Workshop on Localization and Ergodicity | (SMR 3964)

26 Aug 2024 - 30 Aug 2024
ICTP, Trieste, Italy

P01 - ALEKSANDROV Artem

Josephson junction as Heun/Hill equation

P02 - AREFYEVA Nataliya

Effective integrability as a real-time property with application to quantum chaos

P03 - BANDYOPADHYAY Souvik

Sharp detection of the onset of Floquet heating using eigenstate sensitivity

P04 - BEDA Rachel Wortis

Entanglement growth and localization in the disordered Fermi-Hubbard model

P05 - BHATTACHARJEE Budhaditya

Quantum Networks: An investigation into the slowing down of thermalization in weakly non-integrable quantum spin dynamics

P06 - BHATTACHARJEE Sourav

Anderson localization induced by correlated disorder

P07 - BUIJSMAN Wouter

To be announced.

P08 - CALABRESE Pasquale

Quantum Mpemba effect

P09 - CHAKRABARTY Aditi

Extended unitarity and absence of skin effect in periodically driven systems

P10 - CHEN Weitao

Describing the critical behavior of the Anderson transition in infinite dimension by random-matrix ensembles: logarithmic multifractality and critical localization

P11 - DAVIES Rose

Resonant fractional conductance in 1D Wigner Chains

P12 - GHOLAMI Zahra

Tensor Network Representation and Entanglement Spreading in Many-Body Localized Systems: A Novel Approach

P13 - GHOSH Soumi

Statistics of local observables in non-Hermitian systems

P14 - GUPTA Sparsh

Effect of quantum jumps in driven-dissipative disordered many-body systems

P15 - JEEVANANDAM Bharathi Kannan

Chaos and localized phases in interacting linear kicked rotor system

P16 - KHVALYUK Anton

Near power-law temperature suppression of the superfluid stiffness in strongly disordered superconductors

P17 - KNIAZEVA Lolita

Transfer matrix approach to disordered fermionic chains

P18 - KOGAN Evgeni

Josephson transmission line: the kinks, the solitons and the shocks.

P19 - KOKOVIN Artem

Attenuation of flexural phonons in crystalline two-dimensional materials

P20 - KUTLIN Anton

Anatomy of the eigenstates distribution: a quest for a genuine multifractality

P21 - LUNKIN Aleksey

Local Density of States Correlations in Lévy-Rosenzweig-Porter random matrix ensemble

P22 - MAHAVEER PRASAD -

Long-ranged spectral correlations in eigenstate phases

P23 - MCARDLE George

The Coulomb Staircase of a Quantum Dot in the Absence of Thermalisation

P24 - NAVARRO GIRALDO Jorge Andres

Weak localization in graphene measured at sub-THz frequencies

P25 - NOSOV Pavel

Quantum fluctuations and multifractally-enhanced superconductivity in disordered thin films

P26 - ORLOV Pavel

Adiabatic Transformations in Dissipative and Non-Hermitian Phase Transitions

P27 - PAIN Bikram

Entanglement dynamics and eigenstate correlations in strongly disordered quantum many-body systems

P28 - PARFENOV Maksim

Instanton effects in spin quantum Hall effect

P29 - PASQUA Ivan

Luttinger surface dominance and Fermi liquid behaviour of topological Kondo insulators SmB6 and YbB12

P30 - SADOUNIKAU Arseni

On mobile impurity on the one-dimensional p-wave topological superconductors

P31 - SAFONOVA Elizaveta

Intensity statistics inside an open wave-chaotic cavity with broken time-reversal invariance

P32 - SHLYAPNIKOV Georgy

Novel phase transitions in disorderted quantum systems

P33 - SIERANT Piotr

Error-resilience Phase Transitions in Encoding-Decoding Quantum Circuits

P34 - SLANINA Frantisek

Random cubic graph embedded in a hypercube: Entanglement spectrum and many-body localization

P35 - TAGLIENTE Antonio Maria

Wetting criticality and Kondo proximity effect in a metal-Mott insulator interface away from particle-hole symmetry

P36 - VANONI Carlo

Renormalization group approach to Anderson localization in finite and infinite dimensions

P01

Josephson junction as Heun/Hill equation

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Josephson junctions plays a significant role in modern technology and draw a lot of attention both from theoreticians and experimentalists. Among many interesting features, it seems that everyone knows the staircase structure in current-voltage characterestic, so-called Shapiro steps. The origin of integer & non-integer Shapiro steps was intensively debated and it was proven that only integer steps appear in the most common model for Josephson junction, RSJ model [1]. The appearance of Shapiro steps is related to so-called *phase-locking* phenomenon, Poincare map, and the concept of rotation number. However, the more mathematically rigorous proof for integer Shapiro steps exists [2]. This proof is based on the properites of dynamical system on torus and tightly related to the monodromy of doubly confluent Heun equation. This proof also relates such Heun equation to the Hill equation and establish one-to-one correspondence between the Poincare rotation number and properties of the potential in Hill equation. These interconnections raises a plethora of questions related to a physical meaning of rotation number in the problem of quasinormal modes of black holes and $\mathrm{SL}(2,\mathbb{Z})$ renormalization group flows. Moreover, the monodromy based approach allows to treat the phase locking phenomenon in terms of Lyapunov exponents of Möbius map. The boundaries of phase-locking domains corresponds to the zero Lyapunov exponent. Analysis of Heun equation monodromy allows express the average voltage on Josephson junction via the ratio of the monodromy matrix eigenvalues.

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Effective integrability as a real-time property with application to quantum chaos

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We consider a local interaction quench for some local degree of freedom (open quantum system) inside an integrable quantum environment [1]. Usually, integrability is considered a static concept for Hamiltonian systems. For some parameters of the Hamiltonian, the system is integrable; for others, it is not. Here, we explore effective integrability as a real-time property. We find that due to the local interaction quench, the set of environmental integrals of motion one by one becomes broken and then one by one rearranged into new emerging integrals of motion at certain times. Therefore, there is a dynamic of integrability in the system in real time. This approach in particular can be applied to the problem of quantum chaos. The emerging integrals of motion carry away the entropy and it's production can be used as a marker of quantum chaos. We illustrated this idea on the model of the open quantum kicked top connected to the bosonic bath. At the classical level for the kicked top [2], depending on the kick strength, there is a crossover between integrable and chaotic behavior. For an analogical quantum model, the entropy production was calculated and shown to be significantly different in the integrable and chaotic regimes [3].

The work of N. Arefyeva and E. Polyakov was supported by Rosatom in the framework of the Roadmap for Quantum computing (Contract No. 868-1.3-15/15-2021 dated October 5).

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P03

Sharp detection of the onset of Floquet heating using eigenstate sensitivity

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Chaotic Floquet systems at sufficiently low driving frequencies are known to heat up to an infinite temperature ensemble in the thermodynamic limit. However at high driving frequencies, Floquet systems remain energetically stable in a robust prethermal phase with exponentially long heating times. We propose sensitivity (susceptibility) of Floquet eigenstates against infinitesimal deformations of the drive, as a sharp and sensitive measure to detect this heating transition [1]. It also captures various regimes (timescales) of Floquet thermalization accurately. Particularly, we find that at low frequencies near the onset of unbounded heating, Floquet eigenstates are maximally sensitive to perturbations of the driving protocol and consequently the scaled susceptibility develops a sharp maximum. The susceptibility maximum clearly separates the high frequency finite temperature ETH regime with energy diffusion from the low frequency infinite temperature steady state regime. We further connect our results to the relaxation dynamics of local observables to show that near the onset of Floquet heating, the system is nonergodic with slow glassy dynamics despite being nonintegrable at all driving frequencies. Such transient nonergodicity in local observables is usually a hallmark of chaotic systems near integrability.

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P04

Entanglement growth and localization in the disordered Fermi-Hubbard model

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Many-body localization impedes the spread of information encoded in initial conditions, blocking (or at least radically slowing) thermalization of an isolated quantum system. We examine the potential to tailor the growth of entanglement in the Fermi Hubbard model by tuning disorder in both the charge and spin degrees of freedom. We begin by expressing the Hamiltonian in terms of a set of optimally localized conserved quantities, and examine in detail the growth of entanglement entropy and its connection with the coupling between these local integrals of motion. We demonstrate how the strength of the disorder in charge and in spin controls the time scales seen in entanglement growth. We also see a shift in behaviour between the weakly and strongly interacting regimes, reflecting local integrals of motion losing their close association with Anderson localized single-particle states.

P05

Quantum Networks: An investigation into the slowing down of thermalization in weakly non-integrable quantum spin dynamics

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Abstract

In this work, we study thermalization slowing down of a quantum many-body system upon approach to two distinct integrability limits. Motivated by previous studies of classical systems, we identify two thermalization time scales: one quantum Lyapunov time scale is extracted by quantifying operator growth in time in an appropriately defined basis, while another ergodization time scale is related to statistics of fluctuations of the time-evolved operator around its mean value based on the eigenstate thermalization hypothesis. Using a paradigmatic Quantum Ising chain, we demonstrate that both timescales diverge upon approach to integrability. The relative strength of the divergence of the scales depends on the particular integrable limit. Using this, we define two different universality classes of quantum thermalization: short- and long-range networks. Based on [1]

[1] Budhaditya Bhattacharjee, Alexei Andreanov, Sergej Flach, *Thermalization slowing down of weakly nonintegrable quantum spin dynamics*, arXiv:2405.00786

P06

Anderson localization in presence of correlated disorder[1]

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Localization of single-particle wavefunctions in presence of impurities is a long studied phenomena. Traditionally, these impurities are introduced “on-site” and are “un-correlated” in a lattice setup. The localization results from a destructive interference of the particle wavefunction due to scattering off these impurity sites. However, Anderson localization can also arise from correlated disorder, in the form of irregular edges of the lattice – in this situation, reflection of such edges leads to a destructive interference of the wavefunction. We model such a situation using graphene platelets, where we construct the lattice through a 2D Monte Carlo simulation of the carbon atoms. We observe a structural phase transition as a function of the artificially defined temperature in the MC simulations. Below the critical temperature, the carbon atoms arrange in large domains with smooth edges and the electron wavefunctions are found to be delocalized. Above the critical temperature, the large domains fracture into smaller domains with ragged edges that localize the wavefunctions. Furthermore, we exploit this phenomenon to investigate a highly anistropic setup where a 3D lattice is constructed by stacking the 2D samples generated from MC simulations. Remarkably, we observe that the presence of correlated disorder along planar direction (and absence in the vertical direction) leads to novel situations in which localized and non-localized wavefunctions can coexist within the lattice.

[1]Manuscript in preparation

P07

To be announced.

P08

Quantum Mpemba effect

P09

Extended unitarity and absence of skin effect in periodically driven systems

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One of the most striking features of non-Hermitian quasiperiodic systems with arbitrarily small asymmetry in the hopping amplitudes and open boundaries is the accumulation of all the bulk eigenstates at one of the edges of the system, termed in literature as the *skin effect* [1], below a critical strength of the potential. In this work, we uncover that a time-periodic drive in such systems can eliminate the SE up to a finite strength of this asymmetry. Remarkably, the critical value for the onset of SE is independent of the driving frequency and approaches to the static behavior in the thermodynamic limit. We find that the absence of SE is intricately linked to the emergence of *extended unitarity* in the delocalized phase, providing dynamical stability to the system [2]. Interestingly, under periodic boundary condition, our non-Hermitian system can be mapped to a Hermitian analogue in the large driving frequency limit that leads to the extended unitarity irrespective of the hopping asymmetry and the strength of the quasiperiodic potential, in stark contrast to the static limit. Additionally, we numerically verify that this behavior persists at all frequencies of the drive. Based on our findings, we propose a possible experimental realization of our driven system, which could be used as a switch to control the light funneling mechanism.

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P10

Describing the critical behavior of the Anderson transition in infinite dimension by random-matrix ensembles: logarithmic multifractality and critical localization

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Due to their analytical tractability, random matrix ensembles serve as robust platforms for exploring exotic phenomena in systems that are computationally demanding. In this work, we investigate two random matrix ensembles tailored to capture the critical behavior of the Anderson transition in infinite dimension, employing both analytical techniques and extensive numerical simulations. Our study unveils two types of critical behaviors: logarithmic multifractality and critical localization. In contrast to conventional multifractality, the novel logarithmic multifractality features eigenstate moments scaling algebraically with the logarithm of the system size. Critical localization, characterized by eigenstate moments of order $q > 1/2$ converging to a finite value indicating localization, exhibits characteristic logarithmic finite-size or time effects, consistent with the critical behavior observed in random regular and Erdös-Rényi graphs of effective infinite dimensionality. Using perturbative methods, we establish the existence of logarithmic multifractality and critical localization in our models. Furthermore, we explore the emergence of novel scaling behaviors in the time dynamics and spatial correlation functions. Our models provide a valuable framework for studying infinite-dimensional quantum disordered systems, and the universality of our findings enables broad applicability to systems with pronounced finite-size effects and slow dynamics, including the contentious many-body localization transition, akin to the Anderson transition in infinite dimension.

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Resonant Fractional Conductance In 1D Wigner Chains

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Recent experiments on weakly confined quantum point contacts have shown plateaus in conductance occurring at fractions of the quantum of conductance even in the absence of a magnetic field [1,2]. A discrete model of strongly interacting 1D electrons, where fractionally charged solitons carry the current between two weakly connected contacts, is considered. For spinless electrons, the conductance is unaffected by the interactions in the channel – a discrete counterpart to the lack of renormalisation of conductance in finite Luttinger Liquids [3,4]. The spinful case, however, displays a peak conductance at even-denominator fractions of the quantum of conductance [5].

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Tensor Network Representation and Entanglement Spreading in Many-Body Localized Systems: A Novel Approach

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A novel method has been devised to compute the Local Integrals of Motion (LIOMs) for a one-dimensional many-body localized system. In this approach, a class of optimal unitary transformations is deduced in a tensor-network formalism to diagonalize the Hamiltonian of the specified system. To construct the tensor network, we utilize the eigenstates of the subsystems' Hamiltonian to attain the desired unitary transformations. Subsequently, we optimize the eigenstates and acquire appropriate unitary localized operators that will represent the LIOMs tensor network. Our method for constructing the local unitary operators in the tensor network framework allows us to obtain the unitary operator with high accuracy for blocks of very large length. The effective accuracy of the presented method has been examined and it has been shown that if the block length is larger than the localization length of the LIOM, then the entire Hamiltonian can be diagonalized with a high accuracy by the unitary operator of the tensor network. The efficiency of the method was assessed and found to be both fast and almost accurate. In framework of the introduced tensor-network representation, we examine how the entanglement spreads along the considered many-body localized system and evaluate the outcomes of the approximations employed in this approach. The important and fascinating result is that in the proposed tensor network approximation, if the length of the blocks is greater than the length of localization, then the entropy growth will be linear in terms of the logarithmic time. Also, it has been shown that the entanglement can be computed by only considering two blocks next to each other, if the Hamiltonian has been diagonalized using the unitary transformation made by the provided tensor-network representation.

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P13

Statistics of local observables in non-Hermitian systems

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The thermalization in closed quantum chaotic systems has been manifested using the eigenstate thermalization hypothesis (ETH) which asserts some conditions on the matrix elements of local observables in the energy eigenbasis of such systems. The ETH has been verified for various systems, while violation of ETH has led to interesting phenomena. Very recently, non-Hermitian systems have gained a lot of interest as effective representations of dissipative systems. The concept of dissipative quantum chaos has emerged in this context where universal features of such systems have been shown to correspond to the complex random matrices (Ginibre). This has led to the question about the structure of local observables in presence of dissipative quantum chaos. While the structure of the matrix elements of such local observables has been shown to be quite different in the Ginibre random matrices than the assumptions of ETH, we investigate such structure in the context of a disordered spin-chain in the presence of non-Hermiticity. We specifically look at matrix elements that are invariant under the gauge transformation allowed by the bi-orthonormality of the eigenstates of non-Hermitian matrices. We show that these matrix elements occur naturally in the time evolution of the autocorrelation functions of local operators assuming a definition of inner product that is important to retain the normality of states in the presence of non-Hermiticity. We show that in the quantum chaotic limit (small disorder), these matrix elements indeed have different structures than what is expected in closed chaotic systems. However, in the strong disorder limit, the matrix elements fluctuate from eigenstate to eigenstate in a similar way as in the case of localized states in closed interacting systems.

P14

Effect of Quantum jumps in driven-dissipative disordered many-body systems

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We discuss how quantum jumps affect localized regimes in driven-dissipative disordered many-body systems featuring a localization transition. We introduce a deformation of the Lindblad master equation that interpolates between the standard Lindblad and the no-jump non-Hermitian dynamics of open quantum systems. As a platform, we use a disordered chain of hard-core bosons with nearest-neighbor interactions and are subject to incoherent drive and dissipation at alternate sites. We probe both the statistics of complex eigenvalues of the deformed Liouvillian and dynamical observables of physical relevance. We show that reducing the number of quantum jumps, achievable through realistic post-selection protocols, can promote the emergence of the localized phase. Our findings are based on exact diagonalization and time-dependent matrix-product state techniques. This work is available on arXiv [1]

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P15

Chaos and localized phases in interacting linear kicked rotor system

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Despite the periodic kicks, a linear kicked rotor (LKR) remains an integrable and exactly solvable model, with the kinetic energy term linear in momentum. Recent findings have revealed that spatially interacting LKRs also maintain integrability, leading to dynamical many-body localization (DMBL) in the corresponding quantum regime[1]. This phenomenon of localization has been observed in analogous nonintegrable models, like the coupled relativistic kicked rotors[2]. However, DMBL phases tend to emerge predominantly in scenarios where the underlying classical phase space exhibits regular or mixed characteristics.

In this study, our objective was to probe the possibility of dynamical many-body localization (DMBL) even within systems exhibiting completely chaotic classical dynamics[3]. Employing a two-body linear kicked rotor (LKR), we unveil two pivotal outcomes. Firstly, we demonstrate the induction of chaos in the integrable linear kicked rotor via interactions between the momenta of rotors, offering an analytical estimate of its Lyapunov exponent. Secondly, we delve into the quantum dynamics of this chaotic model, uncovering a diverse spectrum of phases as we manipulate kicking and interaction strengths. These phases encompass classically induced localization, dynamical localization, subdiffusive behavior, and diffusive phenomena. Our findings shed light on how chaos in classical systems influences quantum behavior, leading to the emergence of localization effects. It also presents a significant example of where DMBL can emerge, even amidst chaotic classical dynamics. We highlight the signatures of these phases from the perspective of entanglement production within the system. By defining an effective Hilbert space dimension, the entanglement growth rate can be understood using appropriate random matrix averages.

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P16

Near power-law temperature suppression of the superfluid stiffness in strongly disordered superconductors

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In BCS superconductors, the superfluid stiffness is virtually constant at low temperature and only slightly affected by the exponentially low density of thermal quasiparticles. Here, we present an experimental and theoretical study on the temperature dependence of superfluid stiffness $\Theta(T)$ in a strongly disordered pseudo-gaped superconductor, amorphous InO_x, which exhibits non-BCS behavior. Experimentally, we report an unusual power-law suppression of the superfluid stiffness $\delta\Theta(T) \propto T^b$ at $T \ll T_c$, with $b \sim 1.6$, which we measured via the frequency shift of microwave resonators. Theoretically, by combining analytical and numerical methods to a model of a disordered superconductor with pseudogap and spatial inhomogeneities of the superconducting order parameter, we found a qualitatively similar low-temperature power-law behavior with exponent $b \sim 1.6 - 3$ being disorder-dependent. This power-law suppression of the superfluid density occurs mainly due to the broad distribution of the superconducting order parameter that is known to exist in such superconductors [1, 2], even moderately far from the superconductor-insulator transition. The presence of the power-law dependence $\delta\Theta(T) \propto T^b$ at low $T \ll T_c$ demonstrates the existence of low-energy collective excitations; in turn, it implies the presence of a new channel of dissipation in inhomogeneous superconductors caused by sub-gap excitations that are not quasiparticles. Our findings have implications for the use of strongly disordered superconductors as superinductance in quantum circuits.

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P17

Transfer matrix approach to disordered fermionic chains

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The interplay of disorder and interaction in many-body systems is one of the central topics of condensed matter physics. It is frequently studied in the Hubbard model [1] where particles are located on lattice sites.

Here we consider a pair of identical fermions on a strongly disordered finite closed chain. The Hamiltonian describing this system has the following form:

$$H = \sum_{i=1}^{N} V_i n_i - U \sum_{i=1}^{N} n_i n_{i+1}, \tag{1}$$

where N – the number of sites, n_i – the number of fermions (0 or 1 fermion) on site i, the site energies V_i are taken from some probability distribution $p(V_i)$ with a width W, $-U$ – attraction of the nearest neighbors. Here we neglect the kinetic energy due to Anderson localization [2].

A pair of identical fermions is bound if they occupy neighboring sites. And the aim of this work is to find the probability of formation of a bound pair P_b that is determined by the ratio U/W and N. The general expression of this probability is the following:

$$P_b(U) = N\Big\langle \theta\left(V_N - V_2\right) \prod_{j=2}^{N-1} \theta\left(V_j + V_{j+1} - V_1 - V_2\right) \prod_{j=2}^{N-2} \prod_{l=j+2}^{N} \theta\left(V_j + V_l - V_1 - V_2 + U\right) \times \prod_{l=3}^{N-1} \theta\left(V_l - V_2 + U\right) \Big\rangle. \tag{2}$$

Consider the case where the ground state corresponds to separated fermions, i.e., occupying two non-neighboring sites, e.g., the 1^{st} and the k^{th} ones ($k \neq 2, N$). Due to equivalence of configurations $(1,k)$, $(2,k+1)$, etc., taking into account all the options will be reduced to multiplying by a factor of $N^2/2$. Then it turns out that the problem can be solved using the transfer matrix method with introducing the operator:

$$\hat{A}\left(V, V'\right) = \sqrt{p(V)}\theta\left(V - \varepsilon\right)\theta\left(V + V' - U - E\right)\theta\left(V' - \varepsilon\right)\sqrt{p(V')}. \tag{3}$$

Here we denoted $E = V_1 + V_k$ and $\varepsilon = \max\{V_1, V_k\}$.

In our work [3] we managed to calculate the pairing probability for dimensionless box distribution of disorder $p(V_i) = \theta(V_i)\theta(1 - V_i)$:

$$P_b(U) = 1 - \theta(1/2 - U)\left(1 - U\right)^N \left(\frac{1 - 2U}{1 - U}\right)^2 - \frac{2\left(1 - U\right)^4 \lambda_*^{N-2}(U)}{\lambda_*^2(U) + \left(1 - U\right)^2}\left[1 - e^{-\gamma_k N U}\right], \tag{4}$$

where λ_* – the largest modulus eigenvalue of (3), γ_k – a small coefficient depending on U and λ_*.

This dependence is consistent with the results of the numerical experiment that we conducted before the analytical consideration. Therefore, it describes the crossover between the regimes of coupled and separated fermions.

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P18

Josephson transmission line: the kinks, the solitons and the shocks

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Abstract

The localized running waves in the discrete Josephson transmission lines (JTL), constructed from Josephson junctions (JJ) and capacitors, are analytically studied. The quasicontinuum approximation reduces calculation of the running wave properties to the problem of equilibrium of an elastic rod in the potential field. Making additional approximation, the problem is reduced to the motion of the fictitious Newtonian particle in the potential well. It is shown that there exist running waves in the form of supersonic kinks and solitons and their velocities and profiles are calculated. It is shown that the nonstationary smooth waves which are small perturbations on the homogeneous nonzero background are described by Korteweg–de Vries equation and those on zero background by modified Korteweg–de Vries equation. The effect of dissipation on the running waves in JTL is also studied and it is found that in the presence of the resistors, shunting the JJ and/or in series with the ground capacitors, the only possible stationary running waves are the shock waves, whose profiles are also found.

The modulated harmonic wave in the discrete series-connected JTL is considered. The approach to the modulation problems for discrete wave equations based on discrete calculus is formulated. The approach is checked by applying it to the Fermi–Pasta–Ulam–Tsingou -type problem. Applying the approach to the discrete JTL, the equation describing the modulation amplitude is obtained, which turns out to be the defocusing nonlinear Schrödinger (NLS) equation.

We consider parametric amplification in the discrete JTL. We derive equations describing pump, signal, and idler interaction in the system and calculate the thresholds for the parametric amplification.

We analyse the scattering of the "sound' (small amplitude small wave vector harmonic wave) on the shock wave and calculate the reflection and the transmission coefficients.

Finally we consider the transmission line constructed from ideal linear inductors and nonlinear capacitors. The travelling waves with finite support in the lossless transmission line are the kinks and the solitons, which speeds and profiles were calculated. We also studied lossy transmission lines. The travelling waves with finite support in such systems are the dissipative kinks and the shocks, which speeds and profiles were also calculated.

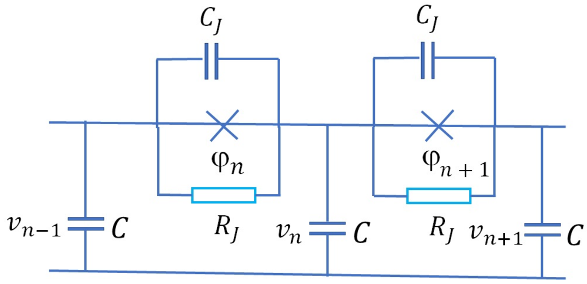

Figure 1: Discrete Josephson transmission line.

Keywords: Josephson transmission line; kinks; solitons; shocks

The discrete model of the Josephson transmission line (JTL) is constructed from the identical Josephson junctions (JJs) capacitors and resistors, as shown on Fig. 1. We take as the dynamical variables the phase differences (which we for brevity will call just phases) φ_n across the JJs and the voltages v_n of the ground capacitors. The circuit equations are

$$\frac{\hbar}{2e}\frac{d\varphi_n}{dt} = v_{n-1} - v_n \tag{1a}$$

$$C\frac{dv_n}{dt} = I_c \sin\varphi_n - I_c \sin\varphi_{n+1} + \left(\frac{1}{R_J} + C_J\frac{d}{dt}\right)\frac{\hbar}{2e}\frac{d}{dt}\left(\varphi_n - \varphi_{n+1}\right), \tag{1b}$$

where C is the capacitance, I_c is the critical current of the JJ, and C_J and R_J are the capacitor and the ohmic resistor shunting the JJ.

Having limited space we decided to present in this abstract the solutions of two problems. The first one: A sound wave is incident from the rear on a shock wave. as is shown in Fig. 2.

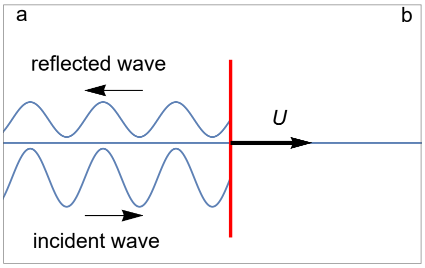

Figure 2: Reflection of a sound wave from a shock wave.

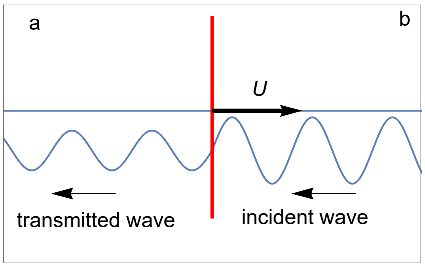

Figure 3: Transmission of a sound wave through a shock wave.

The sound reflection coefficient R is

$$R \equiv \frac{\varphi^{(r)}}{\varphi^{(in)}} = -\frac{\left[u\left(\varphi_a\right) - U\right]^2}{\left[u\left(\varphi_a\right) + U\right]^2} = -\frac{u_{in}^2}{u_r^2}, \qquad (2)$$

where $u_{in} = u\left(\varphi_a\right) - U$ is the speed of the incident sound wave relative to the shock wave, and $u_r = u\left(\varphi_a\right) + U$ is the speed of the reflected sound wave relative to the shock wave.

The second problem: A sound wave is incident from the front on a shock wave as is shown in Fig. 3. The sound transmission coefficient T is

$$T \equiv \frac{\varphi^{(t)}}{\varphi^{(in)}} = \frac{\left[u\left(\varphi_b\right) + U\right]^2}{\left[u\left(\varphi_a\right) + U\right]^2} = \frac{u_{in}^2}{u_t^2}, \qquad (3)$$

where $u_{in} = u\left(\varphi_b\right) + U$ is the speed of the incident sound wave relative to the shock wave, and $u_t = u\left(\varphi_a\right) + U$ is the speed of the transmitted sound wave relative to the shock wave.

We also present the calculated profile of the shock wave (see Fig. 4).

Finally we would like to consider the discrete transmission line constructed from the identical inductors, nonlinear capacitors and resistors as is shown on Fig. 5.

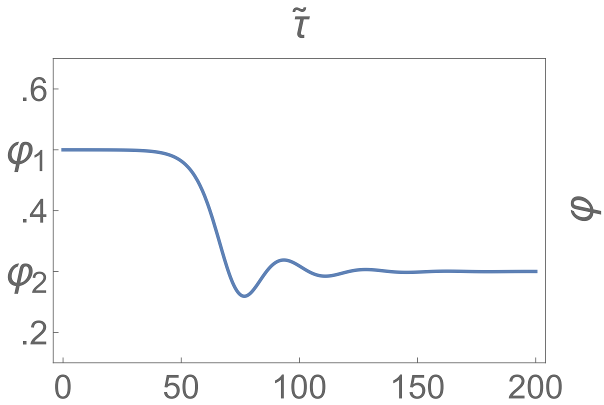

Figure 4: Transmission of a sound wave through a shock wave.

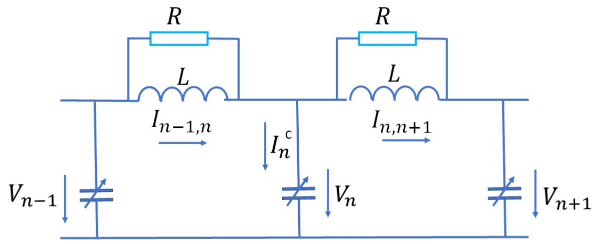

Figure 5: Transmission of a sound wave through a shock wave.

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P19

Attenuation of flexural phonons in crystalline two-dimensional materials

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This work explores the dynamic behavior of flexural phonons in two-dimensional crystalline membranes at the room temperature. We studied the attenuation of flexural phonons due to interaction with in-plane phonons with the help of the Matsubara diagram technique.

At first we found that the decay rate of flexural phonons in the free-standing membrane is independent of temperature, unlike the standard lifetime in three-dimensional crystals due to three-phonon processes. Our analysis show that this unexpected result is because of the strong screening of the interaction at small momenta $q < q_*$ where $q_* \sim \sqrt{YT}/\varkappa$. Here Y and $\varkappa$ denote the Young's modulus and the bending rigidity, respectively.

For static out-of-plane deformations the strong screening of the interaction results, as well-known, in power-law dependence of the Young's modulus and the bending rigidity on momentum, $Y \sim q^{2-2\eta}$ and $\varkappa \sim q^{-\eta}$ [1]. These power-law scaling of elastic moduli persits in the dynamic. We also obtained the exact relation for the dynamical exponent: $\mathsf{z} = 2 - \eta/2$. For long-wave in-plane phonons we obtained non-trivial dynamical exponent $\mathsf{z}'{=}(2{-}\eta)/(1{-}\eta/2)$, contrary to the result of [3].

We studied the effect of an applied stress σ on the attenuation of flexural phonons, which is usually present in the experiments when studying nanoelectromechanical properties of graphene [2]. For sufficiently large flakes the spectral line quality factor Q_k (the ratio of the spectrum to its width) is parametrically large and strongly depends on the temperature and the stress ([5]).

Finally, behaviour of mean squared displacement, $\langle (h(t) - h(0))^2\rangle$, was analysed as a function of time ([4]). At long times, $t \gg \sqrt{\rho/(\varkappa q_*^4)}$ (ρ is the mass density), we obtain $\langle (h(t) - h(0))^2\rangle \propto t^{1-\beta}$, where $\beta = \frac{\eta}{4-\eta} > 0$. The latter implies that fluctuations behave subdiffusively in quantitative agreement with the experiment.

The work was funded in part by the Russian Ministry of Science and Higher Educations and the Basic Research Program of HSE.

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P20

Anatomy of the eigenstates distribution: a quest for a genuine multifractality

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Motivated by a series of recent works [1, 2, 3, 4], an interest in multifractal phases has risen as they are believed to be present in the Many-Body Localized (MBL) phase and are of high demand in quantum annealing [5] and machine learning [6]. Inspired by the success of the Rosenzweig-Porter (RP) model with Gaussian-distributed hopping elements, several RP-like ensembles with the fat-tailed distributed hopping terms have been proposed [7, 8, 9, 10, 11], with claims that they host the desired multifractal phase. In the present work, we develop a general (graphical) approach allowing a self-consistent analytical calculation of fractal dimensions for a generic RP model and investigate what features of the RP Hamiltonians can be responsible for the multifractal phase emergence. We conclude that the only feature contributing to a genuine multifractality is the on-site energies' distribution, meaning that no random matrix model with a statistically homogeneous distribution of diagonal disorder and uncorrelated off-diagonal terms can host a multifractal phase.

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P21

Local Density of States Correlations in Lévy-Rosenzweig-Porter random matrix ensemble

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Abstract:

We present an analytical calculation of the local density of states correlation function $\beta(\omega)$ in the Lévy-Rosenzweig-Porter random matrix ensemble at energy scales larger than the level spacing but smaller than the bandwidth. The only relevant energy scale in this limit is the typical width of the level Γ_0. We show that $\beta(\omega \ll \Gamma_0) \sim W/\Gamma_0$ (here W is width of the whole band) whereas $\beta(\omega \gg \Gamma_0) \sim (W/\Gamma_0)(\omega/\Gamma_0)^{-\mu}$ where μ is an index characterising the distribution of the matrix elements. We also provide an expression for the average return probability at long times: $\ln R(t \gg \Gamma_0^{-1}) \sim -(\Gamma_0 t)^{\mu/2}$. Numerical results based on the pool method and exact diagonalization are also provided and are in agreement with the analytical theory.

P22

Long-ranged spectral correlations in eigenstate phases

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We study non-local measures of spectral correlations and their utility in characterizing and distinguishing between the distinct eigenstate phases of quantum chaotic and many-body localized systems. In this work, we focus on two related quantities, the spectral form factor and the density of all spectral gaps (DOG), and show that they furnish unique signatures that can be used to sharply identify the two phases. We also obtain an analytical form of DOG for Poisson numbers and random matrices (both of which have not been presented in the literature previously to the best of our knowledge). We demonstrate this by numerically studying three one-dimensional quantum spin chain models with (i) quenched disorder, (ii) periodic drive (Floquet), and (iii) quasiperiodic detuning. We also clarify in what ways the signatures are universal and in what ways they are not. More generally, this thorough analysis is expected to play a useful role in classifying phases of disorder systems.

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P23

The Coulomb Staircase of a Quantum Dot in the Absence of Thermalisation

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The Coulomb staircase in Coulomb-blockaded quantum dots is a well-studied phenomenon where electrons can accumulate on the dot as the bias voltage is increased resulting in a staircase in the current-voltage (I-V) characteristics [1]. It is typically assumed that the electrons on the dot completely thermalise [1,2], although this breaks down if the quasiparticle decay rate on the dot is much less than the tunnelling rates to the leads. Such a regime is of interest at sufficiently low energies where localisation in Fock space is predicted to occur [3]. Our work explores the effect of the absence of thermalisation on the I-V characteristics.

When there is a strong asymmetry in the coupling to the leads, the absence of thermalisation does not change the staircase provided that the Fermi energy of the dot in equilibrium is much larger than the charging energy. However, if the Fermi energy of the dot is much smaller than the charging energy, the lowest energy levels on the dot dominate the transport and practically cause the disappearance of the staircase [4]. For approximately symmetric coupling to the leads, the distribution function of electrons on the dot changes from a Fermi function to a double-step form [5]. This is similar to that seen in one-dimensional wires [6], although here it is strongly influenced by the interaction. Experimentally, this effect can be seen as an additional peak in the differential conductance compared to full thermalisation. This peak occurs at voltages equal to the charging energy.

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P24

Weak localization in graphene measured at sub-THz frequencies

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Weak localization arises at low temperatures due to coherent electron scattering with impurities and the constructive interference of self-crossing electron trajectories, which leads to measurable increase in the material's resistivity. In graphene at temperatures around 1 K, the characteristic time of dephasing scattering events that lead to decoherence is of the order of $\tau_\varphi \sim$ 10 ps, or equivalently, a dephasing scattering rate of $\tau_\varphi^{-1} \sim$ 100 GHz. By performing AC magnetotransport measurements on graphene using microwaves in the frequency range 95-350 GHz, we demonstrate that the weak localization signal acquires a frequency dependence not observed before. We argue that as the microwave frequency is comparable to the dephasing scattering rate, it plays a role in the decoherence dynamics that is not explained by extending the current theory of weak localization in graphene to the AC limit. The presented data uses an advanced frequency and field dependence mapping of graphene samples, showing how advancing in spectroscopic methods can unveil yet new phenomena in this intriguing and extensively studied material.

P25

Quantum fluctuations and multifractally-enhanced superconductivity in disordered thin films

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The interplay between electron-electron interactions and weak localization phenomena in two-dimensional systems can significantly enhance the superconducting transition temperature. We develop the theory of quantum fluctuations within such multifractally-enhanced superconducting states in thin films. In conditions of weak disorder, we employ the Finkel'stein non-linear sigma model to derive an effective action for the superconducting order parameter and the quasiclassical Green's function, meticulously accounting for the influence of quantum fluctuations. This effective action, applicable for interactions of any strength, reveals the critical role of well-known collective modes in a dirty superconductor, and its saddle point analysis leads to modified Usadel and gap equations. These equations comprehensively incorporate the renormalizations stemming from the interplay between interactions and disorder, resulting in the non-trivial energy dependence of the gap function. Notably, our analysis establishes a direct relation between the self-consistent gap equation at the superconducting transition temperature and the known renormalization group equations for interaction parameters in the normal state.

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P26

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WORKSHOP ON LOCALIZATION AND ERGODICITY
Trieste, Italy, 26st – 30th August 2024

Adiabatic Transformations in Dissipative and Non-Hermitian Phase Transitions

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Using the notion of the generator of adiabatic transformations, two distinct generalizations of the quantum geometric tensor (1) for non-Hermitian systems are proposed. One of these generalizations has already emerged in the literature to characterize phase transitions in non-Hermitian Hamiltonians. However, for non-equilibrium steady-states in dissipative systems this quantity is equal to zero for kinematical reasons. Instead, we argue that our second generalization of the geometric tensor can be used as a novel approach for the investigation of phase transitions in either systems with non-Hermitian Hamiltonian or open dissipative systems. As our trial area we use the non-Hermitian Su-Schrieffer-Heeger model as a Hamiltonian system and a general fermionic model with quadratic Lindbladian as a dissipative one. We find that our method allows to identify phase transitions in all models under consideration, giving a universal tool to explore general non-Hermitian systems.

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P27

Entanglement dynamics and eigenstate correlations in strongly disordered quantum many-body systems

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We present a microscopic theory of the ultraslow growth of entanglement in terms of dynamical eigenstate correlations in the many-body localised regime of strongly disordered, interacting quantum systems. These correlations involve sets of four or more eigenstates and hence, go beyond correlations involving pairs of eigenstates which are usually studied in the context of eigenstate thermalisation or lack thereof. We consider the minimal case, namely the second Rényi entropy of entanglement, wherein the correlations involve quartets of four eigenstates. We identify that the dynamics of the entanglement entropy is dominated by the spectral correlations within certain special quartets of eigenstates. We uncover the spatial structure of these special quartets and the ensuing statistics of the spectral correlations amongst the eigenstates therein, which reveals a hierarchy of timescales or equivalently, energyscales. We show that the hierarchy of these timescales along with their non-trivial distributions conspire to produce the logarithmic in time growth of entanglement, characteristic of the many-body localised regime. This microscopic theory therefore provides a much richer perspective on entanglement growth in strong disordered systems compared to the commonly employed phenomenological approach based on the ℓ-bit picture.

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P28

Instanton effects in spin quantum Hall effect

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Recently, studing of criticality in quantum systems has attracted a great interest. There are some theoretical evidences of SQHE in two dimensional superconducting systems with $d_{x^2-y^2} + id_{xy}$ pairing [1]. In this study [5] we develop the theory of the spin quantum Hall transition, using the generalization of Pruisken replica NLσM with θ-term [2] on superconducting class C [3, 4]. Using NLσM action, we show explicitly the presence of the non-trivial topological configurations of Q-matrix field, called instantons. To find the analytical form of such configurations with topological charge equals to one, we construct solutions of self-duality (anti-self-duality) equations, using the symmetries of target coset space $G/K = Sp(2N)/U(N)$. In Gaussian approximation we find action for small fluctuactions around the instanton. We find whole instanton manifold and identify all instanton eigenparameters as zero modes of kinetic operators for fluctuations. After this we compute instanton contribution to the partition function, anomalous dimensions for all pure-scaling operators without derivatives and longitudinal and transverse spin conductivities. Finally, we construct phase diagram for SQHE transition in one-instanton approximation, where we obtain quantum phase transition between phases with $g_H = 0$ and $g_H = 2$ at $g_H = 1$. This phase diagram is closely connected with boundary theory of chiral fermions in the unconventional superconductors [1]. Addition of the Zeeman field breaks $SU(2)$ symmetry and induces a crossover to universality class A, where transition occurs between $g_H = 0$ and $g_H = 1$ at $g_H = 1/2$, as it is for IQH transition [6].

This work was supported by the Russian Science Foundation (Grant No. 22-42-04416).

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P29

Luttinger surface dominance and Fermi liquid behaviour of topological Kondo insulators SmB_6 and YbB_{12}

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In the last years an increasing effort has been devoted to study the role of topology beyond the non-interacting picture. The interplay between topology and correlations in strongly interacting systems is very hard to tackle and yet not well understood.
Here we first consider a model for a Quantum Spin Hall Insulator [1] (QSHI) and we add an on site Coulomb repulsion between the electrons. Using the Dynamical Cluster Approximation we investigate the role of the non-local correlations in the QSHI-MI (Mott Insulator) phase transition. Between the QSHI and the MI we find a crossover to a phase where both topological poles and zeros of the Green's function coexist in a novel phase we called *"Topological Pseudogap Insulator"* [2].
We use the phenomenology of this novel phase to understand the remarkable dichotomy that has been observed in the topological Kondo insulators SmB_6 and YbB_{12}. Prompted by the peculiar mixed-valence nature of these compounds, involving f and d electrons of the lanthanide, we argue that the f and d subsystems, when considered separately, act, respectively, as electron- and hole-doped Mott insulators, featuring Fermi pockets coexisting with Luttinger surfaces responsible for the pseudogap. When the two are coupled to each other a hybridisation gap opens up and the whole turns into a topological insulator endowed with genuine chiral edge states. However, the Luttinger surfaces persist and support neutral quasiparticles. This scenario effectively resolves the paradoxical phenomenology of SmB_6 and YbB_{12} [3].

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P30

On mobile impurity on the one-dimensional p-wave topological superconductors

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We investigate the behavior of a Kitaev wire locally interacting with a single mobile impurity. In the mean-field approximation, we have found the character of the polaron-molecule transition significantly depends on the phase of the Kitaev chain. For the topological wire's phase we have found a smooth crossover from the bound molecule in the strong coupling regime to a polaron at the weaker interactions. While if the host chain is in a trivial phase, we observe a sharp quantum phase transition. These results were confirmed by the exact diagonalization and DMRG calculations. We further explore this phase transition by mapping the chain to the Ising model and analyzing the combined system of Dirac equation (representing the original system) and Schrodinger equation (representing the impurity). Perhaps the effect might serve as a way to diagnose the phase of nanowires.

P31

Intensity statistics inside an open wave-chaotic cavity with broken time-reversal invariance

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Using the supersymmetric method of random matrix theory within the Heidelberg approach framework we provide statistical description of stationary intensity sampled in locations inside an open wave-chaotic cavity, assuming that the time-reversal invariance inside the cavity is fully broken. In particular, we show that when incoming waves are fed via a finite number M of open channels the probability density $\mathcal{P}(I)$ for the single-point intensity I decays as a powerlaw for large intensities: $\mathcal{P}(I) \sim I^{-(M+2)}$, provided there is no internal losses. This behaviour is in marked difference with the Rayleigh law $\mathcal{P}(I) \sim \exp(-I/\overline{I})$ which turns out to be valid only in the limit $M \to \infty$. We also find the joint probability density of intensities $I_1, \ldots, I_L$ in $L > 1$ observation points, and then extract the corresponding statistics for the maximal intensity in the observation pattern. For $L \to \infty$ the resulting limiting extreme value statistics (EVS) turns out to be different from the classical EVS distributions.

P32

Novel phase transitions in disorderted quantum systems

P33

Error-resilience Phase Transitions in Encoding-Decoding Quantum Circuits

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Understanding how errors deteriorate the information encoded in a many-body quantum system is a fundamental problem with practical implications for quantum technologies. In this contribution, I will consider a class of encoding-decoding random circuits subject to local coherent and incoherent errors [1]. I will analytically demonstrate the existence of a phase transition from an error-protecting phase to an error-vulnerable phase occurring when the error strength is increased. This transition is accompanied by Rényi entropy transitions and by the onset of multifractal features in the system. The described results provide a perspective on storing and processing quantum information, while the introduced framework enables an analytic understanding of dynamical critical phenomena in many-body systems. I will discuss how the demonstrated transition affects the non-stabilizerness in the system and provide an outlook on a typicality approach to the considered system.

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P34

Random cubic graph embedded in a hypercube: Entanglement spectrum and many-body localization

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Since the beginning of the study of many-body localization, there was a tight connection to Anderson localization on locally tree-like graphs. Notorious examples include random regular graphs (RRG), localization properties of which have been investigated in depth. However, the connection to realistic models, like 1D disordered Heisenberg spin chains is not fully clear and relation of experimentally observed signs of the breakdown of thermalization to localization on RRG seems elusive. In our work we aim at bridging the gap, at least partially, by introducing a model that features both the simplicity of locally-tree-like topology and opportunity to directly study thermalization. The model consists in a framework which is a hypercube within which a random regular graph of order 3 (i.e. the cubic graph) is embedded. We study the spectrum and eigenvector properties of the model using exact diagonalization. As a witnesses of many-body localization, we use the entanglement entropy and signatures of eigenvector thermalization hypothesis (ETH). We investigate in detail the flow of entanglement entropy with increasing system size. This way we estimate the width of the critical region around the suspected transition point. We show that a generic local observable in a pure state near to the center of the spectrum has Gaussian distribution in ergodic (thermal) phase while it is bimodal in many-body localized (athermal) phase, which indicates that the microcanonic and single-eigenstate statistical ensembles are not equivalent in thermodynamic limit, i.e. ETH is broken. In the critical region, there are indication of power-law distribution of local observable values. In addition to entanglement entropy, we calculate also the entanglement spectrum, showing that it has generically a Marčenko-Pastur shape in the thermal phase, with model-specific features which tend to vanish in the thermodynamic limit. At the transition, the character of the spectrum changes substantially. For a finite system the change in shape is gradual, which provides another hint at the width of the critical region around the transition point.

P35

Wetting criticality and Kondo proximity effect in a metal-Mott insulator interface away from particle-hole symmetry

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We study a Mott insulator slab in contact with a metallic one away from particle-hole symmetry by the Gutzwiller approximation, both the conventional one and the so-called ghost-Gutzwiller approximation[1] that gives access to the Hubbard bands and thus to the Kondo proximity effect in the Mott insulator[2].

The first-order nature of the Mott transition away from particle-hole symmetry within the Gutzwiller approximation allows for a wetting critical behaviour characterized by a metal wetting layer that grows logarithmically approaching the first-order transition, thus realizing a surface critical phenomenon. Such critical behavior shows up both in the electron density and quasiparticle residue.

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P36

Renormalization group approach to Anderson localization in finite and infinite dimensions