Random Matrix Theory, IntegrableSystems, and Topology in Physics workshop Talk Schedule

Events for:
Monday, November 2nd - Friday, November 6th

Monday, November 2nd

9:00am **Poul Damgaard - SCGP 102**

Title: Random Matrix Theory and Low-Energy QCD

Abstract: "Random Matrix Theory has become a crucial tool for interpreting and understanding results from numerical simulations of Quantum Chromodynamics (QCD). I will review this development, which shows how Random Matrix Theory ties in beautifully with effective field theory, also beyond applications to QCD."

10:00am **Coffee - SCGP Cafe**

10:30am **Takuya Kanazawa - SCGP 102**

Title: A new look at chiral random matrix theory

Abstract: I will discuss my recent findings regarding a link between chiral random matrix theory, nonrelativistic Fermi gases and dense QCD with exotic chiral symmetry breaking. Results of preliminary numerical simulations that corroborate analytical predictions will also be presented.

11:30am **Rajamani Narayanan, Florida International University - SCGP 102**

Title: Massless QED in three dimensions with even number of flavors

Abstract: Massless QED in three (two space and one Euclidean time) with even number of flavors does not break parity. There are analytical arguments for chiral symmetry to be spontaneously broken and some numerical evidence supporting these arguments. An interesting ""open"" question is the possibility of a critical number of flavors below which chiral symmetry is broken. Numerical results obtained using dynamical Wilson fermions will be presented with emphasis on the behavior of the low lying eigenvalues of the Wilson Dirac operator. Finite volume analysis and comparison with random matrix theory will be used to obtain conclusions about the absence or presence of a chiral condensate.

12:30pm **Lunch - SCGP Cafe**

2:00pm **Tamas Kovacs - SCGP 102**

Title: The Anderson transition in lattice QCD

3:00pm **Tea - SCGP Lobby**

3:30pm **Savvas Zafeiropoulos - SCGP 102**

Title: Random Matrix Theory for Wilson Fermions

Abstract: We summarize recent results of Random Matrix Theory (RMT) for Wilson fermions. We focus on the Hermitian as well as the non-Hermitian Wilson Dirac operator and provide analytical and numerical results of their eigenvalue densities. The results span both QCD and QCD-like theories. We conclude by utilizing the analytical RMT formulae in order to extract Low Energy Constants of Quantum Chromodynamics from a dynamical simulation of Twisted Mass Wilson fermions on the lattice.

Tuesday, November 3rd

9:00am **Andreas Ludwig - SCGP 102**

Title: Topological Phases of Matter and the “Ten-Fold Way”: Overview of Approaches to the Classification of Topological Insulators and Superconductors of Non-Interacting Fermions, and Beyond

10:00am **Coffee - SCGP Cafe**

10:30am **Ilya Gruzberg - SCGP 102**

Title: Low-frequency conductivity of disordered wires: integrability and instantons

Abstract: Generic states of non-interacting electrons in disordered wires are localized, and the DC conductivity of a wire vanishes at zero temperature. However, the AC conductivity is non-vanishing, and its general form at low frequency, was obtained by Mott who used intuitive qualitative arguments. Then this formula was rigorously obtained by Berezinsky for a strictly one-dimensional (1D) disordered system. Using optimal fluctuation (instanton) methods, we compute the AC conductivity for a model of a disordered quasi-1D wire at low frequencies and large negative energies. Such instanton techniques were applied to the 1D case by Hayn and John. After some surprising cancellations, we obtain the Mott-Berezinsky formula. The present model is special in its high degree of symmetry, and our calculation uses the integrability of the saddle-point equations in an essential way. We consider whether Mott-Berezinsky formula would survive the loss of these features.

11:30am **Lunch - SCGP CAfe**

1:00pm **SCGP Weekly Talk - SCGP Rm 102**

Speaker: Thomas Guhr, University of Duisburg-Essen

Title: Random Matrices: Tour d'Horizon

Abstract: Random Matrix Theory (RMT) for dynamical systems was introduced by Wigner in the 50's and found fruitful applications for modeling spectral properties in many-body systems, particularly in nuclei. RMT is closely connected to various aspects of harmonic analysis in mathematics. In the 80's a burst of activities started, when the relevance of RMT for mesoscopic systems and quantum chaos was discovered. Moreover supersymmetry became indispensable for calculations which now also catches the attention in the mathematics community. RMT is nowadays ubiquitous in physics, statistics and mathematics, and continues to find new applications in, e.g., wireless communication and finance. I will try to give a broad overview for non-experts without going into the technical details. Given the enormous range of RMT applications, I have to restrict myself to a selection of conceptually important aspects.

2:15pm **Pierre Le Doussal - SCGP 102**

Title: from replica Bethe ansatz solutions of Kardar Parisi Zhang growth to non-crossing directed paths in a random potential

Abstract: TBA

3:15pm **Tea - SCGP Lobby**

3:45pm **Nicholas Witte, University of Melbourn - SCGP 102**

Title: Singular Values of Products of Ginibre Random Matrices and a generalisation of Painlev\'e III.

Abstract: "Recently Strahov has extended Tracy and Widom's Fredholm theory of the hard edge of single ($ M=1 $) random matrices with unitary symmetry to products of matrices ($ M>1 $ in number). This advance was preceded by the work of many authors who showed that the singular values of such products of standard Gaussian random matrices could be described in terms of a determinantal point process with a kernel involving Meijer G-functions. The particular Meijer G-functions satisfy a linear differential equation of order M+1, generalising the Bessel functions. In the earlier Fredholm theory it was discovered that certain solutions to Painlev\'e's third transcendent were central in determining the distribution of the lowest singular value of the random matrix ensemble. In the recent work a generalisation of this integrable system plays the same role and we explore some of the properties of the simplest extension, i.e the $ M=2 $ case, in some detail. This is joint work with Peter Forrester.

Wednesday, November 4th

9:00am **Gernot Akemann - SCGP 102**

Title: Products of random matrices: from independent to coupled matrices

Abstract: TBA

10:00am **Coffee - SCGP Cafe**

10:30am **Jesper Ispen - SCGP 102**

Title: Products of random matrices: from correlated to uncorrelated eigenvalues

Abstract: Products of random matrices is an old topic within random matrix theory and dates back to pioneering work by Bellman, Furstenberg, Kesten, Oseledec and others. In this talk, we will use new insight provided by recently discovered exactly solvable models to revisit an old question asking for the spectral properties of a product matrix as the number of factors tends to infinity. We will see that the eigenvalues, which are strongly correlated for a small number of matrices, become uncorrelated as the number of factors tend to infinity

11:30am **Maciej Nowak - SCGP 102**

Title: Dynamics of Hermitian versus non-Hermitian random matrices - unexpected links

Abstract: TBA

12:30pm **Lunch - SCGP Cafe**

2:00pm **Ismail Zahed - SCGP 102**

Title: Hydrodynamics of the Polyakov loop and Dirac spectra

Abstract: TBA

3:00pm **Tea - SCGP Lobby**

3:30pm **Paul B. Slater - SCGP 102**

Title: Investigations into the a priori probability that pairs of quantum bits (qubits) are separable/disentangled

Abstract: In a much-cited 1998 Physical Review A paper, "Volume of the set of separable states", the four authors, K. Zyczkowski, P. Horodecki, A. Sanpera and M. Lewenstein (ZHSL) posed "The question of how many entangled or, respectively, separable states there are in the set of all quantum states"? In particular, they suggested considering "the problem of quantum separability or inseparability from a measurement theoretical point of view, and ask about relative volumes of both sets." They gave "philosophical", "practical" and "physical" reasons for so doing. In its most basic mathematical form, this problem concerns the relative volumes of two complementary subsets of the 15-dimensional convex set (Q) of 4 x 4 Hermitian positive semidefinite (density) matrices of unit trace. The high-dimensionality apparently precludes direct analytical computations. I (and, in part recently with Charles Dunkl) have taken a considerable variety of indirect-type approaches to the question. Most notably, a diversity of evidence--though yet no formal proof--has emerged strongly indicating that the probability that a state in Q is separable/disentangled is 8/33. These analyses pertain to the use of the Hilbert-Schmidt (flat/Euclidean) measure on Q. I will survey the development of this body of (in large part, Mathematica-based) evidence. Important tools employed, among others, have been moment-inversion procedures and generalized hypergeometric functions. The clear relevance of "Dyson-indices" has emerged. Recent work of Milz and Strunz--which we have been attempting to extend to a bivariate framework--has shown an interesting (univariate) “Bloch radius”-invariance in the general problem.

Thursday, November 5th

9:00am **Herbert Neuberge - SCGP 102**

Title: Wilson loop eigenvalue distributions

Abstract: A matrix model motivated by large N reduction of an SU(N) gauge theory produces a single-eigenvalue distribution consistent with a four dimensional interacting infrared fixed point. Such fixed points were first conjectured by Caswell on the basis of his computation in 1974 of the two loop term of beta functions in gauge theories with arbitrary fermionic matter content.

10:00am **Coffee - SCGP Cafe**

10:30am **Shinsuke M. Nishigaki - SCGP 102**

Title: Spectral crossover and Anderson localization in QCD Dirac spectra

Abstract: TBA

11:30am **Sayantan Sharma - SCGP 102**

Title: The Dirac eigenvalues in high temperature QCD: connection with topology and RMT.

Abstract: The QCD Dirac eigenvalue spectrum has rich information about the strong interaction dynamics. I would present our recent work on the eigenvalue spectrum of QCD with chiral fermions on the lattice. We observe that the near-zero eigenvalues at T>1.2 T_c, the chiral crossover temperature, can be explained from a weakly interacting instanton gas. The bulk eigenvalues also have many interesting properties. Not only do these contribute to U_A(1) breaking but also have level spacing fluctuations and other properties that can be described using Random Matrix Theory.

12:30pm **Lunch - SCGP Cafe**

2:00pm **Thomas Spencer - SCGP 102**

Title: Zirnbaeur's SUSY sigma model and Reinforced walks

Abstract: I will review some results and conjectures about a lattice SUSY hyperbolic sigma model and its relation to edge reinforced random walk.

3:00pm **Tea - SCGP Lobby**

3:30pm **Alexander Mirlin - SCGP 102**

Title: Anderson transitions and electron-electron interaction

Abstract: TBA

4:30pm **Thomas Guhr, University of Duisburg-Essen - SCGP Rm 102**

Title: New and Exact Results for the Real, Correlated Wishart Model

Abstract: The correlated Wishart model plays a prominent role when analyzing time series of a large variety of systems in the natural sciences, but also in climate, medicine, tele communication and finance. There are many connections to other random matrix models, particularly in the context of Quantum Chromodynamics. Many explicit calculations require harmonic analysis and group integrals. While the complex case is often tractable, the real case poses severe problems, because a result analogous to the Harish-Chandra-Itzykson-Zuber integral is missing. Some recent results will be presented in which this problem could be outmanouvered or considerably simplified by exact maps on equivalent matrix models.

6:00pm **Workshop Banquet - SCGP Cafe**

Friday, November 6th

9:00am **Dmitry Savin - SCGP 102**

Title: Probing eigenfunction nonorthogonality by parametric shifts of resonance widths

Abstract: Resonances feature themselves in the energy-dependent S-matrix as its poles in the complex energy plane. They can be analytically described as the complex eigenvalues of an effective non-Hermitian operator. Notably, the associated resonance wavefunctions are known to be nonorthogonal, which has many important applications ranging from nuclear physics to quantum optics and solid state. This talk will consider an open (scattering) quantum system under the action of a perturbation of its interior. It is demonstrated that the resulting change of resonance widths is a sensitive indicator of the nonorthogonality of resonance wavefunctions, being zero only if those were orthogonal. Focusing further on chaotic systems, we will introduce a new type of parametric statistics in open systems, and apply RMT to derive the exact distribution of resonance width shifts in the regime of weakly open system. Applications and recent data for microwave cavities will be also discussed.

10:00am **Coffee - SCGP Cafe**

10:30am **Toshihiko Kawano - SCGP 102**

Title: Random-matrix approach to the statistical compound nuclear reaction at low energies using the Monte-Carlo technique

Abstract: "Using a random-matrix approach and Monte-Carlo simulations, we generate scattering matrices and cross sections for compound-nucleus reactions. In the absence of direct reactions we compare the average cross sections with the analytic solution given by the Gaussian Orthogonal Ensemble (GOE) triple integral, and with predictions of statistical approaches such as the ones due to Moldauer, to Hofmann, Richert, Tepel, and Weidenm\""{u}ller, and to Kawai, Kerman, and McVoy. We find perfect agreement with the GOE triple integral and display the limits of validity of the latter approaches. We establish a criterion for the width of the energy-averaging interval such that the relative difference between the ensemble-averaged and the energy-averaged scattering matrices lies below a given bound. Direct reactions are simulated in terms of an energy-independent background matrix. In that case, cross sections averaged over the ensemble of Monte-Carlo simulations fully agree with results from the Engelbrecht-Weidenm\""{u}ller transformation. The limits of other approximate approaches are displayed.

11:30am **Roman Riser - SCGP 102**

Title: Fine Asymptotic Behavior for Eigenvalues of Random Normal Matrices

Abstract: TBA

12:30pm **Lunch - SCGP Cafe**

2:00pm **Dr. Mihail Poplavskyi - SCGP 102**

Title: On asymptotic behavior of pure complex spectrum probability for the real Ginibre matrix.

Abstract: TBA

3:00pm **Tea - SCGP Lobby**

3:30pm **Sebastian Muller - SCGP 102**

Title: Semiclassics and random matrices for many-particle systems

Abstract: TBA