Workshop 'Fluctuation and Correlation in Stochastic Systems'
October 15, 2014
Room 3300, Faculty of Science and Engineering, Building No.3 (3rd floor),
Chuo University (Korakuen Campus)

Organizers: Makoto KATORI (Chuo), Hiroyuki SUZUKI (Chuo),
Kazumasa A. TAKEUCHI (Tokyo), Tomohiro SASAMOTO (Tokyo Inst. Tech.)

PROGRAM (version 1: 22/Sept/2014)

9:50-9:55 **Makoto KATORI (Chuo Univ.)**
Opening address

10:00-10:30 **Takashi IMAMURA (Chiba Univ.)**
Combinatorial identities in the KPZ replica analysis

10:40-11:10 **Saburo KAKEI (Rikkyo Univ.)**
Hirota bilinear method and Hermite ensemble

11:20-11:50 **Shinsuke M. NISHIGAKI (Shimane Univ.)**
Individual eigenvalue distributions for chGSE-chGUE crossover and low-energy constants in SU(2) × U(1) gauge theory

12:00-12:30 **Shinsuke M. NISHIGAKI (Shimane Univ.)**
Critical statistics at the mobility edge of QCD Dirac spectra

[12:40-14:00 lunch]

14:00-14:30 **Grégory SCHEHR (Paris-Sud, CNRS)**
The number of distinct and common sites visited by N random walkers

14:40-15:10 **Grégory SCHEHR (Paris-Sud, CNRS)**
The maximal height of N non-intersecting Brownian motions till their survival

[15:20-15:40 coffee break]

15:40-16:10 **Jun-ichi WAKITA (Chuo Univ.)**
Collective behavior of bacterial cells in interfacial environment

16:20-16:50 **Kazumasa A. TAKEUCHI (Univ. of Tokyo)**
Weak ergodicity breaking in KPZ-class interfaces

17:00-17:30 **Tomohiro SASAMOTO (Tokyo Inst. Tech.)**
Spectral theory for a q-boson zero range process and its generalization

[18:00- Banquet] at Room 3507 (5th floor of the same building)

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ABSTRACTS

Takashi IMAMURA (Chiba Univ.)

Combinatorial identities in the KPZ replica analysis

Recently much progress has been made on studies of height fluctuation properties in the one-dimensional Kardar-Parisi-Zhang(KPZ) equation and related integrable discrete models. In particular, the replica method of the KPZ equation is a powerful approach to get exact height distribution functions. In this method combinatorial identities play a crucial role: by them sum of messy terms is miraculously factorized. In this talk we discuss some of these identities and their role in the analyses of the KPZ equation and related models.

Saburo KAKEI (Rikkyo Univ.)

Hirota bilinear method and Hermite ensemble

It was shown that a Fredholm determinant associated with the Hermite ensemble is related to a particular solution of the fourth Painleve equation (Tracy-Widom, 1994). In this talk, we reconsider this problem from the viewpoint of Hirota's bilinear method in soliton theory.

Shinsuke M. NISHIGAKI (Shimane Univ.)

Individual eigenvalue distributions for chGSE-chGUE crossover and low-energy constants in SU(2) × U(1) gauge theory

We evaluate individual distributions of four smallest eigenvalues from chiral random matrix ensembles interpolating chGSE and chGUE by the quadrature method applied to the Fredholm Pfaffian of dynamical Bessel kernel containing a crossover parameter. These distributions are then fitted with the staggered Dirac spectra of the quenched SU(2) lattice gauge theory in the presence of fluctuating or constant U(1) fields. Combination of the four best-fitting crossover parameters from matching each random matrix theory prediction to the corresponding histogram of the k-th Dirac eigenvalue allows for an efficient and precise determination of low-energy constants F and Σ in the chiral Lagrangian of Nambu-Goldstone bosons on the coset space $\mathrm{SU}(2n)/\mathrm{Sp}(2n)$ from relatively small lattices.

Shinsuke M. NISHIGAKI (Shimane Univ.)

Critical statistics at the mobility edge of QCD Dirac spectra

We examine statistical fluctuation of eigenvalues from the near-edge bulk of QCD Dirac spectra above the critical temperature. We start by reviewing on the scale-invariant intermediate spectral statistics at the mobility edge of Anderson tight-binding Hamiltonians. By fitting the level spacing distributions, Stieltjes-Wigert random matrix ensembles are shown to provide an excellent effective description for such a critical statistics. Next we carry over the above strategy for the Anderson Hamiltonians to the Dirac spectra. For the staggered Dirac operators of QCD with 2+1 flavors of dynamical quarks at the physical point and of SU(2) quenched gauge theory, we identify the precise location of the mobility edge as the scale-invariant fixed point of the level spacing distribution. The eigenvalues around the mobility edge are shown to obey critical statistics described by the aforementioned deformed random matrix ensembles of unitary and symplectic classes.

Grégory SCHEHR (Paris-Sud, CNRS)

The number of distinct and common sites visited by N random walkers

I will present an analytical study of the number of distinct sites $S_N(t)$ and common sites $W_N(t)$ visited by N independent one dimensional random walkers, all starting at the origin, after t time steps. One can show that these two random variables can be mapped onto extreme value quantities associated to N independent random walkers. Using this mapping, one computes exactly their probability distributions $P_N^d(S,t)$ and $P_N^c(W,t)$ for any value of N in the limit of large time t, where the random walkers can be described by Brownian motions. In the large N limit, $P_N^d(S,t)$ and $P_N^c(W,t)$ are described by non trivial scaling functions which are computed exactly.

Grégory SCHEHR (Paris-Sud, CNRS)

The maximal height of N non-intersecting Brownian motions till their survival

I will consider N Brownian particles moving on a line starting from initial positions $\boldsymbol{u} \equiv \{u_1, u_2, \dots u_N\}$ such that $0 < u_1 < u_2 < \cdots < u_N$. Their motion gets stopped at time t_s when either two of them collide or when the particle closest to the origin hits the origin for the first time. For $N = 2$, I will present an exact computation of the probability distribution function $p_1(m|\boldsymbol{u})$ and $p_2(m|\boldsymbol{u})$ of the maximal distance travelled by the 1^{st} and 2^{nd} walker till t_s. For general N particles with identical diffusion constants D, one can show that the probability distribution $p_N(m|\boldsymbol{u})$ of the global maximum m_N, has a power law tail $p_i(m|\boldsymbol{u}) \sim N^2 B_N \mathcal{F}_{\mathcal{N}}(\boldsymbol{u})/m^{\nu_N}$ with exponent $\nu_N = N^2 + 1$. I will present explicit expressions of the function $\mathcal{F}_{\mathcal{N}}(\boldsymbol{u})$ and of the N dependent amplitude B_N which can be analyzed for large N using techniques borrowed from random matrix theory.

Jun-ichi WAKITA (Chuo Univ.)

Collective behavior of bacterial cells in interfacial environment

Collective behavior of biological organisms is generally considered to be complex, since individual organisms are supposed to behave in complex ways. However, that of unicellular organisms such as bacterial cells may be not so complex under some conditions. Bacterial colony formation on agar plate surface is an example, since the colonies expand their territories simply by the motility and the multiplication of individual cells. Although some characteristic types of colony patterns have been found about bacterial species *Bacillus subtilis, Proteus mirabilis, Serratia marcescens* and *Escherichia coli* by changing agar and nutrient concentrations, it is expected that they can be understood from a physical view point through the variances of cell motility and cell multiplication. While collective behavior of bacterial cells in a two-dimensional circular pool which is not so large compared with the size of bacterial cells is another example. We have investigated the collective behavior of *Bacillus subtilis* by varying cell size and cell density. Then the behavior has been found to be classified into six distinct types: rotational motion with randomness, rotational laminar flow (single layer), rotational laminar flow (two layers), turbulent flow, intermittent motion and random motion. Furthermore, not the cell sizes but the ratios of an averaged cell size to a pool size have been found to be essential for the collective behavior of bacterial cells.

Kazumasa A. TAKEUCHI (Univ. of Tokyo)

Weak ergodicity breaking in KPZ-class interfaces

The last fifteen years have witnessed remarkable progress on the (1+1)-dimensional KPZ class: some universal fluctuation properties of growing interfaces, especially their height distribution and spatial correlation, were derived rigorously and confirmed experimentally. Yet the same level of understanding is not reached on their time correlation, mainly because of the absence of exact expressions. Here I show, on the basis of experiments on turbulent liquid crystal, that time correlation is similarly intriguing, showing qualitatively different behavior between flat and circular interfaces. I will argue that the notion called weak ergodicity breaking may be a key concept to resolve this difference, and present an ongoing attempt in this direction. This is joint work with Takuma Akimoto in Keio University.

Tomohiro SASAMOTO (Tokyo Inst. Tech.)

Spectral theory for a q-boson zero range process and its generalization

The q-boson totally asymmetric zero range process (q-TAZRP) is a discretization of the KPZ equation. We develop a spectral theory for this process and explain how one can obtain the current distribution. We also discuss a few generalization.