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Abstracts

Workshop on The Statistical Physics of Continuum Particle Systems

(29 Aug–9 Sep 2022)

1 Yacin Ameur

Lund University, Sweden

The perfect freezing transition and its characterization in terms of Beurling-Landau densities

Abstract

In 1967, H.J. Landau, extending earlier work due to A. Beurling, obtained necessary conditions for sets of sampling and interpolation with respect to Paley-Wiener spaces, in terms of (lower and upper) "densities" of the set. The Beurling-Landau framework has by now been expanded and adapted to a variety of other situations. In my talk I will discuss how related concepts can be used in the study of equidistribution for Fekete sets and low temperature β-ensembles, specifically in dimensions one and two. In particular, I will discuss a recent result which shows that a Gaussian ensemble is almost surely equidistributed if and only if $\liminf_{n\to\infty} \frac{\beta_n}{\log n} > 0$, where n is the sample-size of a Gaussian process $\{x_j\}_1^n$ at inverse temperature β_n. This result is from joint work with Felipe Marceca and José-Luis Romero.

2 Anirban Basak

International Centre for Theoretical Sciences, TIFR, India

Spectral properties of random perturbations of non-self-adjoint operators

Abstract

Understanding spectral properties of non-self-adjoint operators are of significant importance as they arise in many problems such as scattering systems, open or damped quantum systems, and the analysis of the stability of solutions to nonlinear PDEs. Absence of suitable methods (e.g. variational methods) renders the study of the spectrum of such operators to be difficult. On the other hand, its high sensitivity to small perturbations leads to serious numerical errors. Motivated by problems in different fields such as numerical analysis, semiclassical analysis, fluid dynamics, and mathematical physics, during the last fifteen years there have been several works in understanding the spectral properties of random perturbations of non-self-adjoint operators. In this talk, we will focus on random perturbations of large dimensional non-self-adjoint Toeplitz matrices, and discuss (i) Weyl type law for the empirical measure of its eigenvalues, (ii) limiting eigenvalue density inside the zone of spectral instability (i.e. limit law for outlier eigenvalues), and (iii) localization/delocalization of its eigenvectors, and the universality and non-universality of these features. I will also present some fun pictures and simulations. Based on joint works with Elliot Paquette, Martin Vogel, and Ofer Zeitouni.

3 Alexander Bufetov

CNRS, France and Steklov, IITP RAS, Russia
Determinantal point processes and random entire functions

Abstract

The 5 hour minicourse will start with a thorough introduction to determinantal point processes, concentrating on the key example of the sine-process. Our first aims will be the Soshnikov Central Limit Theorem and the Ghosh Completeness Theorem (whose generalization, a proof of the Lyons-Peres conjecture, has been obtained in joint work with Qiu and Shamov). Next, to a realization of the sine-process we will assign a random entire function, the analogue of the characteristic polynomial of a random matrix (and, more precisely, the scaling limit of the ratio of the values of the characteristic polynomial). Taking the logarithm of our entire function, we will arrive at a Gaussian process, indexed by pairs of point of the Lobachevsky plane and invariant under Lobachevskian isometries. A study of this Gaussian field implies the convergence to the Gaussian Multiplicative Chaos of the square

of the modulus of the random entire function considered above. The formalism of Berestycki based on the Girsanov Theorem is the most convenient for the proof of the convergence to the Gaussian Multiplicative Chaos. A corollary of the convergence to the Gaussian Multiplicative Chaos is the result claiming that the sine-process has excess one, that is to say, that a generic realization of the sine-process without one particle is a complete and minimal set for the Paley-Wiener space. This result provides a complement to the Ghosh Completeness Theorem. The proof is based on the scaling limit of the Borodin-Okounkov-Geronimo-Case formula and on an analogue of the Johansson change of variable formula based on the quasi-invariance of the sine-process under diffeomorphisms of compact support.

4 Sung-Soo Byun

Korea Institute for Advanced Study, Korea
Various scaling limits of planar symplectic ensembles

Abstract

In this talk, I will discuss complex eigenvalues of non-Hermitian random matrices with symplectic symmetry, which are known to form Pfaffian point processes. From the statistical physics point of view, this is often called the configurational canonical Coulomb gas ensemble in the upper-half plane with an additional complex conjugation symmetry.

I will present various scaling limits of planar symplectic ensembles and explain their unified integrable structure of Wronskian form. Examples include edge scaling limits of the Ginibre ensemble (with boundary confinements), bulk/edge scaling limits of the elliptic Ginibre ensemble in the almost-Hermitian regime and bulk scaling limits of the induced Ginibre ensemble in the almost-circular regime. Furthermore, based on the unified Wronskian structure and the generalised Christoffel-Darboux type formulas, I will present an intimate relation between planar symplectic ensembles and random normal matrix models (i.e. determinantal Coulomb gas ensembles).

This talk is based on several joint works in recent years with Gernot Akemann, Christophe Charlier, Markus Ebke, Nam-Gyu Kang, and Seong-Mi Seo.

5 Yogeshwaran D

Indian Statistical Institute, Bangalore, India
Limit theorems for continuum interacting particle systems

Abstract

We consider interacting particle systems defined on spatial graphs constructed on stationary Euclidean point processes restricted to finite windows. The graph structure, point processes and initial states satisfy jointly a weak decay of correlations. We establish the asymptotic normality, expectation, and variance asymptotics of statistics of the particle system evolution as the window size increases to the full space. We will describe examples of particle systems and other spatial random models that fall within our framework. This is a joint work with B. Blaszczyszyn (INRIA-ENS, Paris) and J. E. Yukich (Lehigh University, USA).

6 Amir Dembo

Stanford University, USA
Limit law for line ensembles of Brownian polymers with geometric area tilts

Abstract

Consider non-crossing Brownian bridges above a hard wall, each tilted by the area of the region below it with geometrically growing pre-factors. This line ensemble, which mimics the level lines of the (2+1)D solid-on-solid model above a hard wall, was studied by Caputo, Ioffe and Wachtel. In a joint work with Eyal Lubetzky and Ofer Zeitouni, we prove their conjecture that when the length of bridges, followed by the number of paths, go to infinity, the law of the top k paths converges to the same limit under both zero and most, free-like, boundary conditions.

7 Thomas Leblé

CNRS - Université Paris Cité, France
Fluctuations of two-dimensional Coulomb gases

Abstract

I will review results about fluctuations of 2d Coulomb gases and related systems, with a focus on methods and remaining open problems.

8 Mathieu Lewin

Université Paris Dauphine, France

Coulomb and Riesz gases: a review of what's known and unknown

Abstract

In this course, I will review what is known and unknown for Coulomb and Riesz gases, from the point of view of statistical mechanics. I will start by recalling what has been proved in the short range case, before turning to more complicated long range systems including Coulomb. The lecture will be based on a recent review on the subject, published by the Journal of Mathematical Physics :https://aip.scitation.org/doi/10.1063/5.0086835

9 Alon Nishry

Tel Aviv University, Israel

Hole events for Gaussian complex zeros and quadrature domains

Abstract

The zero process of the Gaussian Entire Function is a natural example of a two-dimensional random point configuration whose distribution is invariant under rigid motions of the plane.

We consider the hole event - when there are no zeros of the function in some domain. As the size of the hole increases, the density of zeros vanishes, not just inside the hole, but also on a macroscopic region beyond the (rescaled) hole - a 'forbidden region' emerges. Surprisingly, the shape of this region is rigid under perturbations of the hole.

I will discuss the shape of the forbidden region for general simply connected holes, and touch upon a curious emergence of quadrature domains from potential theory.

Based on joint work A. Wennman

10 Hirofumi Osada

Chubu University, Japan

The rigidity of translation invariant random point fields implies sub-diffusivity

Abstract

The celebrated Nash theory for symmetric diffusions clarifies the relation of the time decay of the transition probability density of diffusion with translation invariant measure and Nash inequality. If Nash inequality holds, then the diffusion is diffusive. However, there exists no analogy for infinite-dimensional space.

In this talk, we present criteria for sub-diffusivity of tagged particles of the stochastic dynamics associated with the translation-invariant random point fields that are number rigid. This result implies the tagged particles of the Ginibre interacting Brownian motion and the diffusions related to the planner Gaussian analytic function are sub-diffusive. We also show a sufficient condition of diffusivity in terms of Palm measures.

11 Mircea Petrache

Pontificia Universidad Católica de Chile, Chile

Recovering discrete Fourier spectra from random perturbations

Abstract

For periodic or quasiperiodic sets, we study the effect of random perturbations on their Fourier transform. The basic result is that under mixing assumptions on the random perturbations, the effect of the perturbations is almost surely that of multiplying the Fourier transform by a weight. This allows to recover the support of the Fourier transform. The case of perturbed lattices was studied by Yakir, and here we extend this result to quasicrystals and to discrete settings, in which cases new difficulties arise.

12 Lakshmi Priya

Tel Aviv University, Israel

Zeros of stationary Gaussian processes: overcrowding estimates & a phase transition

Abstract

We study an aspect of the zeros of centered stationary Gaussian processes (SGP) on $\mathbb{R}$, namely $\mathscr{N}_T$, which is the number of zeros in the interval $[0, T]$. In earlier studies, under varying assumptions on the spectral measure of the SGP, the following results/statistics were obtained for $\mathscr{N}_T$: expectation, variance asymptotics, CLT, exponential concentration, and finiteness of moments. We are interested in the overcrowding event, which is the rare event that $\mathscr{N}_T$ is much larger than its expected value.

Overcrowding estimates: In the first part of the talk, under some mild assumptions on the spectral measure, we obtain estimates for the probability of the overcrowding event.

Phase transition: In the second part of the talk, we will restrict our attention to SGP with compactly supported spectral measure μ. Let $A > 0$ be the smallest number such that $\mathrm{supp}(\mu) \subseteq [-A, A]$. We study the event $E_\eta := \{\mathscr{N}_T \geq \eta T\}$, as η varies. We will show that:

1. For small values of η, E_η has substantial probability, i.e., $\mathbb{P}(E_\eta) \geq \exp(-C_\eta T)$.
2. For large enough η, E_η is extremely unlikely, i.e., $\mathbb{P}(E_\eta) \leq \exp(-c_\eta T^2)$.
3. The critical value of η where this transition in the behaviour of $\mathbb{P}(E_\eta)$ occurs is $\eta_c = A/\pi$.

The second part of the talk is based on a joint work with Naomi Feldheim & Ohad Feldheim

13 Simona Rota Nodari

Université Côte d'Azur, France

Renormalized Energy Equidistribution and Local Charge Balance in Coulomb Systems

Abstract

We consider a classical system of n charged particles confined by an external potential in any dimension bigger or equal than 2. The particles interact via pairwise repulsive Coulomb forces and the pair-interaction strength scales as

the inverse of n (mean-field regime). The goal is to investigate the microscopic structure of the minimizers.

It has been proved by Sandier-Serfaty (d=2) and Rougerie-Serfaty ($d > 2$) that the distribution of particles at the microscopic scale, i.e. after blow-up at the scale corresponding to the interparticle distance, is governed by a renormalized energy which corresponds to the total Coulomb interaction of point charges in a uniform neutralizing background.

In this talk, I will present some results which show that for minimizers and in any large enough microscopic set, the renormalized energy concentration and the number of points are completely determined by the macroscopic density of points. In other words, points and energy are "equidistributed".

Works in collaboration with S. Serfaty and M. Petrache.

14 Gregory Schehr

Sorbonne Université, France

Noninteracting fermions in a rotating trap and random matrix theory

Abstract

I will consider N non-interacting fermions in a $2d$ harmonic potential of trapping frequency ω and in a rotating frame at angular frequency Ω, with $0 < \omega - \Omega \ll \omega$. At zero temperature, the fermions are in the non-degenerate lowest Landau level and their positions are in one to one correspondence with the eigenvalues of an $N \times N$ complex Ginibre matrix. Hence the bulk density of fermions is simply uniform over a disk of radius $\sim \sqrt{N}$. As the rotating frequency Ω decreases, I will show that the bulk density exhibits a non-trivial profile, reminiscent of a multi-layered wedding cake structure. Zooming in on the edge of the k-th layer, we find that the edge density exhibits k kinks located at the zeroes of the k-th Hermite polynomials.

15 Tomoyuki Shirai

Kyushu University, Japan

Zeros of the i.i.d. Gaussian Laurent series on an annulus

Abstract

Peres and Virág showed that the zeros of the i.i.d. Gaussian power series on the disk, whose covariance kernel is the Szegő kernel, form the determinantal point process associated with the Bergman kernel. In the present talk, I will discuss the zeros of the i.i.d. Gaussian Laurent series on an annulus, whose convariance kernel is given by the weighted Szegő kernel studied by McCullough and Shen.

Based on a joint work with Makoto Katori (Chuo University, Japan).

16 Mikhail Sodin

Tel Aviv University, Israel

Random Weierstrass zeta-function

Abstract

Why some stationary planar point processes generate stationary fields with divergence equaled the counting measure of the point process minus the Lebesgue measure (the infinite Ginibre determinantal process and the zero set of the Gaussian Entire Function belong to this class), while others (like the Poisson point process) don't? In the talk we give a simple answer to this question and discuss curious properties of that stationary field, for instance, the logarithmic divergence of their covariance, and the size of fluctuations of their line integrals.

If time permits, we will also touch existence of somewhat counter-intuitive exotic objects generated by stationary planar point processes.

The talk will be based on an ongoing joint work with Oren Yakir and Aron Wennman.

17 Rongfeng Sun

National University of Singapore, Singapore

A new correlation inequality for Ising models with external fields

Abstract

We study ferromagnetic Ising models on finite graphs with an inhomogeneous external field. We show that the influence of boundary conditions on any

given spin is maximised when the external field is identically 0. One corollary is that spin-spin correlation is maximised when the external field vanishes. In particular, the random field Ising model on Z^d, $d \geq 3$, exhibits exponential decay of correlations in the entire high temperature regime of the pure Ising model. Another corollary is that the pure Ising model on Z^d, $d \geq 3$, satisfies the conjectured strong spatial mixing property in the entire high temperature regime. Based on joint work with Jian Ding and Jian Song.

18 Balint Virag

University of Toronto, Canada
Bisectors in random plane geometry

Abstract

In Euclidean geometry, bisectors are perpendicular lines. What happens in a random geometry? Surprisingly, many features are not sensitive to which model we use. There is a universal random geometry and its bisectors help answer some open questions in particle systems.

19 Balint Virag

University of Toronto, Canada
Random plane geometry – a gentle introduction

Abstract

Consider Z^2, and assign a random length of 1 or 2 to each edge based on independent fair coin tosses. The resulting random geometry, first passage percloation, is conjectured to have a scaling limit.

Most random plane geometric models (including hidden geometries) should have the same scaling limit.

I will explain the basics of the limiting geometry, the "directed landscape", the central object in the class of models named after Kardar, Parisi and Zhang.

20 Oren Yakir

Tel Aviv University, Israel
Random polynomials near the unit circle

Abstract

It is well known that a random polynomial with iid coefficients has most of its roots close to the unit circle. Recently, we found that both the minimum modulus of the polynomial on the unit circle itself, as well as the closest root to the unit circle has a limiting exponential distribution. In my talk I will explain the joint mechanism behind these results.

Joint works with Nicholas Cook, Hoi Nguyen and Ofer Zeitouni.

21 Dmitry Zaporozhets

St. Petersburg Department of Steklov Mathematical Institute of Russian Academy of Sciences, Russia
Convex hulls of random walks

Abstract

We will show how the convex hulls of multidimensional random walks can be studied using the properties of the intrinsic volumes of the polyhedral cones. In particular, we will discuss some unexpected corollaries from the conic version of the Gauss-Bonnet formula. Based on the joint work with Fedya Petrov and Julien Randon-Furling.