Research internship proposal:

Laboratory name: IPhT, CEA Saclay
CNRS identification code: UMR 3681
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Internship location: IPhT, CEA Saclay, 91191 Gif-sur-Yvette

Thesis possible after internship: YES
Funding: NO

Accretion of scalar dark matter on a rotating black hole

The accretion of matter onto a black hole or a compact object is a classic problem (Bondi or Hoyle-Lyttleton accretion) but the case where the accreting matter is not ordinary matter but dark matter has been somewhat less studied. In the cosmological setting, a scenario which has attracted renewed interest in the last 8 years is that of ultralight dark matter (such as axion-like particles). In this internship we will consider the accretion within the framework of such dark matter models with non-negligible repulsive self-interactions. Then, the problem can be mapped to hydrodynamics in the nonrelativistic regime, but we will also consider the relativistic regime close to the black hole horizon.

The study of the accretion onto a static black hole (Schwarzschild metric) has already been studied **[1, 2]**. However, black holes usually have a nonzero rotation (Kerr metric). The objective of the internship is thus to compute the accretion of the dark matter in the case of a rotating black hole.

Such studies are also partly motivated by the detection of gravitational waves emitted by black hole binary systems, which can be modified by the matter environment of the black holes.

This is a theoretical internship, which will involve both analytical and numerical works (e.g., Fortran, Python, Mathematica). The student will learn and use basics of black hole accretion and ultralight dark matter scenarios, the analytical and numerical study of partial differential equations and hydrodynamical codes (AMRVAC).

Keywords: gravitational dynamics, hydrodynamics

Requirements: strong interest in both analytical and numerical works.

Coding: Fortran, Python, Mathematica

References:
[1] "Fate of scalar dark matter solitons around supermassive galactic black holes" (2020) https://arxiv.org/abs/1909.02614

[2] "Supersonic friction of a black hole traversing a self-interacting scalar dark matter cloud" (2023) https://arxiv.org/abs/2307.15391

Condensed Matter Physics: NO
Soft Matter and Biological Physics: NO
Quantum Physics: NO
Theoretical Physics: YES