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LiBERA - Stochastic interacting systems: Limiting Behavior, Evaluation, Regularity and Applications

LiBERA will pursue three general objectives (Research&Innovation, Training, and International Collaboration) that will be achieved through the development of new skills and products and exchange of multidisciplinary and complementary knowledge and competences within the international Partners from Italy, Brazil, Canada, Colombia, Finland, France, Germany, Japan, Portugal, United Kingdom and United States.
LiBERA aims at addressing several challenging mathematical questions related to differential stochastic interacting systems, with particular emphasis on their asymptotic behaviour in several limiting regimes, the regularity properties of the solutions, and their numerical evaluation. Trough sharing the nonlinearity as a common underlying trait, the equations we analyse naturally arise from the modelling of real-world phenomena in several fields of application linked to the UN Sustainable Development Goals (SDG), like spiking neural systems (SDG 3), climatology (SDG 13) and financial/energy markets (SDG 7,13). and. Critically, nonlinearity intertwines with other relevant features that make the analysis fall out of the existing theories. These features include low regularity of the coefficients, noise degeneracy, jump-diffusion dynamics, slow-fast time scales, and high-dimensionality.
In the models we study, nonlinearity often arises as a macroscopic effect of the interactions in stochastic systems. For instance, in the case large mean-field particle systems, the empirical distributions can be approximated with the solution to a stochastic evolution equation of McKean-Vlasov (MKV) type. In these equations, the nonlinearity is displayed as a direct dependence of the coefficients on the law of the solution. Introduced in the mid-20th century as models for fluid dynamics, mean-field stochastic systems (MFSS) and MKV equations have received increasing attention since the 2000's, due to their versatility and their rich mathematical structure. The pioneering works of Kac and McKean have attracted researchers interested in the study of stochastic partial differential equations arising as macroscopic limit of interacting stochastic systems.
The study of stochastic interacting systems is highly multidisciplinary from a two-fold perspective, having simultaneously an inter/transdisciplinary approach. On one hand, they have become a widespread modelling tool in a variety of applications (interdisciplinarity). For example, MFSS are used to model human neuron interfaces, but also interacting agents in economics and finance, in relation to managing risk and decentralized production of renewable energy. On the other hand, the set of mathematical and computational tools needed to reach a holistic understanding of stochastic systems is very vast (transdisciplinarity): ranging from the theory of stochastic (partial) differential equations, random measures, rough paths, gradient flows in metric measure spaces, numerical probability, and computer simulation.

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