Soutenances de Thèses 2025

Marco Biroli

Mercredi 11 juin 2025, Petit amphithéâtre Bâtiment Pascal n°530 **Soutenance de thèse**

Strongly correlated stochastic systems

This thesis develops exact analytical tools to study strongly correlated stochastic systems, with a focus on extreme value statistics, gap statistics, and full counting statistics in multi-particle processes. A central contribution is the universal characterization of conditionally independent identically distributed variables —random variables that become independent upon conditioning on latent parameters. This structure arises naturally in systems with stochastic resetting, a mechanism that generates strong long-range correlations while retaining analytical tractability. Using this framework, we derive universal closed-form expressions for several observables across diverse models, including Brownian motion, Lévy flights, ballistic particles, and Dyson Brownian motion, under various resetting protocols. Inparticular, we demonstrate that resetting induces analytically tractable non-equilibrium steady states characterized. Theoretical predictions are supported by numerical comparisons and experimental comparisons in systems such as diffusive particles in switching harmonic traps. Applications to search optimization are also explored, identifying regimes where resetting enhances or impairs first-passage efficiency, and proposing rescaling-based protocols that out perform traditional resetting.

Jury : O. Bénichou, J.P. Bouchaud, L. Cugliandolo, M. Henkel, S.N. Majumdar (directeur de thèse), S. Reuveni, G. Schehr, P. Vivo

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Alessandro Pacco

Mercredi 15 octobre 2025, Grand amphithéâtre Bâtiment Pascal n°530 **Soutenance de thèse**

Exploring high-dimensional random landscapes: from spin glasses to random matrices, passing through simple chaotic systems

High-dimensional random landscapes underlie phenomena as diverse as glassy physics and machine learning, yet even their simplest toy models already display extraordinarily rich behavior. This thesis aims to deepen our understanding of that behavior, by combining landscape based approaches, via the Kac–Rice formalism, with dynamical approaches, paying special attention to both systems with reciprocal and with non-reciprocal interactions. After surveying core techniques and results through the pure spherical p-spin model, this thesis delivers three main advances: (i) exact dynamic–static comparison in a class of solvable non-reciprocal models, pinpointing differences and similarities of the two approaches; (ii) a stability-based calculations of the mean number of fixed points in the Sompolinsky–Crisanti–Sommers random neural network, for any level of non-reciprocity of the interactions; (iii) two approaches to probe the barriers and the distribution of deep local minima in the landscape of the p-spin model; (iv) some results on overlaps among eigenvectors of spiked, correlated random matrices, which are useful when exploring the geometry of energy landscapes. Together, these results sharpen our understanding of such systems, while opening new doors for future research directions.

Jury : E. Bertin, Y. Fyodorov, C. Monthus, F. Ricci-Tersenghi, V. Ros (directrice de thèse), A. Rosso (co-directeur de thèse)

Charbel Abetian

Mardi 9 décembre 2025, Grand amphithéâtre Bâtiment Pascal n°530 **Soutenance de thèse**

Overlaps after a boundary quantum quench in the integrable XXZ spin chain

The aim of this thesis is to provide an exact analytical approach for computing overlaps between eigenstates of the open XXZ chain before and after a boundary quench, that is, an abrupt change of one of the boundary magnetic fields. These overlaps constitute a fundamental building block for the description of the out-of-equilibrium dynamics of quantum systems and play a crucial role in understanding their post-quench evolution. We focus on the open XXZ spin-½ chain with parallel boundary magnetic fields in the massive antiferromagnetic regime, one of the simplest (non-trivially interacting) integrable models with non-periodic boundary conditions. This system can be interpreted as a quantum chain interacting with its environment through boundary degrees of freedom. The Quantum Inverse Scattering Method (QISM) and the Algebraic Bethe Ansatz (ABA) provide a strong theoretical framework for studying such quantities. The goal of our analysis is to derive, within this formalism, exact expressions for the overlaps in the thermodynamic limit. Using Slavnov's determinant formula for scalar products of Bethe states, we first derive a determinant representation for the overlaps between pre- and post-quench eigenstates. By employing what we refer to as the Gaudin extraction method, we show that we can extract from this (typically encountered) ratio of determinants, a Cauchy-like determinant, suitable for taking the thermodynamic limit. We show that the overlap between the gapped ground states (i.e., states whose Bethe root configurations contain no holes) before and after the quench can be written in a product form, valid up to exponentially small corrections in the system size. This allows us to obtain a closed analytical expression for the overlap in the infinite-size limit, that depends only on the physical parameters of the model, namely, the anisotropy parameter and the boundary magnetic fields. We further verify this formula through direct comparison with numerical diagonalization results. We extend this analysis to a broader class of (ground/excited) states characterized by the presence of a finite number of holes in their Bethe root distributions. We show that the Gaudin extraction method yields once again a Cauchy-type structure, now, perturbed by a matrix of rank equal to the number of holes. In this case, the overlap factorizes into a prefactor that can be written in a product form, similar to the case of the ground state, multiplied by a finite determinant whose size is equal to the number of holes n. In the thermodynamic limit, we obtain an explicit expression for the overlap that depends on the anisotropy, the boundary magnetic fields, and the hole positions. The results presented here lay the groundwork for a broader analytical study of boundary-driven quenches in integrable quantum systems through ABA techniques.

Jury : P. Baseilhac, O. Castro-Alvaredo, J. De Nardis, N. Kitanine (co-directeur de thèse), K. Kozlowski, V. Pasquier, V. Terras (directrice de thèse)