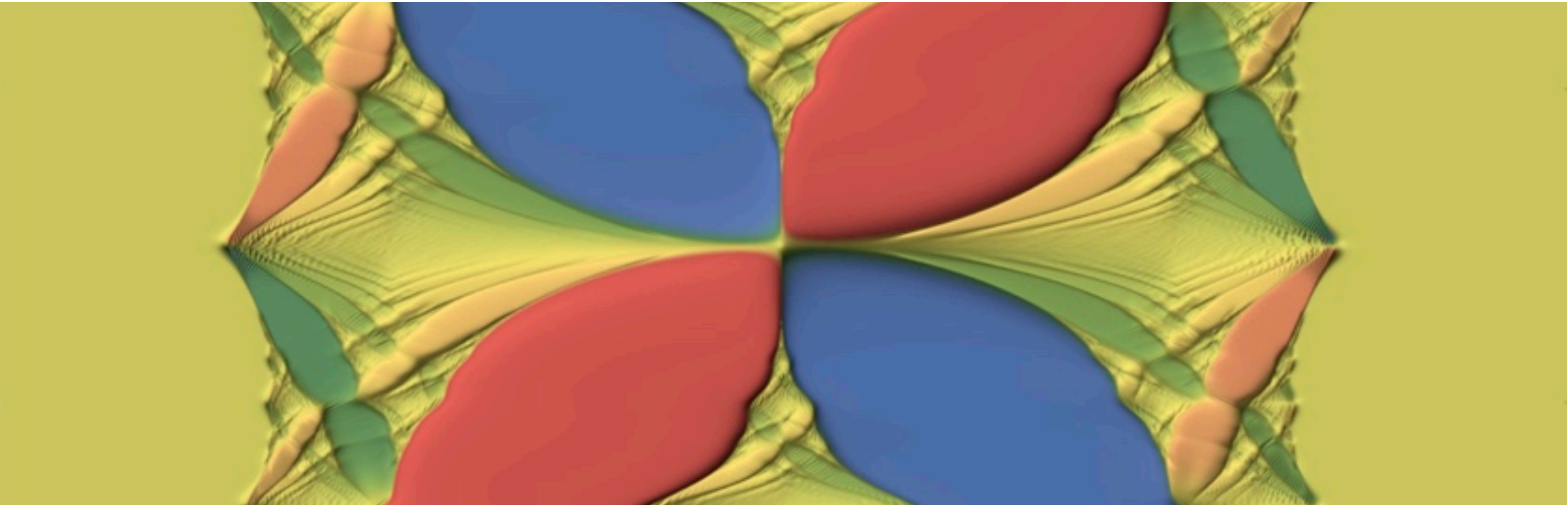

Cuernavaca Conference on

Random Matrix Theory and its Applications

on the occasion of the

80th Birthday of Thomas H. Seligman

70th Birthday of Jacobus Verbaarschot

70th Birthday of Francois Leyvraz

July 22 to 26, 2024

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CONAHCYT

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Participants:

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2. Jacobus Verbaarschot (Stony Brook University)
3. Francois Leyvraz (UNAM)
4. Tomaz Prozen (University of Ljubljana)
5. Marko Znidaric (University of Ljubljana)
6. Alexander Altland (Köln University)
7. Barbara Dietz (IBS PCS Daejeon)
8. Lucas Sa (Cambridge University)
9. Jiri Vanicek (EPFL)
10. Arul Lakshminarayan (Indian Institute of Technology Madras)
11. Luciano Pomatto (Caltech)
12. Markus Müller (UAE-Morelos)
13. Jorge Hirsch (UNAM)
14. Alejandro Frank (UNAM)
15. Carlos Pineda (UNAM)
16. Isaac Perez (UNAM)
17. Rafael Mendez (UNAM)
18. Gabriela Baez (UAM)
19. Manan Vyas (UNAM)
20. Antonio Mendez (BUAP)
21. Thomas Gorin (UdG)
22. Yenni Ortiz (University of Barcelona)
23. Raul Hernandez (Universidad Veracruz)
24. Francisco González (University of Leeds)
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31. Gabriela Tapia (BUAP)
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Talks:

Talk 1: Monday 10:00-11:00

Spectral Properties of Relativistic Quantum Billiards with Shapes of Integrable Billiards

Barbara Dietz
IBS PCS Daejeon (South Korea)

The central question is to what extent the Berry-Tabor conjecture stating that the spectral properties of typical nonrelativistic quantum systems with an integrable classical counterpart agree with those of Poissonian random numbers, applies to relativistic neutrino billiards (NBs) [1] that consist of a spin-1/2 particle governed by the Dirac equation and confined to a bounded planar domain. In distinction to nonrelativistic quantum billiards (QBs), NBs do not have a well-defined classical limit. Yet, comparison of their length spectra revealed that NBs exhibit peaks at the lengths of periodic orbits of the classical dynamics associated with the QB with an even number of reflections at the boundary. We find that the spectral properties of neutrino billiards with shapes generating an integrable classical dynamics do not necessarily exhibit Poissonian statistics. We evaluate Husimi functions and length apectra and compare the latter to their semiclassical approximation which was recently derived for massive NBs [2] for an understanding of these findings in terms of the classical dynamics.

Talk 2: Monday 11:00-11:40

Non-linear Time Series Analysis: Traditional Methods and a New Proposal

Markus Müller
Universidad Autónoma del Estado de Morelos (Mexico)

Detecting determinism and nonlinear properties from empirical time series is highly nontrivial. Traditionally, nonlinear time series analysis is based on an error-prone phase space reconstruction that is only applicable for stationary, largely noise-free data from a low-dimensional system and requires the nontrivial adjustment of various parameters. We present a data-driven index based on Fourier phases that detects determinism at a well-defined significance level, without using Fourier transform surrogate data. It extracts nonlinear features, is robust to noise, provides time-frequency resolution by a double running window approach, and potentially distinguishes regular and chaotic dynamics. We test this method on data derived from dynamical models as well as on real-world data, namely, intracranial recordings of an epileptic patient and a series of density related variations of sediments of a paleolake in Tlaxcala, Mexico

Talk 3: Monday 12:00-12:40

Elastic wave transport through chaotic cavities: experimental results

Gabriela Baez
Universidad Autónoma Metropolitana (Unidad Azcapotzalco, Mexico)

The out-of-plane elastic wave transport through two-dimensional chaotic cavities is analyzed from experimental measurements for one and two channels in cavities with and without reflection symmetry. The analysis of the results shows evidence of universal behavior.

Talk 4: Monday 12:40-13:20

Stylized facts on the income distribution in Mexico, and some considerations on their Universality

Raúl Hernandez
Universidad de Veracruz (Mexico)

We present an analysis of the distribution of individual and household income data in Mexico using a sample from INEGI data from the late 1980s to 2018. We observe that the shape of the income distribution in Mexico is consistent with the empirical form considered universal and observed in other societies and countries and even some systems outside of Physics.

Talk 5: Monday 15:20-16:20

Family of Gaussian wavepacket dynamics methods from the perspective of a nonlinear Schrödinger equation

Jiri Vanicek
EPFL (Swiss)

Many approximate solutions of the time-dependent Schrödinger equation can be formulated as exact solutions of a nonlinear Schrödinger equation with an effective Hamiltonian operator depending on the state of the system. I will show that various Gaussian wavepacket dynamics methods fit into this framework if the effective potential is a quadratic polynomial with state-dependent coefficients. By studying such a nonlinear Schrödinger equation in full generality, it is possible to derive general equations of motion for the Gaussian's parameters, demonstrate time reversibility and norm conservation, and analyze conservation of energy, effective energy, and symplectic structure. The general theory will be illustrated by examples of this family of Gaussian wavepacket dynamics, including the variational and nonvariational thawed and frozen Gaussian approximations and their special limits based on the global harmonic, local harmonic, single-Hessian, local cubic, and local quartic approximations for the potential energy. I will also propose a new method by augmenting the local cubic approximation with a single fourth derivative. Without substantially increasing the cost, the proposed "single-quartic" variational Gaussian approximation improves the accuracy over the local cubic approximation and, at the same time, conserves both the effective energy and symplectic structure, unlike the much more expensive local quartic approximation.

J. J. L. Vanicek, J. Chem. Phys. 159, 014114 (2023).

Talk 6: Monday 16:40-17:00

Topological and spectral properties of random digraphs

C. T. Martínez-Martínez, UAGRO

In this work, we investigate the topological and spectral properties of Erdős-Rényi (ER) random digraphs of size n and connection probability p, denoted as $D(n, p)$.

Topological Properties

Our primary focus is on analyzing the number of non-isolated vertices $V_x(D)$ and two vertex-degree-based topological indices: the Randić index $R(D)$ and the sum-connectivity index $\chi(D)$. Through scaling analysis, we demonstrate that the average degree $\langle k \rangle$ serves as a scaling parameter for the average values of $V_x(D)$, $R(D)$, and $\chi(D)$. Additionally, we provide expressions that relate the number of arcs, the largest eigenvalue, and the number of closed walks of length 2 to (n, p), the parameters of ER random digraphs.

Spectral Properties

Using the adjacency matrix of the digraph, which corresponds to a non-Hermitian binary matrix, we observe that the largest eigenvalue is characterized by the average degree of the digraph. Meanwhile, the bulk of the eigenvalues converges to a circle of radius $\sqrt{np(1-p)}$, in accordance with the circular law.

We further compute six different invariants related to the eigenvalues of $D(n, p)$ and find that these quantities also scale with $\sqrt{np(1-p)}$. Moreover, we reformulate a set of bounds previously reported in the literature for these invariants as functions of (n, p). Finally, we phenomenologically establish relations between invariants that enable us to extend previously known bounds.

Talk 7: Monday 17:00-17:40

Effects of autocorrelated disorder on the dynamics around the many-body localization transition

Jonathan Torres
Benemérita Universidad Autónoma de Puebla (México)

The presence of frozen uncorrelated random on-site potential in interacting quantum systems can induce a transition from an ergodic phase to a localized one, the so-called many-body localization. Here we numerically study the effects of autocorrelated disorder on the static and dynamical properties of a finite one-dimensional many-body quantum system which exhibits many-body localization. Specifically, by means of some standard measures of energy level repulsion and localization of energy eigenstates, we show that a strong degree of correlations between the on-site potentials in the one-dimensional spin-1/2 Heisenberg model leads to suppression of the many-body localization phase, while level repulsion is mitigated for small disorder strengths, although energy eigenstates remain well extended. Our findings are also remarkably manifested in the time domain, on which we put the main emphasis, as shown by the time evolution of experimentally relevant observables, like the survival probability and the spin autocorrelation function.

Talk 8: Tuesday 10:00-11:00

Don't judge matrices by their spectra

Marko Znidaric
University of Ljubljana (Slovenia)

Quantum mechanics is ruled by Hermitian generators inducing unitary propagation, nevertheless, when tracing out some degrees of freedom, or doing coarse graining, one can end up with non-Hermitian or, in general, non-normal operators. When dealing with Hermitian operators we often rely on spectral properties, e.g., relaxation time is given by the spectral gap of a Markovian matrix. However, with non-Hermitian matrices one has to be careful -- our "Hermitian" intuition can completely fail. For instance, it can happen that the spectrum is irrelevant in the thermodynamic limit and one should rather look at the pseudospectrum. I will present two examples of such behavior. One will deal with matrices with a spectrum on a unit circle, where one would naively expect dynamics with no growth in time, however, in reality one gets exponential growth. The second example will be about entanglement dynamics in random circuits where the correct entanglement production rate is given by the pseudospectrum rather than the spectrum. The phenomenon can be also related to the non-Hermitian skin effect, which here emerges out of fully unitary dynamics.

Talk 9:   Tuesday 11:00-11:40

Tunable Perfect Absorption of Microwave Radiation via Dielectric Slabs in Irregular Arrangements: A Non-Hermitian Approach

John Alexander Franco
CONAHCYT, Universidad Autónoma de San Luis Potosí (Mexico)

In this talk, we are going to introduces a novel approach for achieving tunable perfect absorption of microwave radiation, employing non-Hermitian physics to manipulate electromagnetic waves without conductive elements. By utilizing common dielectric slabs in irregular configurations within a rectangular waveguide, we can completely absorb electromagnetic energy, distinctively retaining it within the electromagnetic field instead of converting it into heat. This method contrasts with traditional metamaterials that rely on conductive components to absorb energy. Employing the transfer matrix method and Sequential Quadratic Programming for optimization, our research identifies specific non-uniform placements of FR4 slabs that maximize absorption within targeted microwave bands. Experimental validation, executed in a standard WR90 waveguide connected to a vector network analyzer, confirms the theoretical and finite element simulation results, underscoring the effectiveness of our passive strategy.

Talk 10: Tuesday 12:00-12:40

Chaos and Thermalization in quantum systems

Jorge G. Hirsch
Universidad Nacional Autónoma de México

The relationship between chaos and thermalization in quantum systems with a small number of components has garnered significant attention in recent years, owing to observations across various experimental setups. We present results for two distinct systems: the Dicke model, which describes atoms within a perfectly reflecting cavity, and the Aubrey-André model with interactions, illustrating bosonic atoms confined in an optical trap. Both systems exhibit regular and chaotic regions contingent upon model parameters and energies. The former possesses a well-defined classical limit with two degrees of freedom, facilitating a comparison between classical and quantum chaos signatures. Conversely, the latter model permits analysis solely of quantum aspects. In both instances, the Eigenvalue Thermalization Hypothesis is demonstrated to hold within the chaotic regions. Certain initial states within these regions fail to thermalize, indicative of quantum scars, characterized by enduring revivals in their survival probabilities.

Talk 11: Tuesday 12:40-13:20

Singular-value statistics of directed random graphs

Antonio Mendez-Bermudez
Benemérita Universidad Autónoma de Puebla (México)

Singular-value statistics (SVS) has been recently presented as a random matrix theory tool able to properly characterize non-Hermitian random matrix ensembles [PRX Quantum 4, 040312 (2023)]. Here, we perform a numerical study of the SVS of the non-Hermitian adjacency matrices A of directed random graphs, where A are members of diluted real Ginibre ensembles. We consider two models of directed random graphs: Erdos-Renyi graphs and random regular graphs. Specifically, we focus on the ratio r between nearest neighbor singular values and the minimum singular value s. We show that $< r >$ (where $< ... >$ represents ensemble average) can effectively characterize the transition between mostly isolated vertices to almost complete graphs, while the probability density function of s can clearly distinguish between different graph models.

Talk 12: Tuesday 15:20-16:20

New developments in the theory of stochastic orders

Luciano Pomatto
University of California (Los Angeles, USA)

Stochastic orders are a fundamental tool in the study of decision making and, more generally, for the non-parametric comparison of probability distributions. In this presentation I will provide an overview of some recent findings on stochastic dominance.

Talk 13: Tuesday 16:40-17:20

Electoral statistics inspired by RMT and some other variations

Hugo Hernandez-Saldaña
Universidad Autónoma Metropolitana (Unidad Azcapotzalco, Mexico)

Random Matrix Theory is applied in a wide variety of topics and has inspired approaches to other ones. Here we discuss a statistical approach to three topics inspired in the analysis of eigenvalues of random matrices. The first topic is the distribution of votes for political party in Mexico. After a proper curation of the data two kinds of functions appear: a normal one, and a gamma-like distribution. Both are stationary solutions of Fokker-Planck equations, but the latter is described by non constant diffusion and drift terms. As a second example we return to the time distribution of buses in Cuernavaca that follows a GUE nearest neighbor distribution and discuss a posible mechanism to produce such a behavior. The last example is the distribution of DNA basis letters for several organism and a maximum entropy approach to explain its behavior.

Talk 14: Wednesday 10:00-11:00

Quantum computers challenged by many-body chaos

Alexander Altland
Köln University (Germany)

From the perspective of many-body physics, the transmon qubit architectures currently developed for quantum computing are systems of coupled nonlinear quantum resonators. A significant amount of intentional frequency detuning (disorder) is required to protect individual qubit states against the destabilizing effects of nonlinear resonator coupling. In this talk, we will discuss the stability of this variant of a many-body localized phase for system parameters relevant to current quantum processors. An essential element in of our diagnostic toolbox are classical simulations, which can be run, e.g., for upcoming IBM designs comprising hundreds of qubits. The overall conclusion of this study is that it will take considerable engineering efforts to protect transmon quantum computers from the destructive influence of chaotic fluctuations.

Talk 15: Wednesday 11:00-11:40

Current vortices in aromatic carbon molecules

Yenni Ortiz
Universidad de Barcelona (Spain)

The local current flow through three small aromatic carbon molecules, namely, benzene, naphthalene, and anthracene, is studied. Applying density functional theory and the nonequilibrium Green's function method for transport, we demonstrate that pronounced current vortices exist at certain electron energies for these molecules. The intensity of these circular currents, which appear not only at the antiresonances of the transmission but also in the vicinity of its maxima, can exceed the total current flowing through the molecular junction and generate considerable magnetic fields. The π electron system of the molecular junctions is emulated experimentally by a network of macroscopic microwave resonators. The local current flows in these experiments confirm the existence of current vortices as a robust property of ring structures. The circular currents can be understood in terms of a simple nearest-neighbor tight-binding Hückel model. Current vortices are caused by the interplay of the complex eigenstates of the open system which have energies close to the considered electron energy. Degeneracies, as observed in benzene and anthracene, can thus generate strong circular currents, but also nondegenerate systems like naphthalene exhibit current vortices. Small imperfections and perturbations can couple otherwise uncoupled states and induce circular currents.

Signatures of quantum dissipative chaos in the absence of classical chaos

David Villaseñor
Universidad Nacional Autónoma de México

The Bohigas-Giannoni-Schmit conjecture links chaos in the classical limit with spectral correlations in the quantum domain. The Berry-Tabor conjecture complements the correspondence between regular classical motion and uncorrelated quantum levels. The Grobe-Haake-Sommers (GHS) conjecture extends the last conjectures to Markovian dissipative quantum systems [1]. We show that the GHS conjecture does not hold for the open Dicke model, which is a paradigmatic light-matter interaction system experimentally accessible. While the open isotropic Dicke model exhibits repulsion between the complex eigenvalues [2], its classical limit is non-chaotic. Chaotic structures can be found in classical dynamics only for the anisotropic Dicke model [3].

[1] R. Grobe et al., Phys. Rev. Lett. 61, 1899 (1988).
[2] D. Villaseñor et al., Phys. Rev. E 109, 014206 (2024).
[3] K. C. Stitely et al., Phys. Rev. Res. 2, 033131 (2020).
This talk is based in the recent work arXiv: 2406.07616

Colloquium Talk: Wednesday 13:00-14:00

Quantum Many-Body Chaos

Tomaz Prosen
University of Ljubljana (Slovenia)

I will review recent development on the topic of quantum many-body chaos, specifically from the perspective of exactly solved models. A fruitful idea in this field came from space-time duality which allowed for a number of exact results for the so-called dual unitary quantum circuits. Perhaps the most notable is the proof of random matrix spectral form factor for a class of dual-unitary Floquet spin chains.

Talk 17:   Wednesday 16:00-16:40

Coupled-resonantor phononic structures: emulating molecular orbitals and condensed-matter systems

Rafael Mendez
Universidad Nacional Autónoma de México

Novel results on the vibrations of the elastic structures composed of resonators coupled by finite phononic crystals (PnCs), known as coupled-resonator phononic structures, are given. When the normal-mode frequencies of the resonator fall within the bandgap of the PnCs the normal-mode wave amplitudes get trapped in the resonators and couple evanescently to other resonators through the PnCs. A key property of the coupled-resonator phononic structures is that are ruled by the tight-binding model of condensed-matter physics. Applications to aromatic and linear molecules are presented. In the first case the Pi molecular orbitals of benzene and borazine are obtained. Topological states, appearing in artificial elastic polymers, also emerge in the coupled-resonator elastic structures.

Talk 18: Wednesday 17:00-17:40

Improving entanglement purification with generalized quantum measurements

Mauricio Torres
Benemérita Universidad Autónoma de Puebla

Entanglement between distant quantum systems is a crucial resource for quantum communication. However, this property can be compromised by external factors and must be restored using efficient entanglement purification protocols. In this talk, we introduce entanglement purification protocols that utilize two-qubit non-unitary operations derived from generalized quantum measurements. By applying these protocols to various classes of two-qubit states, including random density matrices, we show that they outperform traditional recurrence purification schemes.

Talk 19: Thursday 10:00-11:00

Scarring and quantum-classical correspondence for quantum channels

Arul Lakshminarayan
IIT Madras (India)

Quantum channels describe time evolution in open systems. Defining a Koopman operator based classical channel, allows us to study semiclassical features of open systems. We show how the modes of quantum channels, with long lifetimes, can be dominated by regular classical phase space structures or scarred by unstable orbits when there is complete chaos. We interpret the classical channel as a noisy or random dynamical system and the corresponding quantization surprisingly shows features of the underlying deterministic dynamics. These may have implications for scarring in many-body systems such as unitary circuits.

Talk 20: Thursday 11:00-11:40

Smallest eigenvalue distribution in complex many-body systems

Manan Vyas
Universidad Nacional Autónoma de México

Talk 21: Thursday 12:00-13:00

Phase transitions, scale invariance and criticality in self organized systems

Alejandro Franck
Universidad Nacional Autónoma de México
Member of El Colegio Nacional

Symmetry methods have been of crucial importance to physics. Group theory and conservation laws have become a fundamental language, all the way from quantum mechanical phenomena to general relativity. However, these ideas have had less impact in the biological domain. In this talk I present a view of self organized biological systems as characterized by and evolving towards critical points, in the language of phase transitions in physical systems. Self similar (or scale invariant) behavior seems to signal homeostatic dynamical equilibrium in living organisms.

Talk 22: Thursday 15:20-16:20

Emergent non-Hermitian topology in many-body dissipative quantum chaos

Lucas Sa
University of Cambridge (UK)

The identification, description, and classification of topological features is an engine of discovery and innovation in several fields of physics. This research encompasses a broad variety of systems, from the integer and fractional Chern insulators in condensed matter, to protected states in complex photonic lattices in optics, and the structure of the QCD vacuum. Here, we introduce another playground for topology: the dissipative dynamics of the Sachdev-Ye-Kitaev (SYK) model, N fermions in zero dimensions with strong q-body interactions coupled to a Markovian bath. For q=4,8,… and certain choices of N and bath details, involving pseudo-Hermiticity, we find a rectangular block representation of the vectorized Liouvillian that is directly related to the existence of an anomalous trace of the unitary operator implementing fermionic exchange. As a consequence of this rectangularization, the Liouvillian has purely real modes for any coupling to the bath. Some of them are demonstrated to be topological by an explicit calculation of the spectral flow, leading to a symmetry-dependent topological index ν. Topological properties have universal features: they are robust to changes in the Liouvillian provided that the symmetries are respected and they are also observed if the SYK model is replaced by a quantum chaotic dephasing spin chain in the same symmetry class. Moreover, the topological symmetry class can be robustly characterized by the level statistics of the corresponding random matrix ensemble. In the limit of weak coupling to the bath, topological modes govern the approach to equilibrium, which may enable a direct path for experimental confirmation of topology in dissipative many-body quantum chaotic systems.

*A. M. García-García, L. Sá, J. J. M. Verbaarschot, and C. Yin, arXiv:2311.14640 (2023)

Talk 23: Thursday 16:40-17:20

Coarse graining quantum many-body systems

Carlos Pineda
Universidad Nacional Autónoma de México

Using the quantum map formalism, we provide a framework to construct fuzzy and coarse grained quantum states of many-body systems that account for limitations in the resolution of real measurement devices probing them. The first set of maps handles particle-indexing errors, while the second deals with the effects of detectors that can only resolve a fraction of the system constituents. By construction, both maps are simply related via a partial trace, which allow us to concentrate on the properties of the former. We show that the volume of the tomographically accessible states decreases at a double exponential rate in the number of particles, imposing severe bounds to the ability to read and use information of a many-body quantum system. We investigate the volume of the preimages of the effective states, allowing us to look for typical states observed under imperfect measurement devices. Finally, we study the emerging dynamics arising from such maps.

Talk 24: Friday 10:00-10:40

Edge-state transport in twisted bilayer graphene

Thomas Stegmann
UNAM (Mexico)

We investigate the electronic structure and transport properties of twisted bilayer graphene (TBLG) at a twist angle of $\theta \approx 1.696°$. Using a combination of molecular dynamics and tight-binding calculations, we find two superlattice gaps in the energy spectrum of the bulk, which emerge close to the Fermi level from the atomic rearrangement of the carbon atoms leading to a corrugation of the graphene sheets. Nanoribbons made from 1.696°-TBLG show edge-localized states inside the superlattice gaps. Applying the Green's function method, we demonstrate that the edge states carry electronic current with conductance values close to the conductance quantum. The edge states can generate a non-local resistance, which is not due to one-way transport at the edges but due to the fact that these states are localized only at certain edges of the system, depending on how the nanoribbon has been cut from the bulk.Using a combination of molecular dynamics and tight-binding calculations, we find two superlattice gaps in the energy spectrum of the bulk, which emerge close to the Fermi level from the atomic rearrangement of the carbon atoms leading to a corrugation of the graphene sheets. Nanoribbons made from 1.696°-TBLG show edge-localized states inside the superlattice gaps. Applying the Green's function method, we demonstrate that the edge states carry electronic current with conductance values close to the conductance quantum. The edge states can generate a non-local resistance, which is not due to one-way transport at the edges but due to the fact that these states are localized only at certain edges of the system, depending on how the nanoribbon has been cut from the bulk.

Talk 25: Friday 10:40-11:40

Modeling cross talk errors in quantum devices with normal quantum channels

Thomas Gorin
Universidad de Guadalajara (Mexico)

Until today and in the near future only noisy intermediate-scale quantum (NISQ) machines will be available, where error mitigation is more relevant than full quantum error correction and it is likely that one will rather work with processes which are only partially coherent. Therefore, sufficiently precise error and decoherence models are important. Cross talk errors, i.e. two- or more qubit errors are dominant in todays quantum information processing. Such errors have first been modeled by simple correlated Pauli channels, and more recently by Lindblad master equations. Both methods only allow to compute the resulting effective quantum channel, but fail to describe higher order averages -- necessary to estimate statistical uncertainties of experimental finite sample averages. Here, we present an error model which is defined in terms of a diffusive random walk in the group manifold of unitary operations. On the one hand, this induces a unital quantum channel, which we will call 'normal'. On the other hand, it defines a unital quantum process, generated by a Lindblad master equation. Importantly, the harmonic analysis on the group allows to calculate the resulting quantum channel as well as higher order moments of this process. In this talk I will show examples which highlight the concept of Markovianity, the difference between classical and quantum cross talk, as well as the fact that different models can yield the same quantum channel, but different statistical uncertainties for experimental finite sample averages.

Reference: Alejandro Contreras Reynoso and Thomas Gorin, JPA 57 (2024) 225301

Talk 26: Friday 12:10-12:50

Large deviation function for the number of eigenvalues of sparse random graphs inside an interval

Isaac Pérez Castillo
Universidad Nacional Autónoma de México
Universidad Autónoma Metropolitana-Iztapalapa

Abstract: I will present a general method to obtain the exact rate function $\Psi[a,b](k)$ controlling the large deviation probability Prob$[\mathcal{I}N[a,b]=kN]\asymp e-N\Psi[a,b](k)$ that an $N\times N$ sparse random matrix has $\mathcal{I}N[a,b]=kN$ eigenvalues inside the interval $[a,b]$. The method is applied to study the eigenvalue statistics in two distinct examples: (i) the shifted index number of eigenvalues for an ensemble of Erdös-Rényi graphs and (ii) the number of eigenvalues within a bounded region of the spectrum for the Anderson model on regular random graphs. A salient feature of the rate function in both cases is that, unlike rotationally invariant random matrices, it is asymmetric with respect to its minimum. The asymmetric character depends on the disorder in a way that is compatible with the distinct eigenvalue statistics corresponding to localized and delocalized eigenstates. The results also show that the level compressibility $\kappa2/\kappa1$ for the Anderson model on a regular graph satisfies $0<\kappa2/\kappa1<1$ in the bulk regime, in contrast with the behavior found in Gaussian random matrices. The theoretical findings are thoroughly compared to numerical diagonalization in both cases, showing a reasonable good agreement.

Talk 27: Friday 12:50-13:30

Waveguide QED using unconventional transmission lines

Carlos Gonzalez
Universidad Nacional Autónoma de México

Posters:

Poster 1

Pink noise turns brown in the 1D Aubry-André model

Miriam Jimenez
Benemérita Universidad Autónoma de Puebla

We characterize the metal-insulator transition in the one-dimensional Aubry-André model (with and without interactions) by using the squared module of the Fourier transform of spacings between adjacent energy levels, that is through so-called power spectrum. We also study some properties of the system in the chaotic regime and localized regime.

Poster 2

Directed multilayer networks: a study from the random matrix theory

Gabriela Tapia Labra

Instituto de Física, Benemérita Universidad Autónoma de Puebla, Puebla 72570, Mexico

(Dated: June 13, 2024)

Abstract: Multilayer networks represent complex systems, both natural and artificial, where groups or communities primarily interact in a linear manner. Increasingly sophisticated attempts to model real-world systems as multidimensional networks have yielded valuable insights in the fields of social network analysis, urban and international transportation, ecology, psychology, biology, physics, and computational neuroscience.

Particularly, many real-world systems can be modeled using directed multilayer networks (those whose contained information follows a specific direction from one layer to another), which can be characterized through the properties of the eigenvalues and eigenvectors of the corresponding adjacency matrices. Therefore, in this work, we will use measures and techniques from random matrix theory to study some properties of the eigenvalues and eigenvectors of the adjacency matrices of directed multilayer networks.

Poster 3

Non-Hermitian diluted banded random matrices: Scaling of eigenfunction and spectral properties

Marisol Hernández Sánchez

Instituto de Física, Benemérita Universidad Autónoma de Puebla, Puebla 72570, Mexico

(Dated: June 13, 2024)

Abstact: In this research, we introduce the non-Hermitian diluted banded random matrix (nHdBRM) ensemble as the set of $N \times N$ real non-symmetric matrices whose entries are independent Gaussian random variables with zero mean and variance one if $|i-j| < b$ and zero otherwise, moreover off-diagonal matrix elements within the bandwidth b are randomly set to zero such that the sparsity α is defined as the fraction of the $N(b-1)/2$ independent non-vanishing off-diagonal matrix elements. By means of a detailed numerical study we demonstrate that the eigenfunction and spectral properties of the nHdBRM ensemble scale with the parameter $x = \gamma[(b\alpha)^2/N]^\delta$, where $\gamma, \delta \sim 1$. Moreover, the normalized localization length β of the eigenfunctions follows a simple scaling law: $\beta = x/(1+x)$.

Poster 4

Analysis of the correlation hole of the survival probability in network models

M.Sc. Kevin Peralta Martínez*
Instituto de Física, Benemérita Universidad Autónoma de Puebla, Apartado Postal J-48, Puebla 72570, Mexico

ABSTRACT

The survival probability also known as return probability indicates the likelihood of finding a system in its initial state after a time t. This quantity has been widely explored in the analysis of different systems ranging from Full Random Matrix Ensembles (FRME) to Two-Body and Many-Body quantum systems.
In this work, we propose the study of the survival probability of random network models as a dynamical property of configuration instances of networks/graphs. In particular, we focus on the analysis of the correlation hole depth for Erdős–Rényi (ER) networks and Random Geometric Graphs (RGGs) as a function of the inherent parameters of the models. For numerical calculations, we use the adjacency matrix as a diluted version of the Gaussian Orthogonal Ensemble matrix from Random Matrix Theory. We also compare the relative depths of both models by fixing their proportion of connected nodes in the network/graph according to the ratio of their average degree over network size minus one, $p \equiv \frac{\langle k \rangle}{n-1} \equiv \alpha$. Finally, we propose a scaling parameter for the correlation hole depth curves in terms of the proportion parameter α.

* kperalta@ifuap.buap.mx

Poster 5

Spin coherent states as a quantum probe of the phase space

Miguel Gonzalez*, Jorge G. Hirsch*, Miguel A.Bastarrachea-Magnani†

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1 Introduction

In this talk I will introduce the scaling analysis of the Inverse Participation Ratio of the spin coherent states (also known as atomic or Bloch coherent states) as a quantum probe to study the phase space of three different models, the $SU(2)$ harmonic oscillator, the Lipkin-Meshkov-Glick model and the Quantum Kicked Top model. Within the context of Quantum Chaos, one can study the transition to the semiclassical limit by increasing the value of the total angular momentum which serves the role as the effective Plank constant $\hbar_{eff} = 1/J$. The second tool that may serve to study the phase space at a fixed value of J is the general dimension $D_2 = Ln(IPR^{-1})/Ln(2J+1)$, this quantity revels information when the Poincaré section of the semiclassical model is completely chaotic.

*Instituto de Ciencias Nucleares, Universidad Nacional Autónoma de México, Apdo. Postal 70-543, C.P. 04510 Cd. Mx., Mexico

†Departamento de Física, Universidad Autónoma Metropolitana-Iztapalapa, Av. Ferrocarril San Rafael Atlixco 186, C.P. 09310 Mexico City, Mexico

Poster 6

QUANTUM MANY-BODY SCARS IN A TRAPPED BOSONIC SYSTEM

Carlos Diaz 1, Javier de la Cruz 1, Sergio Lerma 2, Jorge Hirsch 1

1 Universidad Nacional Autónoma de México, Instituto de Ciencias Nucleares
2 Universidad Veracruzada, Facultad de Física.

Abstract

Quantum chaos and thermalization are two phenomena that are very deep present in many-body systems. However, there are some exceptions that arise from some special structure in the Hamiltonian that enhance weak ergodicity breaking. One of these phenomena is quantum many-body scarring, which its main feature are persistent oscillations between initial and thermal values of observables. In this work we show this effect in the Interacting Aubry Andre model, and how the spectral signatures of quantum chaos (and thermalization) aspects are suppressed in the survival probability at short, medium and long times.

Poster 7

Chaos in the semi-classical dynamics of the Dicke model

Luis Camarillo
Universidad Nacional Autónoma de México

In this work the Dicke model is studied and its semi-classical dynamics are explored using Glauber and Bloch coherent states. A detailed analysis of the semi-classical dynamics is conducted, followed by a numerical study of motion equations, revealing that the Runge-Kutta 8 method better preserves energy. Poincaré sections are used to indicate chaos, and visualizations of semi-classical trajectories are discussed. The study extends methods to the photonic part of the Dicke model, offering an efficient way to analyze semi-classical dynamics. The research focuses on a specific parameter ratio, highlighting the extensive phenomenology of the Dicke model. Future work will explore the quantum counterpart and unstable periodic trajectories in photonic coordinates.

Poster 8

Átomos en cavidades interactuando con pares de fotones

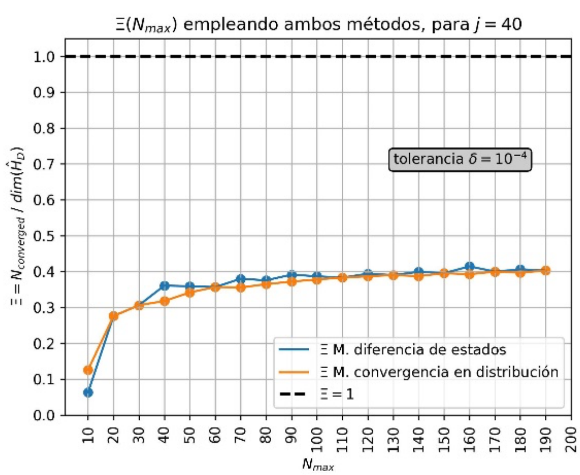
Fabrízio Ramírez S. y Jorge G. Hirsch
Instituto de Ciencias Nucleares, UNAM.

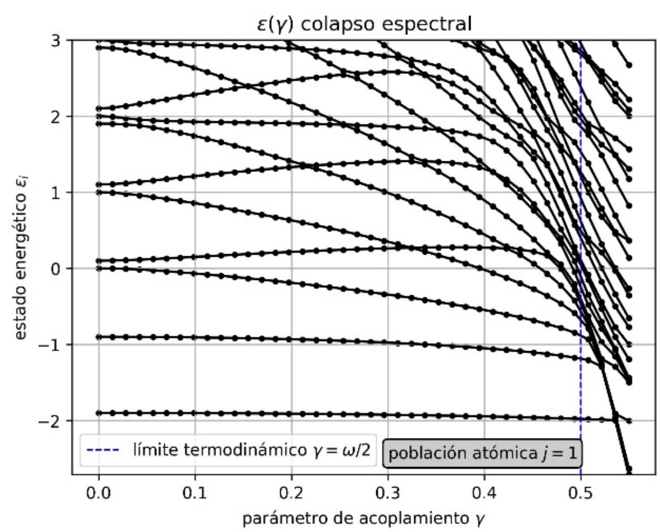
Impulsados por las crecientes aplicaciones tecnológicas en procesamiento de información cuántica, simulación y detección [1, 2, 3], realizamos un estudio detallado del modelo de Dicke de dos fotones [4].

Para el análisis del modelo, se genera el sistema sin el uso de paqueterías con la intención de poder particularizar el problema y hacerlo más eficiente en términos de costo numérico, la solución de dicho sistema se realiza con paqueterías.

Con el objetivo de reconocer si existen indicadores de caos en ciertas regiones este modelo, empleamos estadística de niveles para determinarlo, que está conectado con resultados fundamentales en Teoría de Matrices Aleatorias. La figura de la izquierda muestra la fracción de estados convergidos empleando dos métodos distintos: cambio en las energías propias y localización de la función de onda.

En la figura de la derecha cada punto representa la energía de un estado propio convergido como función del acoplamiento átomo-campo. Se observa claramente el colapso espectral al llegar al valor crítico del acoplamiento.





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Poster 9

Detection of Quantum Chaos with Imperfect Measurement Devices

Jose Alfredo de León
Universidad Nacional Autónoma de México

The precise measurement of many-body quantum systems is extremely challenging. The formalism of fuzzy measurements describes, within the framework of quantum channels, a type of imperfect measurement in which, with a small but non-zero probability, a particle different from the target particle is measured. For example, the neighboring particle in the simplest case. In this work, we study how the detection of quantum chaos in a spin chain is modified if the detectors perform fuzzy measurements. In a previous work, it was proposed that the purity of a spin is an indicator of chaos in the entire chain. Here, we are interested in studying the robustness of this indicator, as well as others, including predictions from random matrix theory.

Poster 10

Probability of observing a target state from a coarse-grained map

Kenan Uriostegui
Universidad Nacional Autónoma de México

This work analyzes the probability of observing a single-qubit target state, parameterized by its Bloch radius, by applying a coarse-graining map (CGM), which is by definition non-bijective, to N-partite states. The considered map describes the situation of an imperfect quantum detector, which with some probability confuses the labels of the particles in a many-body system and is also unable to resolve all the degrees of freedom of the system. For the case where CGM is applied to bipartite states, it is possible to implement a geometric description of the coarse-graining process. However, when the system contains more qubits, such a description becomes too complex. In this case, we implement some results from Random Matrix Theory (RMT), applicable to ensembles of Hermitian matrices, which allow us to obtain the probability density function (PDF) analytically for a general N.

Poster 11

Artificial elastic chain of cis-poliacetylene with third-nearest neighbor hoppings

Bryan Manjarrez
Universidad Nacional Autónoma de México

The elastic coupled resonator realization offers a high control over interactions between close neighbors. Unlike other artificial realizations of the Tight Binding (TB) model with dielectric resonators, optical waveguides, photonic and phononic crystals this offers the opportunity to observe emerging phenomena such as the creation of solitons and conductivity in polymers in some regimes almost impossible to achieve in synthesized materials.

In this work, a generalization of the SSH model is presented, for an artificial periodic chain that imitates cis-polyacetylene in organic chemistry, with first and third neighbors. By controlling the tuning of such hoppings a double topological phase transition can be obtained. Subsequently, finite element simulations are carried out using COMSOL Multiphysics with different hopping parameters. The results show great agreement between both Tight Binding models.

Poster 12

In Search of the Hofstadter Butterfly in the Aubry-André Model with Interactions

Emilio Mateos
Universidad Autónoma Benito Juárez de Oaxaca

We analyze the energy spectrum of the Aubry-André Hamiltonian with nearest-neighbor interactions.Starting from the tight-binding model, we map between fermionic operators and spin operators. We use the inverse participation ratio (IPR) to discern the transition from a localized to a delocalized phase of the eigenstates. At this critical point, we graphically represent the energy eigenvalues of the system as a function of the semi-periodicity factor of the onsite-potential, starting from the magnetization sector with a single excitation in the chain until reaching half-filling.

Poster 13

Effects of stickiness on the quantum states of strongly chaotic leaking systems

Miguel Parado
University of Connecticut

We investigate the effects of classical stickiness (orbits temporarily confined to a region of the chaotic phase space) to the structure of the quantum states of an open system. Using the classical and quantum standard map of the kicked rotor in the presence of a leak, we verify that regions of stickiness survive in the strong chaotic regime of the closed classical map. By scanning the system's phase space with a leak, we analyze how stickiness affects the degree of localization of the quantum states. We find an excellent correspondence between the classical dwell time and finite-time Lyapunov exponents with the quantum dwell time and Wehrl entropy of the quantum states. Our approach suggests that knowledge of the structure of the classically chaotic trajectories can be used to determine the best leak's position to achieve desired escape times for the quantum states.

Poster 14

Reducing dynamical fluctuations and enforcing self-averaging by opening many-body quantum systems

David Zarate
Benemerita Universidad Autónoma de Puebla

We examine the impact of dephasing environments on dynamical fluctuations in many-body quantum systems. Our study focuses on the survival probability, employing various random matrices and a spin-1/2 model with differing disorder strengths. We observe that in isolated systems, the survival probability remains non-self-averaging, with its relative variance unaffected by system size. Introducing an energy dephasing environment reduces these fluctuations, achieving self-averaging in certain regimes. Specifically, full random matrices and power-law banded random matrices in the delocalized phase exhibit self-averaging at long times. For the spin model, self-averaging emerges in the chaotic regime for states centered in the spectrum. These findings underline the potential benefits of environmental interactions in mitigating quantum fluctuations and enhancing the reliability of experimental and numerical analyses.