Master thesis project (stage M2)

Black holes, turbulence and multi-messenger astrophysics

The immediate vicinity of black holes provides exquisite conditions for accelerating particles to extremely high energies, up to PeV and beyond. One likely mechanism is via the collisionless plasma turbulence that is expected in the black hole environment, and whose random electromagnetic fields promote efficient stochastic particle acceleration (diffusion in energy space). Accelerated particles add viscosity to the flow, and therefore damp the turbulence that feeds them, giving rise to an interesting nonlinear interaction between particles and electromagnetic fields. This process is gaining some attention because it can determine the final shape of the energy distribution of accelerated particles. This phenomenon will therefore also control the energy distributions of photons of all energies and neutrinos that are produced by radiative and hadronic interactions of the accelerated particles. This question is of paramount importance in the light of the recent detection of neutrinos at energies >TeV, which likely originate from the immediate vicinity of the central supermassive black hole of a nearby AGN (active galactic nucleus).

The goal of the internship is to study this problem using existing numerical codes that model the acceleration of particles in a turbulent plasma or calculate the multi-messenger signatures of the accelerated particles. The core project will be to couple the two codes in order to self-consistently follow the distribution of the accelerated particles and their secondary products. The physics involved is rich and it involves nonlinear and multi-scale plasma physics processes under extreme conditions: relativistic plasmas in magnetized environments, possibly composed of electron-positron pairs.

This internship can lead to a PhD thesis on the continuation of this internship topic, combining theoretical and numerical aspects.

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