27th Rencontres ITZYKSON : Fluctuations far from Equilibrium

Report of Contributions

https://indico.in2p3.fr/e/29430

Contribution ID: **2** Type: **not specified**

Julien BARRÉ - From interacting particles to fluctuating hydrodynamics with Large Deviations

Friday, June 2, 2023 3:00 PM (45 minutes)

To derive a macroscopic description of a system (in terms of hydrodynamical fields), starting from a microscopic one (in terms of interacting particles), the usual route introduces an intermediate kinetic equation, and takes advantage of the difference of time scales between fast and slow modes to set up a Chapman-Enskog expansion. When finite size effects are important at the macroscopic level, they are taken into account by adding a noise on the hydrodynamical equations, often in an empirical way. We will explain how this whole procedure can be carried out at the level of large deviations functionals, taking the classical example of incompressible Navier-Stokes equations.
In the compressible case, the macroscopic equations are ballistic at leading order. The large deviation structure is more complicated and we will describe a first attempt to understand it using simpler 1D models.

Presenter: BARRÉ, Julien (Institut Poisson, Université d'Orléans)

Contribution ID: **3** Type: **not specified**

Olivier BÉNICHOU - Generalized density profiles in single-file systems

Thursday, June 1, 2023 10:15 AM (45 minutes)

Single-file transport, where particles diffuse in narrow channels while not overtaking each other, is a fundamental model for the tracer subdiffusion observed in confined systems, such as zeolites or carbon nanotubes. This anomalous behavior originates from strong bath-tracer correlations in 1D, which have however remained elusive, because they involve an infinite hierarchy of equations.

For the Symmetric Exclusion Process, a paradigmatic model of single-file diffusion, this hierarchy of equations can in fact be broken, and the bath-tracer correlations satisfy a closed equation, which can be solved. I will suggest that this equation appears as a novel tool for interacting particle systems, since it also applies to out-of equilibrium situations, other observables and other representative single-file systems.

Presenter: BÉNICHOU, Olivier (Sorbonne Université)

Contribution ID: **4** Type: **not specified**

Denis BERNARD - Coherences and fluctuations in noisy mesoscopic systems & Q-SSEP

Wednesday, May 31, 2023 5:00 PM (45 minutes)

An alternative title could have been "How to characterise fluctuations in diffusive out-of-equilibrium many-body quantum systems?"In general, the difficulty to characterise non-equilibrium systems lies in the fact that there is no analog of the Boltzmann distribution to describe thermodynamic variables and their fluctuations. Over the last 20 years, however, it was observed that fluctuations of diffusive transport show universal properties that do not depend on the microscopic details. The general framework to characterise these systems from a macroscopic point of view is now called the "Macroscopic Fluctuation Theory". A natural question is whether this framework can be extended to quantum mechanics to describe the statistics of purely quantum mechanical effects such as interference or entanglement in diffusive out-of-equilibrium systems. With this aim in mind, I will introduce the Quantum Symmetric Simple Exclusion Process (Q-SSEP), a microscopic model system of fluctuating quantum diffusion, and present in particular the recent observation that fluctuations of coherences in Q-SSEP have a natural interpretation as free cumulants, a concept from free probability theory, and heuristic arguments why we expect free probability theory to be an appropriate framework to describe coherent fluctuations in generic mesoscopic systems.

Presenter: BERNARD, Denis (ENS Paris)

Contribution ID: **5** Type: **not specified**

Thierry BODINEAU- Large deviations for out of equilibrium correlations in the symmetric simple exclusion process

Thursday, June 1, 2023 9:30 AM (45 minutes)

For finite size Markov chains, the Donsker-Varadhan theory fully describes the large deviations of the time averaged empirical measure. In this talk, we consider the large size asymptotics of the Donsker-Varadhan functional associated with the one-dimensional symmetric simple exclusion process connected with reservoirs at different densities. The Donsker-Varadhan functional encodes a variety of scales depending on the observable of interest. We will focus on the time-averaged two point correlations and investigate the probability of observing atypical two point correlations for a long time.

Joint work with B. Dagallier

Presenter: BODINEAU, Thierry (IHES)

Contribution ID: **6** Type: **not specified**

Bernard DERRIDA - At the transition between pulled and pushed fronts

Wednesday, May 31, 2023 12:15 PM (45 minutes)

The shift of the position of a front found by Bramson in the case of the Fisher-KPP equation is modified at the transition between pulled and pushed fronts. Based on an exactly solvable case, one can predict the cross-over function which determines this shift near this transition. The correction due to a cut-off is also modified at this transition. This raises the question of whether the cut-off approximation still describes accurately the effect of a weak noise of the stochastic PDE.

B Derrida J. Stat. Phys. 2023

Presenter: DERRIDA, Bernard (Collége de France)

Contribution ID: **7** Type: **not specified**

Benjamin DOYON - Ballistic macroscopic fluctuation theory and long-range correlations

Friday, June 2, 2023 9:30 AM (45 minutes)

Evaluating fluctuations and correlations at large scales of space and time in quantum and classical many-body systems, in and out of equilibrium, is one of the most important problems of emergent physics. I will explain how basic hydrodynamic principles give access to exact results at the ballistic scale, solely from the data of the Euler-scale hydrodynamic equations of the many-body system. This is based on a new theory that we developed recently (with G. Perfetto, T. Sasamoto and T. Yoshimura), dubbed the ballistic macroscopic fluctuation theory"(BMFT), an adaptation of the well-known macroscopic fluctuation theory that has been very successful for purely diffusive systems. A surprising result from the BMFT is that generically, long-range spatial correlations develop over time if the initial state of the many-body system is spatially inhomogeneous. Therefore, thefluid cells"of Euler hydrodynamics are in fact generically correlated amongst each other, something which had not been appreciated before. I will give examples of integrable systems based on generalised hydrodynamics, and present numerical confirmations of the results in the hard rod gas.

Presenter: DOYON, Benjamin (King's College)

Contribution ID: **8** Type: **not specified**

Davide GABRIELLI - Hidden Temperature in the Kipnis-Marchioro-Presutti model

Wednesday, May 31, 2023 4:15 PM (45 minutes)

Stationary non equilibrium states (SNS) have a rich and complex structure. The large deviations rate functionals for the empirical measure of a few one dimensional SNS of stochastic interacting systems have been computed, among wich the exclusion process and the Kipnis-Marchioro-Presutti (KMP) model. The corresponding rate functionals are not local due to the presence of long range correlations. We show for the KMP model that this can be explained introducing new variables that can be interpreted naturally as the temperatures of the oscillators that are exchanging the energies. When two oscillators exchange energy they thermalize at the same time. We deduce that the invariant measure of the KMP model is a mixture of inhomogeneous product of exponential distributions, the law of the mixture is the invariant measure of the auxiliary temperature process. Joint work with Anna De Masi and Pablo Ferrari.

Presenter: GABRIELLI, Davide (DISIM, La Aquila)

Contribution ID: **9** Type: **not specified**

Patricia GONÇALVES - Universal fluctuation limits in multi-species exclusion

Friday, June 2, 2023 10:15 AM (45 minutes)

In this talk, I will present a model which was introduced in [1] and consists of an exclusion process with different types of particles, let us say types A, B, and C. Depending on the interaction rate between different types of particles, the limiting fluctuations end up in different universality classes: either the fluctuations are governed by energy solutions of the stochastic Burgers equation or by the Ornstein-Uhlenbeck equation. These results match the predictions from the non-linear fluctuating hydrodynamics of Spohn, Schutz, and collaborators. (Joint with G. Cannizzaro; A. Occelli, R. Misturini.)
[1] Schuetz, Wehefritz-Kaufmann: Kardar-Parisi-Zhang modes in d-dimensional directed polymers, Phys. Rev. E 96, 032119 (2017).

Presenter: GONÇALVES, Patricia (IST, Lisbon University)

Contribution ID: **11** Type: **not specified**

Jorge KURCHAN - A gift from Lie algebras to transport problems: hidden equilibrium, duality and extensions to the quantum case.

Thursday, June 1, 2023 2:15 PM (45 minutes)

A family of transport models, including the better understood ones, may be mapped onto a dual model that is simpler,
or directly to an equilibrium problem. These properties, unrelated to integrability, are easily understood once one uncovers the group structure
behind them. This structure also allows one to extend the constructions to the quantum case, with minimal mental effort.

Presenter: KURCHAN, Jorge (ENS Paris)

Contribution ID: **12** Type: **not specified**

Joel LEBOWITZ - The Structure Function of Random Point Processes: Fluctuations and Rigidity

Thursday, June 1, 2023 4:15 PM (45 minutes)

We consider a translation invariant point process in R^d or Z^d. Let V(N_B) be the variance in the number of points, N_B, in a ball B of volume |B|. Generally, such as when particles with short range interactions are distributed according to a Gibbs measure, V(N_B)/|B| >0.

There are however many interesting cases when Var(N_B)/N_B->0, as |B|->oo. Such processes are called hyperuniform (or superhomogeneous)

This occurs when the structure function S(k), the Fourier transform of the “full” pair correlation function, G(r)=ndelta(r)+n^2[g(r)-1], n being the density, which is always non-negative, vanishes at k=0, S(k)=0. Just how fast V(N_B)/|B| goes to zero depends on the way S(k) behaves as k->0.

I will discuss examples of such hyperuniform systems both old (Coulomb systems) and recent (facilitated exclusion processes).

When S(k) vanishes in an open set M in k-space (which may or may not include the origin) the system is maximally “rigid”. Rigidity describes the amount of information about the points in B given the configuration of points outside B. This can be zero as in a Poisson process or “maximal” where the exact position of the points in B are determined by the configuration outside B.

Such systems also have other “crystaline” properties. (This is joint work with Subhro Gosh)

Presenter: LEBOWITZ, Joel (Rutgers)

Contribution ID: **13** Type: **not specified**

Pierre LE DOUSSAL / Alexandre KRAJENBRINK - Large deviations for diffusion in random media: integrable crossover from macroscopic fluctuation theory to weak noise KPZ equation.

Friday, June 2, 2023 12:15 PM (45 minutes)

The large deviations for the diffusion of a tracer in a 1D time dependent medium can be described, on diffusive scales,
by the macroscopic fluctuation theory (MFT).
The corresponding MFT variational equations are mapped to the integrable derivative non-linear Schrodinger
equation. We provide a solution using inverse scattering methods, and obtain the large deviation rate function
for the sample to sample fluctuation of the probability of the tracer position.
Furthermore by varying the position of the tracer, i.e. the asymmetry, we uncover the
full integrable crossover from the MFT to the weak noise theory of the KPZ equation, matching our previous results for the latter problem.

Based on
Krajenbrink, A., & Le Doussal, P. (2023). Crossover from the macroscopic fluctuation theory to the Kardar-Parisi-Zhang equation controls the large deviations beyond Einstein's diffusion. Physical Review E, 107(1), 014137.

Presenter: LE DOUSSAL, Pierre (ENS Paris)

Contribution ID: **14** Type: **not specified**

Satya MAJUMDAR - Time at which a stochastic process achieves its maximum

Friday, June 2, 2023 2:15 PM (45 minutes)

For any stochastic time-series of duration T, the time t_max at which the process achieves its maximum is an important observable. For example, for a stock price over a trading period T, one would like to sell the stock at the time when the price is maximal. I'll discuss the statistics of t_max for a variety of stochastic processes. In particular, for a large class of stationary processes, both in and out of equilibrium systems, we show that the distribution of t_max over [0,T] exhibits a universal edge behavior (near 0 and T).

Presenter: MAJUMDAR, Satya (LPTMS-Saclay)

Contribution ID: **15** Type: **not specified**

Baruch MEERSON - Fluctuations of "Brownian bees" and of some other interacting particle systems with reset

Friday, June 2, 2023 3:45 PM (45 minutes)

The "Brownian bees"model, suggested by J. Berestycki, E. Brunet, J. Nolen, and S. Penington, is a new member of a family of Brunet-Derrida particle systems which mimic some aspects of biological selection. Like other Brunet-Derrida systems, the Brownian bees can be also considered as a system of interacting particles with reset. The model describes an ensemble of N independent branching Brownian particles. When a particle branches into two particles, the particle farthest from the origin is eliminated so as to keep the number of particles constant. In the limit of N $\to\infty$, the coarse-grained particle density is governed by the solution of a free boundary problem for a simple reaction-diffusion equation. At long times the particle density approaches a spherically symmetric steady-state solution with a compact support. We studied fluctuations of the "swarm of bees"due to the random character of the branching Brownian motion in the limit of large but finite N, and we focused on the fluctuations of the swarm radius l(t) in 1d [1]. We found that the autocorrelation function of l(t) in the steady state, g(τ), exhibits a logarithmic scaling with τ=t1-t2, which corresponds to a 1/f noise in the frequency domain. The variance of l(t) exhibits an anomalous scaling (1/N) ln N with N. These anomalies appear because a broad range of spatial scales contribute to the fluctuations. I will also briefly consider another model - an N-particle system with reset of the farthest particle to the origin [2] - which shares these anomalies.

[1] M. Siboni, P. Sasorov and B. Meerson, Fluctuations of a swarm of Brownian bees. Phys. Rev. E 104, 054131 (2021).
[2] O. Vilk, M. Assaf and B. Meerson, Fluctuations and first-passage properties of systems of Brownian particles with reset. Phys. Rev. E 106, 024117 (2022).

Presenter: MEERSON, Baruch (Hebrew University, Jerusalem)

Contribution ID: **16** Type: **not specified**

David MUKAMEL - Local drive (a pump or a battery) in interacting diffusive systems

Wednesday, May 31, 2023 10:15 AM (45 minutes)

The long-range nature of the effect of a pump or a battery on an interacting diffusive fluid is discussed. It is shown that off criticality the pump generates long-range modulation in the density profile of the form of a dipolar electric potential and a current profile in the form of a dipolar electric field. The density profile is drastically modified when the fluid is at its critical point: here, in addition to the long-rage influence of the current generated by the battery, the fluid is dominated by its intrinsic long- range critical correlations. It is demonstrated that the resulting density profile is of the same form as that of a fluid in equilibrium but under the influence of dipolar ordering field. As a result, the density profile at criticality can be expressed in terms of the equilibrium critical exponents of the fluid. In contrast, the current is shown to retain it off critical dipolar field form.

Presenter: MUKAMEL, David (Weizmann Institute)

Contribution ID: **18** Type: **not specified**

Marielle SIMON - Hydrodynamic limit for a facilitated exclusion process

Wednesday, May 31, 2023 2:15 PM (45 minutes)

In this talk we will be interested in a one-dimensional exclusion process subject to strong kinetic constraints, which belongs to the class of cooperative kinetically constrained lattice gases. More precisely, its stochastic short range interaction exhibits a continuous phase transition to an absorbing state at a critical value of the particle density. In one dimension, and if the microscopic dynamics is symmetric, we will see that its macroscopic behavior, under periodic boundary conditions and diffusive time scaling, is ruled by a non-linear PDE belonging to free boundary problems (or Stefan problems). One of the ingredients is to show that the system typically reaches an ergodic component in subdiffusive time.
The asymmetric case can also be fully treated: in this case, considered on the infinite line, the empirical density converges to the unique entropy solution to a hyperbolic Stefan problem.

Based on joint works with O. Blondel, C. Erignoux, M. Sasada and L. Zhao.

Presenter: SIMON, Marielle (ENS-Lyon)

Contribution ID: **19** Type: **not specified**

Herbert SPOHN - Hydrodynamic scale of integrable many-particle systems

Thursday, June 1, 2023 12:15 PM (45 minutes)

Integrable many-particle systems arise in wide variety. To illustrate their generalized hydrodynamics, the Calogero fluid will be used as prime example. The fluid consists of classical particles moving on the line and interacting through the repulsive 1/sinh^2 pair potential. Discussed are generalized Gibbs ensembles, the corresponding random Lax matrix, its density of states, and GGE averaged currents.

Presenter: SPOHN, Herbert (TUM Munich University)

Contribution ID: **20** Type: **not specified**

Stefano OLLA - Diffusive behavior in completely integrable infinite dynamics

Wednesday, May 31, 2023 11:30 AM (45 minutes)

We investigate the macroscopic behaviour of the density fluctuations of a one dimensional dynamics of hard rods with random length. After recentering on the effective velocity the density fluctuations of particles of a given velocity v on the diffusive space-time scaling will evolve driven by a browian motion with a diffusivity depending on v. This rigid evolution of fluctuations is expected in other completely integrable systems (Box-Ball, Toda Lattice,..), in contrast with the behavior in chaotic dynamics where space-time white noise appears in the evolution equations. Joint work with Pablo Ferrari (U. Buenos Aires).

Presenter: OLLA, Stefano (Dauphine)

Contribution ID: **21** Type: **not specified**

Makiko SASADA - Axiomatization of the theory of hydrodynamic limits and its benefits

Thursday, June 1, 2023 3:00 PM (45 minutes)

Over the past 30 years, the hydrodynamic limit has been proved for many interacting particle systems. However, there are still many models for which rigorous proofs are missing, especially those called non-gradient models. Also, most of the existing results are for models on Z^d lattices with one conserved quantity. There has been no theory of how much existing theories can be generalized, and to do so, it is necessary to abstractly define the class of models to be covered and the several key concepts, such as “number of conserved quantities” and “gradient condition”. In this talk, I will introduce an abstract framework and definitions that set the stage for a general formulation of the hydrodynamic limit, and present results obtained in such a general setting, as well as some conjectures. Applications for specific models obtained by such a generalization will be also presented.

Presenter: SADADA, Makiko (Tokyo University)

Contribution ID: **22** Type: **not specified**

Hiroki MORIYA - Current fluctuation of diffusive models and classical integrability

Thursday, June 1, 2023 5:00 PM (45 minutes)

Over the last two decades, the macroscopic fluctuation theory has been developed and applied to various diffusive models to study large-scale fluctuations of physical quantities such as current. The equations of motion that the theory induces are in general quite difficult to solve under the appropriate mixed time boundary conditions. Fortunately, as long as the equations of motion belong to a certain class, the inverse scattering method (ISM) could be a powerful tool to solve them. Indeed, the current large deviation of the symmetric simple exclusion process (SEP) can be derived via the ISM when the initial state can fluctuate. This framework also allows us to study the current fluctuation of some diffusive models starting from the fixed initial condition. In particular, we discuss how to derive the higher cumulants of SEP.

Presenter: MORIYA, Hiroki (LPTMC)

Contribution ID: **23** Type: **not specified**

Percy DEIFT - Toda without Hamiltonian structure — the methodology of R.Leite, N.Saldanha, D.Torres and C.Tomei

Thursday, June 1, 2023 11:30 AM (45 minutes)

We describe an approach to the Toda lattice relying only on basis facts of linear algebra, making no use of symplectic geometry. This approach is due to Leite et al, and has many advantages, particularly to the analysis of the long-time behavior of solutions of the Toda lattice.

Presenter: DEIFT, Percy (Courant Institute, NYU)

Contribution ID: **24** Type: **not specified**

Gianni JONA-LASINIO - On the origin of the macroscopic fluctuation theory and some perspectives

Friday, June 2, 2023 11:30 AM (45 minutes)

The macroscopic fluctuation theory (MFT) is a consistent and self-contained description of macroscopic fluctuations using
only transport coefficients. In the formulation of the Rome group an important motivation was the discovery that we could reproduce by a purely macroscopic calculation the result of Derrida, Lebowitz and Speer obtained solving the microscopic symmetric simple exclusion process.
Then the MFT developed in several directions allowing a unified treatment of different physical problems where a
separation of scales is possible . Directions for future research include: i) extension of the MFT to the quantum case ; ii) the possible use of an additional Hamiltonian structure discovered on the way; iii) a formula which recalls Clausius view of entropy; iv) developing the recent work on the integrability of the time dependent MFT. Time permitting I will discuss some perspectives.

Presenter: JONA-LASINIO, Gianni (La Sapienza, Rome)

Contribution ID: **25** Type: **not specified**

Ivan LOBASKIN - Steady states of the matrix product type for driven tracers in a narrow channel: an easy case and a not-so-easy case

Wednesday, May 31, 2023 5:45 PM (45 minutes)

Single-file diffusion with a defect particle is fundamental to the understanding of driven tracers in narrow channels. In this talk, two variations on the simple exclusion process on a ring geometry are considered as minimal models of such a setup. The first variation is a totally asymmetric tracer in a bath of symmetric particles. The second variation is a defect particle with priority in a partially asymmetric process. The matrix product ansatz is used to solve the steady states of these models. Steady-state density profiles and currents are obtained. In particular, the asymptotic analysis of the second model reveals a phase diagram with uniform and shock-type density profiles.

I Lobaskin, M R Evans, J Stat Mech, 2020 (5) 053202

I Lobaskin, M R Evans, K Mallick, J Phys A, 2022 (20) 205002

Presenter: LOBASKIN, Ivan (Edinburgh University)

Contribution ID: **26** Type: **not specified**

Tomohiro SASAMOTO - Macroscopic fluctuation theory and classical integrable systems

Wednesday, May 31, 2023 3:00 PM (45 minutes)

Presenter: SASAMOTO, Tomohiro (TokyoTech)