Combinatorics from singular SPDEs to kinetic equations

Yvain Bruned[1]

Universite de Lorraine, CNRS, IECL, F-54000 Nancy, France
Email: yvain.bruned@univ-lorraine.fr

Abstract

Conference organised in Nancy from 17 to 19 of June 2026, funded by the ERC Starting Grant LoRDeT (Low Regularity Dynamics via Decorated Trees) https://cordis.europa.eu/project/id/101075208. The PI of the project is Yvain Bruned.

Wednesday 17 June 2026

Talks take place at IECL, Salle Döblin.

- 14h00-14h50: Ricardo Grande.

  Wave kinetic theory for the forced/dissipated NLS equation

  We will present some recent developments concerning the rigorous derivation of kinetic equations in the presence of forcing and dissipation. Such settings are of particular physical relevance since they allow the study of cascades, namely the transfer of energy from large scales to small scales. In this talk, we provide the first rigorous derivation of a kinetic equation for a wave system governed by the cubic Schrödinger equation with stochastic forcing and viscous dissipation. We will describe several regimes depending on the relative strength of the forcing, dissipation, and nonlinear interactions, leading to different effective kinetic equations. Joint work with Zaher Hani.

- 14h50-15h40: Yvain Bruned.

  Kruskal-style algorithm for molecule reduction I: Cubic NLS

  We are interested in the molecule reduction algorithm introduced by Deng and Hani. They use this algorithm to establish a rigidity theorem, which plays a central role in the kinetic-time derivation of the wave equation associated with the cubic Schrödinger equation. We will explain that this algorithm is a graph traversal algorithm of Kruskal type, and we prove that it constructs a Kruskal spanning tree of the input molecule. The same type of algorithm has been used for the long time derivation of the Boltzmann equation.

- 15h40-16h10: Coffee break.
- 16h10-17h00: Corentin Le Bihan.

  Un modèle jouet pour le problème de Lenard-Balescu

  On s'intéresse à un système de N particules dans le régime de champ moyen, c'est-à-dire avec des interactions de faible intensité (d'ordre 1/N) mais à longue distance (d'ordre 1). Sur les temps courts (d'ordre 1), ce système est décrit par l'équation de Vlasov, qui est conservative. Sur des temps beaucoup plus longs (d'ordre N), par contre, la théorie de Lenard-Balescu prédit la relaxation du système vers l'équilibre (au sens fort, avec de la dissipation d'entropie). Formellement, cette relaxation lente s'explique par les corrélations entre les particules. Cependant, aucune justification rigoureuse n'a été obtenue à ce jour: les seuls résultats sont des preuves de consistance (dérivation au temps 0).
  Dans cet exposé, nous revisitons le problème en partant d'un modèle simplifié, qui s'inspire de la version linéaire du problème (due à Duerinckx et Saint-Raymond) et dans lequel la hiérarchie BBGKY est tronquée à un ordre arbitraire. Partant d'une approche perturbative en diagrammes de Feynman, utilisant des idées de renormalisation, et des estimations hypoelliptiques pour les propagateurs renormalisés, nous parvenons à atteindre le temps cinétique (d'ordre N) pour ce modèle.
- 19h30-22h30: Conference dinner at Grand Café Foy.

Thursday 18 June 2026

- 9h00-14h00: Colloquinte of the Probability and Statistic team.

Talks take place at IECL, Salle de Conférences.

- 14h30-15h20: Xue-Mei Li.

  Long range dependence in stochastic systems

  We will discuss the role played by correlated noise in SDEs and SPDEs.

- 15h20-15h50: Coffee break.
- 15h50-16h40: Lorenzo Zambotti.

  Combinatorics and a priori estimates for rough S(P)DEs

  Rough paths and regularity structures study pathwise S(P)DEs using local expansions. The associated remainders are usually estimated via analytic methods but one can also write them explicitly, and in fact there are many possible ways of expressing them. With Lorenzo Agabiti and Alberto Bonicelli we have found a particularly nice way of rearranging the terms in this sum, which allows to give seemingly optimal a priori bounds on the solution. The formula

is however surprisingly difficult and involves several non-trivial combinatorial tools.

- 16h40-17h30: Antonin Chodron de Courcel.

  Effective models in high dimensional unstable regimes: some examples from mean-field models and machine learning

  Deriving macroscopic effective models from high dimensional microscopic dynamics is a classical challenge in mathematical physics, particularly when trying to rigorously preserve underlying instabilities or oscillations. In this talk, we explore this challenge through the lens of modern machine learning by treating the parameters of overparameterized networks as interacting particles, focusing on Maximum Mean Discrepancy (MMD) gradient flows.
  While the classical continuous-time limit of MMD flows yields a well-behaved mean-field limit, modern deep learning typically operates in a highly unstable regime driven by large discretisation steps. We will show how to construct modified effective models to capture this "Edge of Stability"—a regime characterized by persistent oscillatory dynamics—providing theoretical insights into the algorithm's stabilization mechanisms and implicit bias.
  Finally, time permitting, we will briefly discuss non-local porous media equations which serve as another prime example of where effective continuum equations must be carefully constructed to handle inherent instabilities and singular behaviors arising from underlying dynamics.

Friday 19 June 2026

Talks take place at IECL, Salle de Conférences.

- 9h00-9h50: Gaspard Gomez.

  The multiplicative stochastic heat equation with Lévy stable noise

  Singular SPDEs driven by non-Gaussian stable noises remain much less understood than their Gaussian counterparts. In this talk, I will discuss recent results on the multiplicative stochastic heat equation driven by stable Lévy noise, which admits an explicit polynomial-chaos representation. We construct and analyze the equation throughout the full subcritical regime.

- 9h50-10h20: Coffee break.

- 10h20-11h10: Valentin Clarisse.

  Kruskal-style algorithm for molecule reduction II: Boltzmann equation

  We are interested in the molecule reduction algorithm introduced by Deng and Hani. They use this algorithm to establish a rigidity theorem, which plays a central role in the kinetic-time derivation of the wave equation associated with

the cubic Schrödinger equation. We will explain that this algorithm is a graph traversal algorithm of Kruskal type, and we prove that it constructs a Kruskal spanning tree of the input molecule. The same type of algorithm has been used for the long time derivation of the Boltzmann equation.

- 11h10-12h00: Pierre Le Bris.

  Linear Landau equation as a limit of a tagged particle in mean field interaction with a free gas

  We consider a tagged particle in mean field interaction with a free gas of density N at equilibrium. In dimensions $d \geq 4$, we prove the convergence of its trajectory, as N goes to infinity, to the one of a diffusion process associated with the linear Landau equation. The proof of the convergence of the martingale problem relies on two key ingredients: long time stability results of the microscopic dynamics, and controls on the probability of particle recollisions. This is joint work with T. Bodineau (IHES).

- 14h00-16h00: PhD Defence of Yingtong Hou at IECL, Salle de Conférences.