Dottorato di Ricerca in Fisica – PhD in Physics
(XLII Ciclo)

Research Project:

Title:

Rare events in stochastic dynamics from biological system to machine learning.

Abstract:

Rare events play a crucial role in a wide range of fields, from biology to weather forecasting. In stochastic models, the investigation of rare events is often guided by the so-called *Big-Jump Principle*, which identifies the dominant mechanisms leading to extreme fluctuations. Originally established for sums of independent and identically distributed random variables, this principle has recently been extended to stochastic walkers exhibiting more complex dynamical behaviors. The primary goal of this project is to extend the Big-Jump Principle to systems of interacting particles, which represent the typical framework for stochastic dynamics in biological systems.
A further research direction concerns stochastic dynamics in machine learning. In these systems, a key issue is the choice of the dynamics governing the hidden variables. Of particular interest are out of equilibrium dynamics that violate detailed balance, such as those underlying stochastic gradient descent algorithms. In this context, theoretical frameworks from statistical physics—especially those addressing non-equilibrium stochastic processes and rare-event phenomena—have the potential to provide powerful analytical tools and novel insights into the mechanisms underlying learning dynamics.

Dr./Prof.
Alessandro Vezzani
alessandro.vezzani@unipr.it