00

I report several interesting spectra of lattice models with randomness of discrete probability distributions, particularly the binary distribution. We have found seemingly fractal density of states [Phys. Rev. E 93, 042310 (2016)] as well as the energy dependence of the localization length. The computation of the localization length was done with the use of a new algorithm developed with J. Feinberg [Phys. Rev. E 94, 063305 (2016)].

Kac-Rice fixed point analysis for large complex systems

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Oct 04 – Thu – 17:20

How many fixed points does a large complex system have? We consider a class random nonlinear dynamical systems which allows us to answer this question explicitly. The method used is based on the multi-variate Kac-Rice formula and is valid for sufficiently regular Gaussian functions. Two main properties of this class of random models will be emphasized: (i) the average number of fixed points is an universal quantity in the sense that it does not depend on the finer details of how the models is constructed, and (ii) these models contain a phase transition between a phase with single fixed point and phase where the number of fixed points grows exponentially with the dimension.

Many-body localization in SYK models

Alex Kamenev University of Minnesota, United States
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Oct 07 – Sun – 15:50

I will discuss structure and localization properties of the many-body Fock space in Sachbev-Ye-Kitaev model and some of its generalizations. A particular focus will be on relations between localization/delocalization transition and the replica symmetry breaking phenomenon.

Moments of moments

Jon Keating University of Bristol, United Kingdom
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Oct 05 – Fri – 09:20

I will discuss the connection between the extreme value statistics of the characteristic polynomials of random unitary matrices and the moments, defined with respect to an average over the CUE, of their moments defined with respect to an average over the unit circle. These moments of moments are the subject of recent conjectures; they connect RMT with the general theory of log-correlated Gaussian fields. The integer moments can be computed exactly, and studied asymptotically, using a variety of techniques. I will discuss the results of these calculations.

Local statistics of Lyapunov exponents: From GUE to picket fences

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Oct 07 – Sun – 17:40

There are several ways how the transition from a chaotic quantum system to an integrable one is realized in the spectral statistics. The most prominent one is the transition between GUE to Poison statistics, where a GUE matrix is added to a real diagonal random matrix exhibiting Poison spectral statistics, meaning independent eigenvalues. Another well-known realization of an integrable system is the picket fences statistics, where all eigenvalues are fixed and equally spaced. When these eigenvalues have a lower bound then it is the spectrum of the harmonic oscillator. Anew one may ask the question between a transition between GUE and picket fences statistics and the most natural realization would be again the additive construction. Yet, there is another way to find a transition between these two statistics via looking at the Lyapunov exponents of a product of complex Ginibre matrices. By taking the double scaling limit of large matrix size and a large number of matrices multiplied, Gernot Akemann, Zdzislaw Burda and I discovered a transition of these two statistics. Surprisingly, one can even find mixed statistics for particular double scaling, where one part of the spectrum shows picket fences behavior while another part is governed by GUE statistics. I will report on these discoveries in my talk.

Non-ergodic extended phase in generalized Rosenzweig-Porter RMT

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Oct 04 – Thu – 12:10

The spectral and eigenfunction statistics is considered in the generalized Rosenzweig-Porter ensemble. It is shown that in a range of control parameter the eigenfunction statistics is multifractal, the local DoS consists of mini-bands, and the survival probability has a simple exponential form with the characteristic decay time of the order of the width of a mini-band. The multifractal phase terminates at the localization transition at large values of disorder parameter and at the new type of ergodic transition at small disorder.

Universal random matrix kernels from quantum mechanical hydrogen atom problem

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Oct 04 – Thu – 09:00

Using the ideas of spectral projection suggested by Olshanski and Borodin and advocated by T. Tao we derive the spectral properties of the complex Wishart ensembles; first, the Marcenko-Pastur distribution interpreted as a Bohr-Sommerfeld quantization condition for the hydrogen atom; second, hard (Bessel), soft (Airy) and bulk (sine) kernels from properly rescaled radial Schroedinger equation for the hydrogen atom. Then we extend the ideas of spectral projections to the case of bi-orthogonal ensembles formed by the squared singular values of the product of Wishart matrices and matrix product ensembles of Hermite type. We demonstrate that the Narain transform is a natural extension of the Hankel transform for the products.

On the persistence probability for random truncated orthogonal matrices and Kac polynomials

Mihail Poplavskyi King's College London, United Kingdom
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Oct 05 – Fri – 11:40

We study ensemble of random matrices consisting of truncations of random orthogonal matrices. We discuss asymptotic behavior for the probability of having no real eigenvalues for these matrices and in the case of order one truncations prove that it decays as a power law with the power $-3/8$. This ensemble was previously shown to be connected to classical model of random polynomials and we argue that corresponding persistence probability decays as a power law with the power $-3/4$. This answers a question originally raised in the paper of A. Dembo, B. Poonen, Q. M. Shao, O. Zeitouni. This is a joint work with M. Gebert (QMUL), G. Schehr (LPTMS).

Many-body interference, chaos and operator spreading in interacting quantum systems

Klaus Richter Universität Regensburg, Germany
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Oct 07 – Sun – 10:50

Concepts based on multi-particle interference have proven very fruitful for better understanding various many-body phenomena, such as quantum dynamics of cold atoms, many-body localization and more recently information scrambling. With regard to the latter, so-called out-of-time-order correlators (OTOCs) presently receive particular attention as sensitive probes for chaos and the temporal growth of complexity in interacting systems. We will address such phenomena in general, and OTOCs in particular, by using semiclassical path intergral techniques based on interfering Feynman paths, bridging classical and quantum many-body approaches. This enables us to compute OTOCs and related observables non-perturbatively in terms of coherent sums over interfering solutions of the corresponding classical mean-field equations, thereby including entanglement and correlation effects. Most notably, OTOCs exhibit a characteristic exponential growth as a function of time until the Ehrenfest (scrambling) time, where they saturate. We will show for quantum chaotic many-body (Bose-Hubbard) systems that this saturation arises from quantum interference effects and derive corresponding analytical expressions. Moreover, on the numerical side we devise a semiclassical method for large-N Bose-Hubbard systems far-out-of equilibrium that allows us to calculate many-body quantum interference in Fock space on time scales far beyond the Ehrenfest time.

Power spectrum analysis and zeros of the Riemann zeta function

Roman Riser University of Haifa, Israel
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By the Bohigas-Giannoni-Schmit conjecture (1984), the spectral statistics of quantum systems whose classical counterparts exhibit chaotic behavior are described by random matrix theory. An alternative characterization of eigenvalue fluctuations was suggested where a long sequence of eigenlevels has been interpreted as a discrete-time random process. It has been conjectured that the power spectrum of energy level fluctuations shows $1/\omega$ noise in the chaotic case, whereas, when the classical analog is fully integrable, it shows $1/\omega^2$. In the first part of this talk, I will introduce the definition of the power spectrum and consider its analysis in the case of the Circular Unitary Ensemble. Our theory produces a parameter-free prediction for the power spectrum expressed in terms of a fifth Painlevé transcendent. In the second part, I will show numerical results which uses zeros of the Riemann zeta function. I will present a fair evidence that a universal Painlevé V curve can indeed be observed in the power spectrum. The talk is based on [Phys. Rev. Lett. 118, 204101 (2017)].

Nonequilibrium quantum dynamics: From full random matrices to real systems

Lea Santos Yeshiva University, New York, United States
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We study numerically and analytically the quench dynamics of isolated many-body quantum systems. Using full random matrices from the Gaussian orthogonal ensemble, we obtain analytical expressions for the evolution of the survival probability and density imbalance. These expressions serve as a reference for the description of the entire evolution of systems studied experimentally with cold atoms and ion traps. We reveal different behaviors at different time scales and show that the relaxation time increases exponentially with system size.

Nonequilibrium quantum dynamics: From full random matrices to real systems

Uzy Smilansky Weizmann Institute, Israel
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A quantum graph $\mathcal{G}(V,E;\mathcal{L})$ with V vertices, E edges, and a list of rationally independent edge lengths $\mathcal{L}=(\mathcal{L}_1,\dots,\mathcal{L}_E)$ is defined topologically in terms of its V dimensional adjacency matrix, and metrically by endowing the edges with the standard metric and edge lengths $\mathcal{L}$. The associated Schrödinger operator consists of the one-dimensional Laplacian with appropriate boundary conditions. Its ordered spectrum $\{k_n\}_{n=1}^{\infty}$, $k_{n+1}\geq k_n$ is specified by the counting function $\mathcal{N}_0(k)=\#\{k_n: k_n\leq k\}$. Permute the lengths of $t\leq E$ edges in $\mathcal{L}$. The spectrum is changed and its counting function is denoted by $\mathcal{N}_t(k)$. We measure the difference between the two spectra by the variance

$$\Delta(t)=\lim_{K\to\infty}\frac{1}{K}\int_0^K dk\,[\mathcal{N}_t(k)-\mathcal{N}_0(k)]^2$$

while

$$\lim_{K\to\infty}\frac{1}{K}\int_0^K dk\,[\mathcal{N}_t(k)-\mathcal{N}_0(k)] \quad = 0.$$

We study the averaged variance over the different permutations of t lengths, $\langle\Delta(t)\rangle$, and its dependence on the connectivity of $\mathcal{G}(V,E;\mathcal{L})$.
Similarly, given a $N\times N$ Hermitian matrix H, its ordered spectrum $\{x_n\}_{n=1}^{\infty}$, $x_{n+1}\geq x_n$ is specified by the counting function $\mathcal{N}_0(x)=\#\{x_n : x_n\leq x\}$. Permuting t of its diagonal elements, the spectrum is changed, and its counting function is denoted by $\mathcal{N}_t(x)$. Again, the difference between the spectra is measured by the variance

$$\Delta(t)=\int\ dx\,[\mathcal{N}_t(x)-\mathcal{N}_0(x)]^2-\left(\int\ dx\,[\mathcal{N}_t(x)-\mathcal{N}_0(x)]\right)^2.$$

We study $\langle\Delta(t)\rangle$, the average variance over the ensemble of matrices from which H is chosen, and its dependence on t for various matrix ensembles. Finally, we compare the mean variances for the graphs and the matrix ensembles and discuss the cases where they are not in agreement.

Product matrix processes

Eugene Strahov Hebrew University of Jerusalem, Israel
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I will discuss a family of random processes in discrete time related to products of random matrices (product matrix processes). Such processes are formed by singular values of random matrix products, and the number of factors in a random matrix product plays a role of a discrete time. I will explain that the product matrix process associated with truncations of Haar distributed unitary matrices can be understood as a scaling limit of the Schur process, which gives determinantal formulas for (dynamical) correlation functions and a contour integral representation for the correlation kernel. The relation with the Schur processes implies that the continuous limit of marginals for q-distributed plane partitions coincides with the joint law of singular values for products of truncations of Haar-distributed random unitary matrices.

Eigenvector non-orthogonality in non-Hermitian random matrices

Wojciech Tarnowski Jagiellonian University, Krakow, Poland
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Non-Hermitian matrices besides complex eigenvalues can possess distinct left and right eigenvectors which are not orthogonal. This leads to the enhanced sensitivity of the spectrum to perturbations and allows for the transient amplification in the dynamics of the system governed by such matrices. In this talk I will present an approach to probe the properties of non-orthogonality in matrices with unitarily invariant pdf in the large N limit. This formalism is a natural generalization of the Green's function approach to two-point functions and extends ideas by Chalker and Mehlig. A particularly simple form of the two-point eigenvector correlation function is obtained for the class of matrices described by the Feinberg and Zee's single ring theorem. An application to a toy model with PT-symmetry will be given. The talk is based on [arXiv: 1801.02526].

SYK model with quadratic perturbations: The route to a non-Fermi-liquid

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Oct 07 – Sun – 15:10

We study stability of the SYK_4 model with a large but finite number of fermions N with respect to a perturbation, quadratic in fermionic operators. We develop analytic perturbation theory in the amplitude of the SYK_2 perturbation and demonstrate stability of the SYK_4 infra-red asymptotic behavior characterized by a Green function $G(\tau) \propto 1/\tau^{3/2}$, with respect to weak perturbation. This result is supported by exact numerical diagonalization. Our results open the way to build a theory of non-Fermi-liquid states of strongly interacting fermions.

Universal behavior in the SYK model: From compound nuclei to black holes

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Oct 07 – Sun – 12:10

The Sachdev-Ye-Kitaev model, also known as the two-body random ensemble, is a toy-model for a black hole with the hope to learn more about its quantum states. One unsolved question is whether the quantum levels of a black hole are discrete, and one way to answer this question is by studying spectral correlation functions. In this talk we will introduce the SYK model and discuss its spectral properties. We will show that the spectral density near the ground state is exponentially large in N (with N the number of particles) resulting in a nonvanishing zero temperature entropy and it increases with energy as given by the Bethe formula. The spectral correlations are given by one of the standard random matrix ensembles, with a Thouless energy that scales as N^2 in units of the level spacing.

Massive modes for chaotic quantum graphs: Two-point function

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Oct 03 – Wed – 16:40

We address the question whether the two-point function of chaotic quantum graphs is universal. We assume that in the limit of infinite graph size, the spectrum of the Perron-Frobenius operator possesses a finite gap. Within the supersymmetry approach, we introduce the universal mode and the massive modes, paying particular attention to the fact that these modes are defined in a coset space. We express the effective action in terms of the massive modes and use that representation to define a set of Gaussian superintegrals over the massive modes. Universality requires these integrals to vanish in the limit of infinite graph size. We present estimates that lend plausibility to that statement.

Integrable structure at the integer quantum Hall plateau transition

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Oct 04 – Thu – 15:30

Chalker and Coddington proposed a random network model as a description of the critical behavior at the plateau transition of the integer quantum Hall effect. Here we argue that the correlation functions of the network model at criticality are given by a Wess-Zumino-Witten model. The integrability of the latter allows to predict several universal properties of the plateau transition. The talk is based on [arXiv: 1805.12555].

II. Posters

Berry's random wave model in Fock space

Remy Dubertrand Universität Regensburg, Germany
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Oct 07 – Sun – P-1

In the version provided by Sriednicki [Phys. Rev. E 50, 888 (1994)], the celebrated Eigenstate Thermalization Hypothesis (ETH) relies in another, more fundamental property of eigenstates in first-quantized quantum systems describing particle systems with chaotic classical limit: Berry's conjecture. The later states that in the bulk and far from boundaries, chaotic (ergodic) eigenstates are well described in the semiclassical limit $\hbar \to 0$ by a superposition of plane waves with locally defined wavenumber and random phases, the (even more) celebrated Random Wave Model [J. Phys. A 10, 2083 (1977)]. In its modern formulation where it is extended to deal with systems with arbitrary confinement and including subtle correlations induced by the normalization condition [Adv. Phys. 62, 363 (2013)], the RWM is based on two separated and essential ingredients. First, it is assumed (and still unproven) that when probed by local observables, chaotic eigenstates appear as Gaussian Random Fields. Second, all the microscopic and system-specific features of the system are encoded in the two-point correlation function of the field, that in turn is constructed from the exact microscopic Green (or Wigner) function, which in the semiclassical limit takes the well-known Bessel form in the bulk. In this work, we use recently developed methods for second-quantized systems with classical (mean-field) chaotic limit [Phil. Trans. R. Soc. A 374, 20150159 (2016)], and attempt to check the Gaussian conjecture and the universality of the two-point correlation in the large particle number limit $N \to \infty$, thus taking the first steps towards the construction of a RWM in Fock space of chaotic many-body systems. Joint work with J.-D. Urbina and K. Richter.

Experimental notes on the partial sums of the Riemann zeta function

Yochay Jerby Holon Institute of Technology, Israel
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Oct 07 – Sun – P-2

The Riemann zeta function is given in the critical strip $0 < \mathrm{Re}(z) < 1$ by the classical formula:

$$\zeta(z) = \frac{1}{1 - 2^{1-z}} \sum_{k=1}^{\infty} \frac{(-1)^{k+1}}{k^z}.$$

We study the corresponding partial sums

$$S_N(z) = \frac{1}{1 - 2^{1-z}} \sum_{k=1}^{N} \frac{(-1)^{k+1}}{k^z}.$$

We observe that $S_N(z)$ experiences steep changes around the values $N_m = \left[\frac{\mathrm{Im}(z)}{(2m+1)\pi}\right]$. For $m \in \mathbb{N}$, this motivates the definition of the associated spectral functions

$$\lambda_m(z) = \frac{1}{1 - 2^{1-z}} \sum_{k=N_m}^{\infty} \frac{(-1)^{k+1}}{k^z}.$$

We present various properties of these functions. For instance, the first spectral function $\lambda_1(z)$ is seen to be efficiently approximated by the classical function

$$C(z) = \frac{2^z \pi^{z-1} \sin\left(\frac{\pi z}{2}\right) \Gamma(1-z)}{2^{z-1} - 1}.$$

Further variations of the functions $\lambda_m(z)$ (for instance, their smoothening) and relations to the monotonicity property conjectured by Spira [Illinois J. Math. 17, 147 (1973)] will also be presented.

Constructing local integrals of motion in the many-body localized phase

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Oct 07 – Sun – P-3

We consider a many-body localized spin system and its description by the so-called l-bit Hamiltonian. We outline a renormalization flow procedure to construct the extensive set of conserved quantities, and demonstrate that their quasilocality results in exponentially decaying interactions in this effective model. The associated localization length of this decay is shown to manifest properties very similar to the noninteracting case of Anderson localization: normality of its distribution across samples, and its direct qualitative correspondence to the local spectral properties. We therefore argue that these local integrals of motion help to practically identify the many-body localized phase.

Stability and pre-thermalization in chains of classical kicked rotors

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Periodic drives are a common tool to control physical systems, but have a limited applicability because time-dependent drives generically lead to heating. How to prevent the heating is a fundamental question with important practical implications. We address this question by analyzing a chain of coupled kicked rotors, and find two situations in which the heating rate can be arbitrarily small: (i) linear stability, for initial conditions close to a fixed point, and (ii) marginal localization, for drives with large frequencies and small amplitudes. In both cases, we find that the dynamics shows universal scaling laws that allow us to distinguish localized, diffusive, and sub-diffusive regimes. The marginally localized phase has common traits with recently discovered pre-thermalized phases of many-body quantum-Hamiltonian systems, but does not require quantum coherence.

Spatiotemporal dynamics of housing appraisal: The case of Santiago of Chile

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Housing markets play a crucial role in economies, the market value of properties is of great interest to local authorities, mortgage institutions, dissolved companies and other market participants. Appraisal of a property or properties is a complex procedure because different influential factors that constitutes the market values. The correlation matrices of housing appraisal are rarely studied, mainly due to the short length of mass appraisal indices. Using Random Matrix Theory, we investigated the complex spatiotemporal dynamics of Santiago of Chile housing appraisal (2002-2017). We identified valuable economic information in the largest eigenvalues deviating from Random Matrix Theory prediction for the housing market and we found that component signs of the eigenvectors contain geographical information, the extent of differences in house price growth rates or both. We found that during the evolution of the Santiago housing market, the prices diffuse in complex ways that require geographical clusters. The splitting and merging of clusters indicate that the house prices converge. Thus, we show that there are different classifications for converging clusters in different time periods.

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