Soutenances de Thèses 2022

Leonardo MAZZA

Vendredi 8 avril 2022 Grand amphithéâtre Bâtiment Pascal n° 530 **Soutenance Habilitation à diriger des recherches**

Topological matter and out-of-equilibrium physics in cold-atom setups

The study of ultra-cold gases is currently offering a new vision of many-body quantum physics. In this seminar I will briefly overview my recent contributions to the field, focusing on topological physics and out-of-equilibrium dynamics.

In the first part, motivated by the studies on the quantum Hall effect and Chern insulators with cold atoms, I will discuss my recent contributions on the fractional statistics of the quasiholes of several paradigmatic states, with a specific focus on Laughlin and Halperin wavefunctions. The goal is to show that it is possible to extract information on the statistics using only density-profile measurements and without resorting in any way to interference schemes.

In the second part of the talk I will discuss my contributions to the field of out-of-equilibrium dynamics of correlated quantum gases, focusing on the effect of two-body losses in one-dimensional setups. Motivated by recent experiments, I will show that losses can induced intriguing transient dynamics and even stabilize entangled stationary states. The strongly-dissipative limit, also known as quantum Zeno limit, lends itself to an insightful analytical description in terms of appropriate rate equations.

Jury : Isabelle Bouchoule (Institut d'Optique), Nigel R. Cooper (University of Cambridge), Mark O. Goerbig (LPS Orsay), Anna Minguzzi (LPMMC Grenoble), Sylvain Nascimbene (LKB, Collège de France), Tommaso Roscilde (ENS Lyon)

Francesco MORI

Vendredi 10 juin 2022 Petit amphithéâtre Bâtiment Pascal n° 530 **Soutenance de thèse**

Extreme value statistics of stochastic processes : from Brownian motion to active particles

Rare extreme events tend to play a major role in a wide range of contexts, from finance to climate. Hence, understanding their statistical properties is a relevant task, which opens the way to many applications. In this thesis, we investigate the extremal properties of several stochastic processes, including Brownian motion (BM), active particles, and BM with resetting. In the first part, we investigate the times at which extrema of one-dimensional stochastic processes occur. In particular, in the case of a BM of fixed duration, we compute the probability distribution of the time between the global maximum and the global minimum. Moreover, we derive the distribution of the time of the maximum for stationary stochastic processes, both at equilibrium and out-of-equilibrium. This analysis leads to the formulation of a simple criterion to detect nonequilibrium fluctuations in steady states. In the second part, we focus on the run-and-tumble particle (RTP) model. We compute exactly the survival probability for a single RTP in d dimensions, showing that this quantity is completely universal, i.e., independent of d and the speed fluctuations of the particle. We extend this universality to other observables (time of the maximum and records) and generalized RTP models. Moreover, we also investigate the position distribution of a single RTP at late times. We show that, under certain conditions, a condensation transition can be observed in the large-deviation regime where the particle is far from its starting position. Finally, we introduce a new technique, analog to the Hamilton-Jacobi-Bellman equation, to optimally control a dynamical system through stochastic resetting.

Jury : Satya Majumdar (directeur de thèse), David Dean (rapporteur), Matteo Marsili (rapporteur), Martin Evans, Joachim Krug, Cécile Monthus, Grégory Schehr, Raphaël Voiturier

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Félix BENOIST

Mercredi 28 septembre 2022
Petit amphithéâtre Bâtiment Pascal n° 530 **Soutenance de thèse**

Complex Materials : Frustrated Self-Assembly and Nonlinear Elasticity

This thesis is divided into two parts with little overlap. The first part deals with the pathological self-assembly of normally soluble proteins. In a number of cases, they tend to form "frustrated" aggregates which grow only in one direction. We hereby study the shape and size of the equilibrium clusters formed by particles with directional interactions. This investigation hopefully leads to a better understanding of the underlying mechanism of fiber-formation.The second part focuses on the transmission of internal stresses in complex materials such as biological fiber networks and granular matter. We develop a continuum model of such materials, which accounts for the measured asymmetry in their response to tension versus compression. We show analytically and numerically that this may lead fibrous networks to rectify internal stresses towards contraction, and granular media to rectify towards expansion.

Jury : Martin Lenz (directeur de thèse), Haim Diamant, Benoît Roman, Andela Saric, Yair Shokef

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Pierre MERGNY

Mercredi 12 octobre 2022
CFM, 23 rue de l'Université 75007 Paris **Soutenance de thèse**

Spherical integrals and their applications to random matrix theory

Random matrix theory has found applications in many fields of physics (disordered systems, stability of dynamical systems, interface models, electronic transport,…) and mathematics (operator algebra, enumerative combinatorics, number theory,…). A recurrent problem in many domains is understanding how the spectra of two random matrices recombine when we perform their sum or product. In this thesis, we study this problem through the prism of spherical integrals and with the help of statistical physics tools. These spherical integrals play the role of the Fourier transform in random matrix theory and their study allows us to understand better the properties of both the limiting spectral density and the largest eigenvalue of these matrix models.

Jury : Marc Potters (directeur de thèse), Satya Majumdar (co-directeur de thèse), Adam W. Marcus, Pierpaolo Vivo, Florent Benaych-Georges, Giulio Biroli, Alice Guionnet, Jorge Kurchan.

Lorenzo GOTTA

Mardi 8 novembre 2022
Petit amphithéâtre Bâtiment Pascal n° 530 **Soutenance de thèse**

Pairing and two-fluid physics in low-dimensional quantum systems

The present thesis deals mainly with the ground-state properties of quantum many-body systems of spinless fermions that display bound-state formation. We start by discussing the pairing phenomena induced by density-density interactions, showing that extending the range of the latter can lead to the observation of exotic Luttinger liquid phases with cluster granularity. We continue the study of pairing in a one-dimensional chain of spinless fermions where single-particle hopping competes with a correlated pair-hopping interaction. We unveil a novel transition from a weak-coupling Luttinger liquid phase to a paired Luttinger liquid phase, that occurs through an intervening phase where a liquid of isolated fermions coexists with a liquid of pairs without phase separation. We confirm the stability of this novel coexistence phase against the addition of a weak nearest-neighbor density-density interaction, which is shown to induce instead phase separation between paired and unpaired fermions in the strong-coupling regime. Finally, we generalize the pair-hopping term to a generic multimer-hopping term, thereby proving the robustness of the coexistence phase as the generic transition scenario between a Luttinger liquid with single-particle granularity and one with molecular granularity. We conclude by showing that models of spinless fermions featuring pair-hopping can host quantum many-body scars, thus opening further routes towards the study of weak ergodicity breaking in isolated many-body quantum systems.

Jury : Leonardo Mazza (co-directeur de thèse), Guillaume Roux (co-directeur de thèse), Pascal Simon (co-directeur de thèse), Karyn Le Hur, Guido Pupillo, Jonathan Ruhman, Oded Zilberberg