Soutenances de Thèses 2020

Thibault Bonnemain

24 fevrier 2020
LPTM, universite Cergy Pontoise

Soutenance de thèse

Quadratic mean field games with negative coordination

Mean Field Games provide a powerful theoretical framework to deal with stochastic optimization problems involving a large number of coupled subsystems. They can find application in several fields, be it finance, economy, sociology, engineering … However, this theory is rather recent and still poses many challenges. Its constitutive equations, for example, are difficult to analyse and the set of behaviours they highlight are ill-understood. While the large majority of contributions to this discipline come from mathematicians, economists or engineering scientists, physicist have only marginally be involved in it. In this thesis I try and start bridging the gap between Physics and Mean Field Games through the study of a specific class of models dubbed « quadratic ».

Directeurs : Denis Ullmo, Thierry Gobron

Jury : Cecile Appert-Rolland, Olivier Gueant, Max-Olivier Hongler, Jean-Pierre Nadal, Filippo Santambrogio

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Samuel Cazayus-Claverie

25 fevrier 2020
Petit amphitheatre, batiment Pascal

Soutenance de thèse

Effect of residual stress on the elasticity of fiber networks

Cells are the basic units of all living organisms. Eukaryotic cells are stuctured on top of a scaffold of fibers ranging from stiff microtubules to semiflexible actin : the cytoskeleton. As such the cytoskeleton is involved into a broad family of processes of translocation and deformation of cells, it is also responsible for cells mechanical stiffness. The actin filaments into cytoskeleton can be cross-linked into bundles built of as much as 30 parallel filaments, but filaments can get bound at a finite angle also. These processes are in competition during network's self-assembly and result in strong residual stresses. In this thesis, we study the effect of these residual stresses on the elasticity of fiber networks in 2 dimensions of space. We develop an original method to compute stress on the boundaries of a network and its elastic moduli. We find that residual stress induces a stiffening in the infinitesimal response of the network. Residual stress also affects the non linear response of the network : we find that it makes the network unstable under compression, and that they control the onset of non linear response to shear.

Directeur : Martin Lenz

Jury : Anael Lemaitre, Chaouqi Misbah, Giuseppe Foffi, Cecile Leduc, Raphael Voituriez

Giampaolo Folena

10 mars 2020
Universite de Rome, La Sapienza

Soutenance de thèse

The mixed p-spin models: selecting, following, and losing states

The main driving notion behind my thesis research is to explore the connection between the dynamics and the static in a prototypical model of glass transition, i.e. the mean-field p-spin spherical model. This model was introduced more than 30 years ago with the purpose of offering a simplified model that had the same equilibrium dynamical slowing down, theoretically described a few years earlier by mode-coupling theory. Over the years, the p-spin spherical model has shown to be a very meaningful and promising model, capable of describing many equilibrium and out-of-equilibrium aspects of glasses. Eventually it came to be considered as a prototypical model of glassiness. Having such a simple but rich reference model allows a coherent examination of a subject, in our case the glass behavior, which presents a very intricate phenomenology. Thus, the main purpose is not to have a quantitative prediction of the phenomena, but rather a broader view with a strong analytical basis. In this sense the p-spin model has assumed a role for disordered systems which is comparable to that of the Ising model for understanding ferromagnetism. My research is a natural path to reinforce our knowledge and comprehension of this model.

Directeurs : Silvio Franz, Federico Ricci-Tersenghi

Jury : Luca Leuzzi, Chiara Cammarota, Patrick Charbonneau, Florent Krzakala, Luca Dall'Asta, Pierfrancesco Urbani

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Mathieu Isoard

10 septembre 2020
Grand amphithéâtre, batiment Pascal

Soutenance de thèse

Theoretical study of quantum correlations and nonlinear fluctuations in quantum gases

This thesis is dedicated to the study of nonlinear-driven phenomena in two quantum gases which bear important similarities: Bose-Einstein condensates of ultracold atomic vapors and paraxial nonlinear laser beam.

These systems can be described within a hydrodynamic framework which make it possible to investigate their short and long time propagation by means of mathematical methods developed by Riemann and Whitham. In particular, we study the formation and the propagation of dispersive shock waves which arise after a wave breaking event. We obtain a kind of a weak shock theory, from which we can extract a quantitative description of experimentally relevant parameters, such as the velocity of the solitonic edge of the shock or the contrast of its fringes.

In a second part, we study sonic analogues of black holes. In a Bose-Einstein condensate, it is possible to implement a stationary configuration with a current flowing from a subsonic region to a supersonic one. This mimics a black hole, since sonic excitations cannot escape the supersonic region. Besides, quantizing the phonon field leads to a sonic analogue of Hawking radiation. In this thesis, we have shown that a correct account of zero modes is essential for an accurate description of the Hawking process, and results in a excellent comparison with recent experimental datas. In addition, we characterize the entanglement shared among quantum excitations and show that they exhibit tripartite entanglement.

Directeur : Nicolas Pavloff

Jury : Matteo Conforti, Patrik Öhberg, Élisabeth Giacobino, Sandro Stringari, Chris Westbrook

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Sebastian Grijalva

15 octobre 2020
Grand amphithéâtre, bâtiment Pascal

Soutenance de thèse

Boundary effects in Quantum Spin Chains and Finite-Size Effects in the Toroidal Correlated Percolation model

This thesis is divided in two parts: The first one presents a 2D statistical model of correlated percolation on a toroidal lattice. We present a protocol to construct long-range correlated surfaces based on fractional Gaussian surfaces and then we relate the level sets to a family of correlated percolation models. The emerging clusters are then numerically studied, and we test their conformal symmetry by verifying that their finite-size corrections follow the predictions of Conformal Field Theory. We also provide numerical details to produce the results.

The second part studies the quantum integrable XXZ spin-1/2 chain with open boundary conditions for even and odd number of sites. We concentrate in the anti-ferromagnetic regime and use the Algebraic Bethe Ansatz to determine the ground state configurations that arise in terms of the boundary fields. We find the conditions of existence of quasi-degenerate ground states separated by a gap to the rest of the spectrum. We calculate the boundary magnetization at zero temperature and find that it depends on the field at the opposite edge even in the semi-infinite chain limit. We finally calculate the time auto- correlation function at the boundary and show that in the even-size case it is finite for the long-time limit as a result of the quasi-degeneracy.

Directeurs : Véronique Terras, Raoul Santachiara

Jury : Christian Hagendorf, Jacopo De Nardis, Nikolai Kitanine, Karol Kozlowski, Vincent Pasquier, Pierre Pujol

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Nina Javerzat

20 octobre 2020
Grand amphithéâtre, bâtiment Pascal

Soutenance de thèse

New conformal bootstrap solutions and percolation models on the torus

The geometric properties of critical phenomena have generated an increasing interest in theoretical physics and mathematics over the last thirty years. Percolation-type systems are a paradigm of such geometric phenomena, their phase transition being characterised by the behaviour of non-local degrees of freedom: the percolation clusters. At criticality, these clusters are examples of random objects with a conformally invariant measure. Even in the simplest model, uncorrelated percolation, important universal properties remain out of reach, in particular the connectivity properties −the probabilities that points are connected by clusters.

In two dimensions, the presence of conformal symmetry has especially important implications, which can be exploited to obtain a complete determination of the universality classes. We will present results on the universal properties of two families of long-range correlated percolation models, obtained using a conformal bootstrap approach and the study of the clusters connectivities on a torus topology.

The first family is the random cluster Q− state Potts model, whose conformal field theory is not yet −albeit almost, fully solved today. We test conjectures on this conformal field theory by computing the finite size effects induced on the connectivities by the torus topology, and comparing with numerical measurements.

The second family is obtained from the excursion sets of fractional Gaussian surfaces. We use conformal field theory predictions on the torus cluster connectivities, together with numerical simulations, to establish the conformal invariance of these systems, and obtain the first features of this new conformal field theory.

Directeur : Raoul Santachiara

Jury : Bertrand Duplantier, Malte Henkel, Eveliina Peltola, Marco Picco, Silvain Ribaud, Erik Tonni, Jacopo Viti

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Hao Pei

14 decembre 2020
Online, bâtiment Pascal

Soutenance de thèse

Separation of Variables and Correlation Functions of Quantum Integrable Systems

The aim of this thesis is to develop an approach for computing correlation functions of quantum integrable lattice models within the quantum version of the Separation of Variables (SoV) method. SoV is a powerful method which applies to a wide range of quantum integrable models with various boundary conditions. Yet, the problem of computing correlation functions within this framework is still widely open. Here, we more precisely consider two simple models solvable by SoV: the XXX and XXZ Heisenberg chains of spins 1/2, with anti-periodic boundary conditions, or more generally quasi-periodic boundary conditions with a non-diagonal twist. We first review their solution by SoV, which present some similarities but also crucial differences. Then we study the scalar products of separate states, a class of states that notably contains all the eigenstates of the model. We explain how to obtain convenient determinant representations for these scalar products. We also explain how to generalize these determinant representations in the case of form factors, i.e. of matrix elements of the local operators in the basis of eigenstates. These form factors are of particular interest for the computation of correlation functions since all correlation functions can be obtained as a sum over form factors. Finally, we consider more general elementary building blocks for the correlation functions, and explain how to recover, in the thermodynamic limit of the model, the multiple integral representations that were previously obtained from the consideration of the periodic models by algebraic Bethe Ansatz.

Directeur : Véronique Terras

Jury : Christian Hagendorf, Nikolai Kitanine, Karol Kozlowski, Vincent Pasquier, Eric Ragoucy

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Antonio Sclocchi

17 decembre 2020
Online, bâtiment Pascal

Soutenance de thèse

A new critical phase in jammed models: jamming is even cooler than before

Over the last two decades, an intensive stream of research has characterized the jamming transition, a zero-temperature critical point of systems with short-range repulsive interactions. Many of its properties are independent of spatial dimensionality, with mean-field scalings being valid even for two-dimensional systems.

In this thesis, we extend this critical behavior from the jamming transition point to an entire jammed phase. This is obtained by using a short-range linear repulsive interaction potential for soft spheres and for a related mean-field model, i.e. the perceptron.We show that the non-differentiable point in the pairwise interaction potential produces a network of tangent spheres (a “contact network”) at every density beyond the jamming transition. The contact networks characterizing the minima of the system are isostatic, critically self-organized and marginally stable.

In the first part, we study the jammed phase of the perceptron, both numerically and theoretically using techniques developed for mean-field glassy systems. We show the presence of a critical phase and we develop a zero-temperature scaling theory which establishes its universality class.Therefore, we use numerical simulations to study the soft spheres case in two and three dimensions and we point out the presence of the critical jammed phase also in finite dimensions.

In the second part, we define a compression protocol for the perceptron that allows us to study the avalanche dynamics in the critical phase. We show that the avalanche sizes are scale-free power law distributed with divergent first moment and we characterize the finite-size scalings. Our numerical results are robustly consistent with the mean-field theory.

This work shows the existence of a new critical phase in finite dimensions whose universality is strongly connected to the class of jamming universality. This opens new perspectives to study marginally stable glasses and their related energy landscapes.

Directeur : Silvio Franz

Jury : Jean-Louis Barrat, Giuseppe Foffi, Luca Leuzzi, Andrea Liu, Markus Müller, Pierfrancesco Urbani, Matthieu Wyart