Master thesis project (stage M2)

Black holes, turbulence and multi-messenger astrophysics

The immediate environment of black holes provides exquisite conditions for accelerating particles to extremely high energies, up to PeV and beyond. One likely mechanism is collisionless plasma turbulence, which causes particles to diffuse in energy space under the influence of the random electromagnetic fields that it harbors. This gives rise to an interesting nonlinear interaction between particles and electromagnetic fields, which has received little attention so far, but which will presumably determine the final shape of the energy distribution of accelerated particles. This phenomenon thus also controls 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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