PhD offer

High-energy particles and relativistic sources in astrophysics

Where do cosmic rays, neutrinos and high-energy photons come from? How is radiation emitted from black hole environments, blazars, gamma-ray bursts and other relativistic sources? What process gives rise to the electromagnetic counterparts of gravitational wave events? All these questions shape the rapidly-developing fields of high-energy astrophysics and multi-messenger astrophysics. At the heart of these questions lies a same theoretical question: the nature of the process that turns these sources into powerful particle accelerators. The aim of this PhD is to advance our understanding of the mechanisms by which very high-energy particles are accelerated in the turbulent, relativistic and magnetized flows of powerful astrophysical sources, in particular gamma-ray bursts, blazars and pulsar nebulae.

The acceleration process relies on the interaction between these charged particles and the electromagnetic fields carried by the surrounding plasmas. The physics involved is rich and it involves non-linear and multi-scale plasma processes in extreme conditions: relativistic, strongly magnetized flows, possibly composed of electron-positron pairs etc. This research is mostly theoretical, and it relies heavily on high-performance numerical computation, using the particle-in-cell (PIC) method, which allows to resolve in a consistent manner the non-linear relationship between the electromagnetic fields and the accelerated particles.

This thesis proposes to study the physics of high-energy particle acceleration in relativistic and magnetized turbulent flows, as encountered in powerful sources. This work will be carried out in conjunction with massively parallel PIC numerical simulations and advanced analytical models. The PhD candidate will also work on phenomenological applications of these studies to multi-messenger astrophysics.

The thesis will be carried out under the supervision of Martin Lemoine in the « Astroparticule & Cosmologie » laboratory of Université Paris-Cité, in co-direction with Laurent Gremillet (CEA/DAM/DIF).

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