RMT, Time Series and Many-Body Systems
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Pablo Barberis Blostein
(IIMAS, UNAM, México)

Title: Some thoughts about the Quantum Van Trees inequality

Abstract: When a parameter of a quantum system is a random variable, the Quantum Van Trees inequality can be used to check if the combination of quantum measurement and estimator minimizes the error. In this talk we argue that, in general, the Quantum Van Trees inequality can not be saturated; when this happens it is not possible to use it to know if we are using the best measurement strategy. We propose a modification of the Quantum Van Trees inequality and discuss possible applications.

Soham Biswas
(Universidad de Guadalajara, Mexico)

Title: Rich structure in the correlation matrix spectra in non-equilibrium steady states

Abstract: It has been shown that, if a model displays long-range (power-law) spatial correlations, its equal-time correlation matrix will also have a power law tail in the distribution of its high-lying eigenvalues. The purpose of this paper is to show that the converse is generally incorrect: a power-law tail in the high-lying eigenvalues of the correlation matrix may exist even in the absence of equal-time power law correlations in the initial model. We may therefore view the study of the eigenvalue distribution of the correlation matrix as a more powerful tool than the study of spatial Correlations, one which may in fact uncover structure, that would otherwise not be apparent. Specifically, we show that in the Totally Asymmetric Simple Exclusion Process, whereas there are no clearly visible correlations in the steady state, the eigenvalues of its correlation matrix exhibit a rich structure which
we describe in detail.

Anirban Chakraborti
(Jawaharlal Nehru University, India)

Title: Complex network analysis of co-movements of stock indices

Abstract: The global financial markets are interesting examples of a "complex system". We will present a complex network analysis of the correlations in the stock market indices across the globe. We have used the minimum spanning tree approach, which is a method for finding a hierarchical arrangement of the indices by using correlations of the returns, and an appropriate distance metric. Our general aim is to study the dynamical evolution of the correlations in the global markets and visualize the co-movements of the indices.

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5. K. Sharma, B. Gopalakrishnan, A.S. Chakrabarti and A. Chakraborti, "Co-movements in financial fluctuations are anchored to economic fundamentals: A mesoscopic mapping", arXiv: 1612.05952v2 (2017).

David Davalos
(Instituto De Física, UNAM, México)

Title: Divisibility of quantum dynamical maps vs. divisibility of quantum channels

Abstract: We present a comparative study of the divisibility properties of qubit dynamical maps and the divisibility properties of the channels parametrized by such dynamical maps. We first show the implementations of the conditions for Lindbladian divisibility for the qubit case and the characterization of the full Kraus rank Pauli channels. We give concrete physical examples of quantum dynamical maps including the Spin-Boson system and a parametrization of the best approximation of the NOT gate inside the complete positive trace preserving channels which shows interesting regions where markovianity cannot be assessed even if the dynamical map is divisible.

Rubén Fossión
(Instituto De Ciencias Nucleares, UNAM, México)

Title: Homeostasis from a time-series perspective: An intuitive interpretation of the variability of physiological variables

Abstract: The concept of homeostasis implies the approximate constancy of specific regulated physiological variables where the independence of the internal from the external environment is ensured by adaptive physiological responses carried out by other so-called effector variables. The loss of homeostasis is the basis to understand chronic-degenerative disease and age-associated frailty. Technological advances presently allow to monitor a large variety of physiological variables in a non-invasive and continuous way and the statistics of the resulting physiological time series is thought to reflect the dynamics of the underlying control mechanisms. Recent years have seen an increased interest in the variability and/or complexity analysis of physiological time series with possible applications in pathophysiology, but a general understanding is lacking of which variables can be expected to exhibit a large variability (e.g., heart rate variability, HR V) and when on the contrary variability implies a risk factor (e.g., blood pressure variability, BPV). In the present contribution, we argue that in optimal conditions of youth and health regulated variables and effector variables necessarily exhibit very different statistics, with small and large variances, respectively, and that under adverse circumstances such as ageing and/or chronic-degenerative disease these statistics degenerate in opposite directions, i.e. towards an increased variability in the case of regulated variables and towards a decreased variability in the case of effector variables. We demonstrate this hypothesis for HR V, BPV and body temperature for healthy controls and patients with metabolic disease, and suggest that this scheme may explain the phenomenology of variability in time for other physiological variables as well.

Thomas Gorin
(Universidad de Guadalajara, Mexico)

Title: Random matrix environments and non-Markovianity

Abstract: In this talk, I will overview our recent work on random matrix environments from different perspectives: (i) as a source of non-Markovian dynamics in the central system, (ii) as a quantum container system, separating a central system from a exterior thermal reservoir. In (i), we analyse different measures of non-Markovianity in a situation, where statistical noise make it difficult to obtain reliable estimates for these measures. In (ii) we focus on methods to control the container system in order to reduce decoherence or loss of information of the central system.

Takuya Kanazawa
(RIKEN, Japan)

Title: RMT and the supersymmetric SYK model

Abstract: The Sachdev-Ye-Kitaev (SYK) model is a useful platform to study quantum chaos and holography. In this talk, I will first review the SYK model with supersymmetry (SUSY) and then present its complete symmetry classification based on the ten-fold way of RMT. I will show plenty of numerical evidence that support our classification. In particular, a precise agreement between RMT and the smallest energy level fluctuations in the SYK model with N=1 SUSY is demonstrated. Finally I discuss qualitatively new features that emerge in the N=2 SYK model. This work is based on collaboration with Tilo Wettig and preprint arXiv:1706.03044 [hep-th].

Eugene Kanzieper
(Holon Institute Of Technology, Israel)

Title: Power Spectrum in Quantum Chaotic Systems with Broken Time-Reversal Symmetry: Exact Solution

Abstract: We present a non-perturbative analysis of the power spectrum of energy level fluctuations in fully chaotic quantum structures. Focusing on systems with broken time-reversal symmetry, we employ a finite-N random matrix theory to derive an exact multidimensional integral representation of the power spectrum. The $N \to \infty$ limit of the exact solution furnishes the main result of this study -- a universal, parameter-free prediction for the power spectrum expressed in terms of a fifth Painlevé transcendent. Extensive numerics lends further support to our theory which, as discussed at length, invalidates a traditional assumption that the power-spectrum is merely determined by the spectral form factor of a quantum system.

Mario Kieburg
(Bielefeld University, Germany)

Title: Symmetry Classification for Gauge Theories on Cubic Lattices

Abstract: Non-Abelian Gauge Theories are highly complicated theories because of their corresponding non-linear field equations. Thus, quite often only numerical simulations are left for studying the non-perturbative regimes of these theories. In QCD-like theories this non-perturbative regime is the infra-red limit when chiral symmetry (or chiral-like symmetries) is spontaneously broken. The corresponding Goldstone bosons are the lightest pseudo scalar mesons of the theory. In QCD with only the up- and down-quarks these mesons are the three pions. The number as well as the physical properties of these mesons strongly depend on the pattern of spontaneous symmetry breaking and, hence, on the global symmetries of the Dirac operator which are encoded in the eigenvalues closest to the origin (hard edge scaling in random matrix theory). Therefore it is crucial that in the continuum limit of the corresponding lattice theory the global symmetries become those of the continuum theory. For the simplest discretization called naive fermions and an intimately related discretization called staggered fermions, which is widely employed, there seem to be some doubt that this is the case. Indeed it is well known that 3d and 4d staggered fermions do not necessarily exhibit the same symmetries as in the continuum theory. In two dimensions we have even analyzed what the reason for this change of symmetries is. Recently, Tim Robert Wuerfel and I extended this discussion to arbitrary dimension and arbitrary gauge group. Our results are supported by comparing lattice simulations with random matrix results. I will give a report on this project in my talk.

Santosh Kumar
(Shiv Nadar University, India)

Title: Recursion for the smallest eigenvalue density in β-Wishart-Laguerre Ensembles

Abstract: The statistical behavior of the smallest eigenvalue has important implications for systems which can be modeled using a Wishart-Laguerre ensemble. For example, the density of the smallest eigenvalue of Wishart-Laguerre ensemble plays a crucial role in characterizing multiple channel telecommunication systems. Similarly, in the quantum entanglement problem, the smallest eigenvalue of the fixed trace ensemble carries information regarding the nature of entanglement.

For the case of real Wishart-Laguerre matrices, there exists an elegant recurrence scheme suggested by Edelman to obtain the exact expression for the smallest eigenvalue density. For Wishart-Laguerre matrices of other symmetries (e.g. involving complex matrices, and quaternion matrices) the existing results for the smallest eigenvalue density comprise determinants, which become impractical to obtain exact and explicit expressions when the determinants involve large dimension matrices.

We provide a recurrence scheme, analogous to that of Edelman, for the case of β-Wishart-Laguerre ensemble with non-negative integer coefficient α in the weight function $x^{\alpha}e^{-\beta x}$. This includes the important cases of complex (β=2), and quaternion (β=4) Wishart-Laguerre matrices. The analytical results for the smallest eigenvalue density are validated using Monte Carlo simulations based on Dumitriu and Edelman's tridiagonal matrix model.

We also point out some applications of the results, that include entanglement formation in coupled kicked tops, connection with a class of hypergeometric function of matrix argument, and large deviations of the smallest eigenvalue in β-ensembles.

References:

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[3] P. J. Forrester and T. D. Hughes, Complex Wishart matrices and conductance in mesoscopic systems: Exact results, J. Math. Phys. 35, 6736 (1994).
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Francois Leyvraz
(Instituto De Ciencias Física, UNAM, México)

Title: The strange fact of spectra with different symmetries being uncorrelated

Abstract: A standard assumption in quantum chaology is the absence of correlation between spectra pertaining to different symmetries. Doubts were raised about this statement for several reasons, in particular because in semiclassics the spectra of different symmetries are expressed in terms of the same set of periodic orbits. We re-examine this question and notice the absence of correlations in the universal regime. In the case of continuous symmetry, the problem is reduced to parametric correlation, and we expect correlations to be present up to a certain time which is essentially classical but larger than the ballistic time.

References:

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Esteban Martínez Vargas
(Instituto De Física, UNAM, México)

Title: Quantum estimation of unkown parameters: Theoretical insights and calculations.

Abstract: We address the problem of the estimation of a parameter of a quantum system. In general, the quantum Fisher Information is dependent of the value of the parameter to estimate. We propose a modification of the quantum Van Trees bound, which gives a lower bound to the error in the estimation of a parameter. We study the usage of our proposed bound as the basis of Quantum Metrology. We also present a novel method to calculate numerically this bounds considering the convexity of the POVM space and the convexity condition for Fisher Information.

Adam Mielke
(Bielefeld University, Germany)

Title: Universal Distribution of Would-be Topological Zero Modes in Coupled Chiral Systems

Abstract: We consider two quenched, chiral ensembles which are coupled in such a way that a combined chiral symmetry is preserved. The coupling also links the topology of the two systems such that the number of exact zero modes in the coupled system equals the sum of the number of zero modes in the two uncoupled systems counted with sign. The canceled modes that turn non-topological due to the coupling become near-zero modes at small coupling. We analyze the distribution of these would-be zero modes using effective field theory. The distribution is universal and, in the limit of small coupling, the would-be zero modes are distributed according to a finite size chiral Gaussian ensemble, where the width of the distribution scales as the inverse square root of the volume.

Arlex Oscar Marin
(Instituto De Ciencias Física, UNAM, México)

Title: RMT, Graph Theory and Multi-modal Brain Signal Analysis: Preliminary Results from the Human Connectome Project

Abstract: Brain signal analysis have proven to be a challenge. Both simple and complex, linear and non-linear measures of interrelationship among these type of signals have been used to extract relevant information about its dynamics. Despite the complexity of the task, in a high number of cases and experimental conditions, the zero-lag Pearson Correlation Matrix (C) has been useful to achieve this, taking C as starting point, one can use Random Matrix Theory and Graph Theory to obtain a more detailed description of an ensemble of such matrices. In this project, multi-modal (Magnetoencephalography-MEG, and Functional Magnetic Resonance Imaging-fMRI) data from the Human Connectome Project (HCP) will be analyzed. Comparing the behavior of the eigenvalues of C and GT-measures of it, two experimental conditions will be contrasted. This contribution summarizes preliminary results on the analysis of MEG data and multi-modal data analysis.

Roman Riser
(Holon Institute Of Technology, Israel)

Title: Conformal Symmetry of a 2D Coulomb gas

Abstract: We consider the set of n point particles in the complex plane that interact via two-dimensional (i.e. logarithmic) Coulomb repulsion and are subject to a confining potential with some growth condition at infinity. It is well known that in the limit when n goes to infinity, the particles fill a compact domain $K \subset C$. We restrict to the cases where the potential is a non-critical Hele-Shaw potential and K is simply connected. For the Hele-Shaw potential the averaged density of particles becomes constant inside K. Of special interest is the density function at the boundary (in rescaled coordinates holding the mean distance among the particles constant). We will present leading and subleading asymptotics. The conformal map from the outside of K to the outside of the unit disk encodes the geometry of K. We will show a universality law depending on this conformal map. Further we will discuss the behavior of the correlation among the particles.

Mauricio Saavedra Contreras
(Universidad De Guadalajara, México)

Title: Time series analysis of EEG records using clustering of correlation matrices

Abstract: We analyse EEG sleep records with the help of the K-means classification algorithm applied to correlation matrices obtained for each 30 second scoring interval. The result is compared to hipnograms elaborated by sleep technologists, and a surprisingly good agreement is found. This confirms the viability of this method to identify states and also might help in the more precise characterization of sleep stages.

Lea Santos
(Yeshiva University, USA)

Title: Generic dynamical features of quenched interacting quantum systems: power-law decays and correlation hole

Abstract: We study numerically and analytically the quench dynamics of isolated many-body quantum systems out of equilibrium. Using full random matrices from the Gaussian orthogonal ensemble, we obtain analytical expressions for the evolution of the survival probability, density imbalance, and out-of-time-ordered correlator. They are compared with numerical results for a one-dimensional disordered model with two-body interactions and shown to bound the decay rate of this realistic system. Power-law decays are seen at intermediate times and the correlation hole occurs at long times when the system exhibits level repulsion. The fact that these features are shared by both the random matrix and the realistic disordered model indicates that they are generic to nonintegrable interacting quantum systems out of equilibrium.

Kiran Sharma
(Jawaharlal Nehru University, India)

Title: A mesoscopic mapping between financial fluctuations and economic fundamentals

Abstract: A financial market is a striking example of a complex socio-economic system. We will focus on the application of “mesoscopic network” in establishing an empirical linkage between the nominal financial networks and the underlying economic fundamentals across countries [1].

We construct the nominal return correlation networks from daily data to encapsulate sector-level dynamics and figure the relative importance of the sectors in the nominal network through a measure of centrality and clustering algorithms [2]. The eigenvector centrality robustly identifies the backbone of the minimum spanning tree defined on the return networks as well as the primary cluster in the multidimensional scaling map. We show that the sectors that are relatively large in size, defined with the metrics market capitalization, revenue and number of employees, constitute the core of the return networks, whereas the periphery is mostly populated by relatively smaller sectors. Therefore, sector level nominal return dynamics is anchored to the real size effect, which ultimately shapes the optimal portfolios for risk management. Our results are reasonably robust across 27 countries of varying degrees of prosperity and across periods of market turbulence (2008-09) as well as relative calmness (2015-16).

References:

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Jacobus Verbaarschot
(Stony Brook University, USA)

Title: Spectral and Thermodynamical Properties of the SYK Model

Abstract: The two-body random ensemble has a long history in nuclear physics starting from work by Bohigas, Flores, French and collaborators. Contrary to the invariant random matrix ensembles, this model embodies a the two-boy nature of the nuclear reactions and provides us with a more realistic description of nuclear spectra. More recently variants of this model were introduced to condensed matter physics by Sachdev, Ye and Kitaev (SYK). In one version, the fermions are Majorana particles, and because the model may be the simplest possible model with a gravity dual which is maximally chaotic, it may be a description of the quantum states of a black hole and has attracted quite some attention in the field of string theory. The two-body random matrix ensemble, which is a close relative of this model, provides a description of nuclear spectra, and in particular of the spectra of compound nuclei. Because of the chaotic nature of nuclear interactions, all information on the creation of the compound nucleus has been lost, and in this sense the nucleus has no hair. What remains, in close analogy to quantum black holes, is the quantum hair in form of resonances that are distributed according to random matrix theory. We analyze the spectral correlations of the SYK model and find that they are given by the invariant random matrix ensembles of the universality class that is determined by the total number of particles *mod* 8 [1]. We show that the spectral density close to the ground state of the SYK Hamiltonian is given by the Bethe formula, and show that this result is also valid for the two-body random ensemble. Finally we discus the macroscopic spectral density and obtain the simple approximate analytical result, $\rho(E) \sim \exp[2 \arcsin^2(E/E_0)/2 \log \eta]$, where E_0 is the ground state energy and η the suppression factor of intersecting contractions relative to nested contractions [2].

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