Mini-Symposium with Prof. G. Schehr at Chuo University

(version 1: 15/Aug/2023)

Dates/Time: Friday 18 and Monday 21, August 2023, 13:30–17:00

Venue: Room 3507, 5th floor, Building No.3, Korakuen Campus, Department of Physics, Chuo University

Program:

[Part 1: Friday 18 August 2023]

13:30–14:30 Grégory SCHEHR (Sorbonne, France)
When trapped fermions meet random matrix theory [slides]

14:45–15:45 Ryosuke SATO (Chuo, JSPS Research Fellowship)
Determinantal point processes and operator algebras

16:00–16:20 Yuya TANAKA (Chuo)
Rings-to-Disk Transitions in Complex Eigenvalue Processes

16:20–16:40 Ayana EZOE (Chuo)
Switching particle systems for foraging ants showing phase transitions in path selections

16:40–17:00 Saori MORIMOTO (Chuo)
Classifications and Generalizations of Traffic Flow Models in Statistical Mechanics

(17:30– dinner)

[Part 2: Monday 21 August 2023]

13:30–14:30 Grégory SCHEHR (Sorbonne, France)
Universal counting statistics in the Ginibre ensembles (complex, symplectic and real) [blackboard talk]

14:45–15:45 Tomoyuki SHIRAI (Kyushu, Japan)
Zeros of random power series with dependent Gaussian coefficients

16:00–17:00 Ryosuke SATO (Chuo, JSPS Research Fellowship)
Dynamics on determinantal point processed from the viewpoint of operator algebras

(17:30– dinner)

Contact : Makoto Katori
Department of Physics, Chuo University
Room 1538, 5th floor of Building No.1
e-mail: katori@phys.chuo-u.ac.jp
tel: (03) 3817-1776

Abstracts

Grégory Schehr (Sorbonne, France)

When trapped fermions meet random matrix theory

I will pedagogically review recent progress in the study of fermionic quantum many-body systems, both with and without interactions, and in the presence of an external trapping potential, in their ground state. In the simplest instance of N one-dimensional noninteracting fermions in the presence of a harmonic potential, I will show that the positions of these fermions can be mapped onto the eigenvalues of the Gaussian Unitary Ensemble (GUE). In fact, by tuning the interactions and/or changing the form of the trapping potential, it is possible to establish a precise mapping between these fermionic quantum many-body systems and all the classical random matrix ensembles, ranging from the Gaussian beta-ensembles to the so-called Ginibre ensemble. If time permits I will discuss the consequences of these mappings on the study of the full counting statistics as well as on the quantum entanglement entropy for these systems, in particular in the limit of a large number of fermions.

Universal counting statistics in the Ginibre ensembles (complex, symplectic and real)

In this talk, I will discuss the statistics of the number N_R of eigenvalues in the centred disk of radius R in the three classical Ginibre ensembles of random matrices of size $N \times N$, with a special emphasis on the large N limit. In this limit, the statistical properties of N_R (characterized by its cumulants) display markedly different scaling behaviors depending on R: (i) the "origin scaling limit" for R close to the center, (ii) the "bulk scaling limit" for R large but still far from the edge of the spectrum and (iii) the edge scaling limit for R close to the edge of the spectrum. I will first discuss these three different regimes for the complex Ginibre ensemble, extending previous studies by T. Shirai beyond the origin scaling limit. In that case, significant progress can be made thanks to the determinantal structure of the correlations in the complex Ginibre ensemble. Then, I will present very recent results obtained with G. Akemann, S. Byun and M. Ebke for the symplectic Ginibre ensemble (for which the three aforementioned regimes can also be studied in detail) as well as for the mean and variance of N_R in the real Ginibre ensemble (in the origin scaling limit). In these cases, progress were made possible by exploiting the Pfaffian structure of the correlations in these matrix models. I will also finally discuss the universality of these results beyond the Ginibre ensembles, for more general normal matrix models (both complex and sympletic).

Ryosuke SATO (Chuo, JSPS Research Fellowship)

Determinantal point processes and operator algebras

In this talk, we will first summarize several fundamental aspects of operator algebra theory. More specifically, we will discuss operator algebras defined by the canonical anti-commutation relations, which are referred to as (gauge invariant)

CAR algebras. Furthermore, we will explore their connection to determinantal point processes.

Dynamics on determinantal point processed from the viewpoint of operator algebras

After my previous talk, we will discuss determinantal point processes with correlation kernels given by difference operators and study stochastic dynamics on them based on operator algebras. First, we construct "noncommutative" stochastic dynamics on (gauge invariant) CAR algebras and demonstrate how they induce stochastic dynamics on determinantal point processes.

Tomoyuki SHIRAI (Kyushu, Japan)

Zeros of random power series with dependent Gaussian coefficients

The zeros of random power series with i.i.d. complex Gaussian coefficients form the DPP associated with Bergman kernel. As a generalization of this model, we are concerned with zeros of random power series with coefficients being a stationary, centered, complex Gaussian process. We discuss the expected number of zeros in a disk and compare it with the i.i.d. coefficients case. When the spectral density of the Gaussian process of coefficients is a trigonometric polynomial, we discuss the precise asymptotics of the expected number of zeros inside the disk of radius r centered at the origin as r tends to the radius of convergence. This talk is based on a joint work with Kohei Noda (Kyushu Univ.).

Yuya TANAKA (Chuo)

Rings-to-Disk Transitions in Complex Eigenvalue Processes

First I show two movies of complex eigenvalue processes of the non-Hermitian matrix-valued Brownian motions starting from two different initial matrices. The first one shows a simple growing of a disk starting from a point source. The second one shows a transition from a single ring to a disk. I am interested in the latter case and studying its generalization as explained in this talk. I briefly review the hydrodynamic equations of eigenvalue processes following the paper by Burda et al. (Nucl. Phys. **B 897** (2015) 421). The solutions of the hydrodynamic equations describe both cases well. We found the initial matrices showing transitions from double rings to a disk of eigenvalue distributions. I report the double-ring solutions of the hydrodynamic equations. Finally I discuss the general case starting from m-multiple rings with an arbitrary integer m.

Anaya EZOE (Chuo)

Switching particle systems for foraging ants showing phase transitions in path selections

Switching interacting particle systems studied in probability theory are the stochastic processes of hopping particles on a lattice consisting of slow particles and fast particles, where the switching between these two types of particles happens randomly with a given transition rate. In the present paper, we show that such stochastic processes of many particles are useful in modeling of group be-

haviors of ants. Recently the situation-depending switching between two distinct types of primarily relied cues for ants in selecting foraging paths has been experimentally studied by the research group of Prof. H. Nishimori (Meiji University). We propose the interacting random-walk models in which two kinds of hopping rules are included. We report the numerical simulation results which exhibit the global changes of path patterns depending on the model parameters controlling the switching. By introducing two kinds of order parameters, we discuss such global changes as phase transitions realized in path selections of ants.

Saori MORIMOTO (Chuo)

Classifications and Generalizations of Traffic Flow Models in Statistical Mechanics

One of the most serious issues in modern society is a traffic jam. Starting from a simple cellular automaton (CA) model named Rule-184, a series of improvements of traffic flow models have been reported in statistical mechanics. The main purpose of the improvements was to reproduce the fundamental diagram (the density-flow diagram) obtained by empirical data. Following 'a general stochastic traffic CA model' proposed by Sakai et al. (J. Phys. A: Math. Gen. **39** (2006) 15327), I have programmed in Python my own 'generalized CA model' which includes the quick-start model and the slow-to-start model. In the preset talk, I will explain a variety of models and demonstrate the numerical simulations showing dependence of the obtained fundamental diagrams on the parameters of my model. I expect that the traffic flow models studied so far can be classified into two categories by the following two factors: drivers' individual factor and the eivironmental factor.