Abstracts

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Sung-Soo Byun
Seoul National University, Korea

Harer-Zagier type recursion formula for the elliptic GinOE

Random matrix theory enjoys an intimate connection with various branches of mathematics. One prominent illustration of this relationship is the Harer-Zagier formula, which serves as a well-known example demonstrating the combinatorial and topological significance inherent in random matrix statistics. While the Harer-Zagier formula originates from the study of the moduli space of curves, it also gives rise to a fundamental formula in the study of spectral moments of classical random matrices. In this talk, I will introduce the Harer-Zagier type formulas for the classical Hermitian Gaussian random matrix ensembles and present recent results on these formulas for the non-Hermitian random matrix model called the elliptic Ginibre ensemble.

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Yuki Chino
National Yang Ming Chiao Tung University, Hsinchu

Self-avoidance and random environment

It is known that self-avoidance affects to random walk much in lower dimensions in a homogeneous setting.

The lace expansion has been used to understand the asymptotic behaviour, which especially in higher dimensions (above 4), self-avoiding walk (SAW) asymptotically behaves like simple random walk in the sense that both models have the same critical exponent. It is also known that random environment affects to the asymptotic behaviour of models, like random walk in random environment.

In the previous works, it is proved that SAW in random environment shows the strong disorder in 1 and 2 dimensions. However, it is open whether we have only strong disorder regime or there is a crossover between weak and strong disorder regimes in more than 2 dimensions.

We expect the existence of the crossover from the result of directed polymer model.

We are interested in which dimension we have the crossover.

We want to consider the question with comparison to other statistical-mechanical models.

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David Croydon
Kyoto University, Japan

Random walk on a critical percolation cluster on a random hyperbolic half-planar triangulation

Capturing the behaviour expected for critical percolation clusters on high-dimensional integer lattices, we show that the Gromov-Hausdorff-Prohorov scaling limit of a critical percolation cluster on a random hyperbolic triangulation of the half-plane is the Brownian continuum random tree. As a corollary, we obtain that the simple random walk on the critical cluster rescales to Brownian motion on the continuum random tree.

This is a joint work with Eleanor Archer (Université Paris Nanterre).

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Eric Endo
NYU Shanghai, China

Metastates on one-dimensional long-range Ising model with random boundary condition

We introduce the notion of metastates on the one-dimensional long-range ferromagnetic Ising model with polynomially decaying pair interactions $J_{xy}=|x-y|^{-2+\alpha}$, with $0\le \alpha<1$, where the boundary conditions are uniformly randomly chosen.

We show that, at low temperatures, in the thermodynamic limit, the finite-volume Gibbs measures do not converge, but have a distributional limit, the so called metastate. Moreover, for $0\le \alpha<1/2$, the metastate of the model is concentrated on mixed states, whereas for $1/2<\alpha<1$ the metastate has its support just on the set of the two extremal Gibbs measures, the measures with plus and minus boundary conditions.

Joint work with Aernout C.D. van Enter and Arnaud Le Ny.

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Yichao Huang
Beijing Institute of Technology, China

Moments of Gaussian multiplicative chaos: various aspects

We give a short review on different aspects of Kahane's theory of Gaussian multiplicative chaos, focusing on the connection between its moments to models in mathematical physics, from Kolmogorov's theory of turbulence to Polyakov's theory of Liouville conformal field theory. Several extensions and recent results will also be discussed if time permits.

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Stefan Junk
Gakushuin University, Japan

Local limit theorem for directed polymer beyond the L^2-phase

We consider the directed polymer model in the weak disorder (high temperature) phase in spatial dimension d>=3. In the case where the (normalized) partition function is L^2-bounded it has been known for a long time that time polymer measure satisfies a local limit theorem, i.e., that the point-to-point partition function can be approximated by two point-to-plane partition functions at the start- and endpoint. We show that this result extends to the whole weak disorder phase if the partition function is L^p-bounded for some p>1+2/d. We furthermore show that for environments with finite support the required L^p -boundedness holds in the whole weak disorder phase, except possibly for the critical value.

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Naotaka Kajino
Kyoto University, Japan

Geometric Laplacians on self-conformal fractal curves in the plane

This talk will present the speaker's ongoing work on ``geometrically canonical'' Laplacians on self-conformal fractal curves in the plane. The main result is that on a given such curve one can construct a family of Laplacians whose heat kernels and eigenvalue asymptotics ``respect'' the fractal nature of the Euclidean geometry of the curve in certain nice ways.

The idea of the construction of such Laplacians originated from the speaker's preceding studies on the case of a circle packing fractal, i.e., a fractal subset of $\mathbb{C}$ whose Lebesgue area is zero and whose complement in the Riemann sphere $\widehat{\mathbb{C}}:=\mathbb{C}\cup\{\infty\}$ is the union of disjoint open disks in $\widehat{\mathbb{C}}$. He has observed that, on a given such fractal, one can explicitly define a Dirichlet form (a quadratic energy functional) by a certain weighted sum of the standard one-dimensional Dirichlet form on each of the circles constituting the fractal, and that this Dirichlet form ``respects'' the Euclidean geometry of the fractal in the sense that the inclusion map of the fractal into $\mathbb{C}$ is harmonic with respect to this form. The speaker has also proved that such a Dirichlet form is unique for the classical Apollonian gaskets and that, for some concrete families of self-conformal fractals including the Apollonian gaskets, the associated Laplacian satisfies Weyl's eigenvalue asymptotics involving the Euclidean Hausdorff dimension and measure of the fractal.

It would be desirable if one could extend such results to self-conformal fractals which are not circle packing ones, and the talk will present an extension to the simplest case of self-conformal fractal curves in the plane. The key points of the construction of Laplacians is to use (suitable versions of) the harmonic measure in defining the Dirichlet form BUT to use fractional-order Besov seminorms (with respect to the harmonic measure) of the inclusion map into $\mathbb{C}$ in defining the volume measure.

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Yoshinori Kamijima
National Center for Theoretical Sciences, Taipei

Stability of the phase transition and critical behaviour of the Ising model against quantum perturbation

The quantum Ising model is a kind of model of ferromagnetic materials. In this model, spin configurations are regarded as operators but not scalars. Spins are fluctuated by a quantum effect. In the case of the nearest-neighbour setting, Björnberg proved that the (magnetic) susceptibility diverges at the critical inverse temperature and exhibits the power-law behaviour on the integer lattice. In particular, its critical exponent takes the mean-field value 1 in dimensions greater than or equal to 4 at finite temperature and in dimensions greater than or equal to 3 at absolute zero.

In this talk, I show a lace-expansion approach to prove that the critical behaviour for the susceptibility does not change even when the quantum effect is imposed. Physicists believe this conjecture, but we want to give mathematically rigorous proof. So far, we have obtained the differential inequalities for the susceptibility with respect to inverse temperature and derived the lace expansion for the quantum Ising model. They support that the above critical value equals 1. Our derivation of the lace expansion is inspired by the NoBLE, which Fitzner and van der Hofstad derived.

This talk is based on joint work with Akira Sakai.

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Makoto Katori
Chuo University, Japan

Non-Hermitian matrix-valued Brownian motion and the regularized Fuglede--Kadison determinant random-fields

The non-Hermitian matrix-valued Brownian motion is the stochastic process of a random matrix whose entries are given by independent complex Brownian motions. The bi-orthogonality relation is imposed between the right and the left eigenvector processes, which allows for their scale transformations with an invariant eigenvalue process. The eigenvector-overlap process is a Hermitian matrix-valued process, each element of which is given by a product of an overlap of right eigenvectors and that of left eigenvectors.

We derive a set of stochastic differential equations (SDEs) for the coupled system of the eigenvalue process and the eigenvector-overlap process and prove the scale-transformation invariance of the obtained SDE system. The Fuglede--Kadison (FK) determinant associated with the present matrix-valued process is regularized by introducing an auxiliary complex variable. This variable is necessary to give the stochastic partial differential equations (SPDEs) for the time-dependent random field defined by the regularized FK determinant and for its squared and logarithmic variations. Time-dependent point process of eigenvalues and its variation weighted by the diagonal elements of the eigenvector-overlap process are related to the derivatives of the logarithmic regularized FK-determinant random-field. We also discuss the PDEs obtained by averaging the SPDEs.

The present talk is based on the joint work with Syota Esaki (Fukuoka) and Satoshi Yabuoku (Kitakyushu).

A preprint is available at https://arxiv.org/abs/2306.00300

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Kunwoo Kim
Pohang University of Science and Technology, Korea

The compact support property for stochastic heat equations

In this talk, we consider the compact support property of d-dimensional stochastic heat equations (SHE) driven by Gaussian noise, which is white in time and coloured in space. Here, the compact support property (CSP) refers to the property that if the initial function has compact support, then so does the solution for all time. In other words, CSP means finite speed of propagation. We show that, under some mild condition on the noise that guarantees the existence and continuity of the solution, CSP holds with probability one for a large class of SHEs.

This is based on joint work with Beom-Seok Han (Sungshin) and Jaeyun Yi (EPFL).

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Wai-Kit Lam
National Taiwan University, Taipei

Recent progress in planar critical first-passage percolation

In first-passage percolation, one puts i.i.d. nonnegative random weights on the nearest-neighbour edges (or vertices) of a planar lattice, and studies the induced pseudometric. We will focus on the so-called ``critial'' case, where the probability that an edge weight is 0 equals the critical threshold for Bernoulli percolation. The behaviour of the critical case is very different from the usual case (where the probability that an edge weight is 0 is less than the critical threshold), and is in fact more close to that of (near-)critical Bernoulli percolation in two dimensions, but with a richer structure. We will discuss the history and recent progress in planar critical first-passage percolation, including asymptotics, fluctuations, limit theorems and exceptional behaviour.

Based on joint work with M. Damron, J. Hanson, D. Harper, and X. Wang.

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Jhih-Huang Li
National Taiwan University, Taipei

PushASEP model on a periodic ring

We are interested in an interacting particle system called PushASEP model, which is a natural generalization of the TASEP model. Instead of studying the model on an infinite line, we look at a periodic ring, which brings us back to a finite-state Markov process.

More precisely, we are in the following setup. At time 0, N particles are distributed on a periodic ring of size L, and they move to the left and right according to specific rules. We want to understand the asymptotic behavior of such a system for large L and N with the ratio N/L fixed. In particular, we establish results in the relaxation time scale $t \sim L^{3/2}$ which can be described by distributions interpolating the Gaussian distribution and the Tracy-Widom distribution.

It is a joint work with Axel Saenz (Oregon).

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Xinyi Li
Peking University, China

The Boosted Loop-Erased Random Walk

We introduce a novel near-critical version of the loop-erased random walk (LERW) by boosting the weight of random walk path according to its length before loop-erasure. We construct the scaling limit in natural parametrization in two and three dimensions and show that the boosted scaling limit undergoes a phase transition and that the boosted scaling limit gradually becomes space-filling as the perturbation parameter tends to infinity. In particular, these results provide some evidence to a conjecture of Makarov-Smirnov in \cite{MS} on 2D near-critical lattice models. Joint work with Gefei Cai (Peking), Daisuke Shiraishi (Kyoto) and Aoteng Xia (Peking).

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Shuta Nakajima
Meiji University, Japan

Equivalence of fluctuations between SHE and KPZ equation in weak disorder regime

The Kardar-Parisi-Zhang (KPZ) equation is a mathematical model that describes the random evolution of interfaces. The equation has become a fundamental model in non-equilibrium statistical physics. The construction of a solution to the KPZ equation in any dimension presents a significant challenge due to its inherent non-linearity. This has resulted in an enduring open problem, particularly for solutions in two and higher dimensions. On the other hand, the Stochastic Heat Equation (SHE), a linear stochastic partial differential equation, has been extensively studied owing to its tractability and broad applicability. This talk will explore the intriguing connection between the SHE and the KPZ equation, offering a rigorous demonstration of the equivalence of fluctuations in these systems in the weak disorder regime for three and higher dimensions.

The talk is based on joint work with Stefan Junk.

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Kyeongsik Nam
Korea Advanced Institute of Science & Technology, Korea

Universality of Poisson-Dirichlet law for log-correlated fields

It is widely conjectured that the Poisson-Dirichlet behavior appears universally in low-temperature disordered systems. However, this principle has been verified only for the particular models which are exactly solvable. In this talk, I will talk about the universal Poisson-Dirichlet behavior for the general log-correlated Gaussian fields.

This is based on the joint work with Shirshendu Ganguly.

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Maximilian Nitzschner
The Hong Kong University of Science and Technology, China

Bulk deviation lower bounds for the simple random walk

In this talk we present large deviation lower bounds for the probability of certain bulk-deviation events depending on the occupation-time field of a simple random walk on the Euclidean lattice in dimensions larger or equal to three.

As a particular application, these bounds imply an exact leading order decay rate for the probability of the event that a simple random walk covers a substantial fraction of a macroscopic body, when combined with a corresponding upper bound previously obtained by Sznitman. As a pivotal tool for deriving such optimal lower bounds, we recall the model of tilted walks which was first introduced by Li in order to develop similar large deviation lower bounds for the probability of disconnecting a macroscopic body from an enclosing box by the trace of a simple random walk. We then discuss a refined local coupling with the model of random interlacements which is used to locally approximate the occupation times of the tilted walk.

Based on joint work in progress with A. Chiarini (University of Padova).

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Wei Qian
City University of Hong Kong, China and CNRS, France

Conformally invariant fields out of Brownian loop soups

For each central charge $c\in (0,1]$, we construct a conformally invariant field which is a measurable function of the local time field $\mathcal{L}$ of the Brownian loop soup with intensity c and i.i.d. signs given to each cluster. This field is canonically associated to $\mathcal{L}$, in a sense which is similar to the isomorphism theory that associates the Gaussian free field to the loop soup with critical intensity. Isomorphisms between Brownian motions and random fields were previously developed by Symanzik, Brydges-Fröhlich-Spencer, Dynkin and Le Jan in several different settings.

We also extend the coupling between CLE(4) and GFF for all $\kappa\in(8/3,4]$. We show that the (non-nested) CLE loops form level lines for this field and that there exists a constant height gap between the values of the field on either side of the CLE loops.

This talk is based on joint works with Antoine Jego (EPFL) and Titus Lupu (CNRS).

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Alejandro Ramírez
NYU Shanghai, China

KPZ fluctuations in the planar stochastic heat equation

We consider Wick ordered solutions to the planar stochastic heat equation, corresponding to a Skorokhod interpretation in the Duhamel integral representation of the equation. We prove that the fluctuations far from the center are given by the stochastic heat equation.

This talk is based on a joint work with Jeremy Quastel and Balint Virag.

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Insuk Seo
Seoul National University, Korea

Energy landscape and metastability of Ising and Potts model without external field

In this talk, we consider the Ising and Potts model defined on large lattices of dimension two or three at very low temperature regime. Under this regime, each monochromatic spin configuration is metastable in that exit from the energetic valley around that configuration is exponentially difficult. It is well-known that, under the presence of external magnetic fields, the metastable transition from a monochromatic configuration to another one is characterized solely by the appearance of a critical droplet. On the other hand, for the model without external field, the saddle structure is no longer characterized by a sharp droplet but has a huge and complex plateau structure. In this talk, we explain our recent research on the analysis of this energy landscape and its application to the demonstration of Eyring-Kramers formula for models on fixed two or three dimensional lattice or models on growing two-dimensional lattice.

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Jian Song
Shandong University, China

Scaling limit of a long-range random walk in the time-correlated random environment

We consider a long-range random walk in random environment in dimension $1 + 1$, where the environmental disorder is independent in space but has long-range correlations in time. We prove that two types of rescaled partition functions converge weakly to the Stratonovich solution and the Itô- Skorohod solution respectively of a fractional stochastic heat equation with multiplicative Gaussian noise which is white in space and colored in time.

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Mo Dick Wong
Durham University, UK

What can we hear about the geometry of an LQG surface?

The Liouville quantum gravity (LQG) surface, formally defined as a 2-dimensional Riemannian manifold with conformal factor being the exponentiation of a Gaussian free field, is closely related to random planar geometry as well as scaling limits of models from statistical mechanics. In this talk, I shall explain the Weyl's law for the eigenvalues associated to the formal Laplace-Beltrami operator using Liouville Brownian motion, the canonical diffusion process on an LQG surface.

This is a joint work with Nathanael Berestycki.

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Hao Wu
Tsinghua University, China

Multiple SLE and Dyson Brownian motion

Under proper time parameterization, the driving function of multiple SLEs becomes Dyson Brownian motion. In this talk, we will explain the background of multiple SLEs from the point of view in statistical physics models and explain the connection between multiple SLEs and Dyson Brownian motions.

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Wei Wu
NYU Shanghai, China

Two dimensional dimers beyond planarity

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Jinjiong Yu
East China Normal University, China

Universality of the Brownian net

The Brownian web is the collection of one-dimensional coalescing Brownian motions starting from every point in space and time, while the Brownian net is an extension that also allows branching. Previously, Brownian net has been shown to be the scaling limit of the collection of branching-coalescing simple random walks with weak branching. In this talk, we show that the Brownian net is the universal scaling limit of one-dimensional branching-coalescing random walks with weak binary branching and arbitrary increment distributions that have finite $(3+\varepsilon)$-th moment.

Joint work with Rongfeng Sun and Jan M. Swart.

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Qiang Zeng
University of Macau, China

Hessian spectrum at the global minimum of locally isotropic Gaussian random fields

Locally isotropic Gaussian random fields were first introduced by Kolmogorov in 1941. Such models were used to describe various phenomena in statistical physics. In particular, they were introduced to model a single particle in a random potential by Engel, Mezard and Parisi in 1990s. Using Parisi's award winning replica trick, Fyodorov and Le Doussal predicted the high dimensional limit of the Hessian spectrum at the global minimum of these models, and discovered phase transitions according to different levels of replica symmetry breaking. In this talk, I will present a solution to their conjecture in the so called replica symmetric regime. Our method is based on landscape complexity, or counting the number of critical points of the Hamiltonian.

This talk is based on joint works with Antonio Auffinger (Northwestern University), Hao Xu (University of Macau) and Haoran Yang (Peking University).

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