PhD subject
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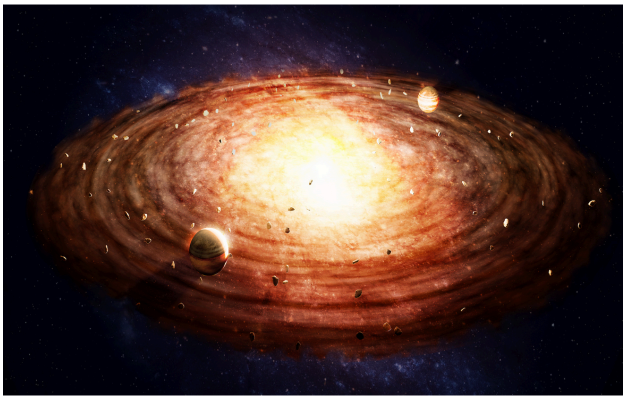
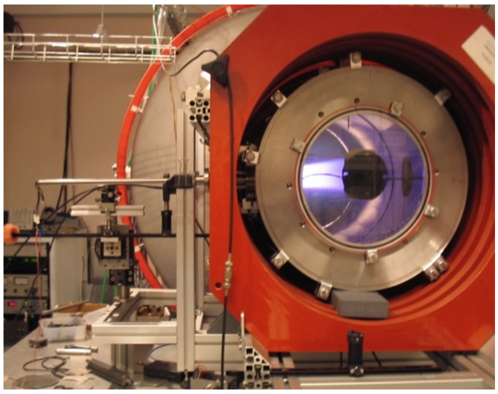
Analysis and control of ExB magnetized plasma column self-organization in the frame of astrophysical accretion mechanisms’ study





Left Fig.: artistic representation of an accretion disk. **Right Fig.**: a magnetized plasma column in the Mistral experiment.

This PhD proposes an innovative way to use a laboratory experiment to study Keplerian rotating discs in astrophysics. Indeed, stellar accretion disks are complex systems whose dynamics cover a large number of research fields. They are indeed made of dust, neutral gas and plasmas orbiting around young or rising stars and seed planet formation [1]. In link with the observation capabilities of modern instruments such as James Webb space telescope [2], intense efforts are nowadays undertaken to explain accretion mechanisms and disk formation. How a Keplerian rotation can lead to matter transport toward the center is still a matter of debate, since collisional diffusion is negligible in these systems, and Keplerian discs are stable with respect to classical hydrodynamics instabilities. How instabilities and transport occur, can be elucidated by setting up dedicated experimental devices. Laboratory plasma experiments with controlled plasma rotation is an innovative way to explore such scientific questions.

Mistral is a cold magnetized plasma experiment with a constant magnetic field [3, 4 ,5, 6]. It is a canonical experiment to study various kind of instabilities of weakly magnetized ExB plasmas, such as centrifugal instabilities [7]. In the presence of a magnetic field B perpendicular to an electric field E, charged particles drift in the ExB direction. Combined with plasma inhomogeneities, this drift is favorable to the apparition of instabilities that considerably increase the transport across the magnetic field B (« anomalous transport »). These cross-field configurations are exploited in numerous applications.

Rotating plasma are easily obtained in the *Mistral* experiment, but there is a lack of control of the azimuthal differential rotation. This can be done by a fine control of the radial electric field profile in the plasma. Indeed, the prediction of the rotation properties and the control of the flow profiles is still an open problem regarding rotating plasmas in such devices. Previous works in our SoPlasma network (https://gitlab.com/soplasma/soplasma), including the *Mistral* device, have shown that rotation of plasmas can be challenging to control. Recent progress however provides a path to achieve this important objective by the use of concentric cold or hot cathodes [8, 9] . Another possible way to control the plasma column rotation specific to Mistral is to control the energetic ionizing electrons in Mistral by independent concentric grids.

Investigation of the plasma self-organization and experimental control of its rotation is the main objective of this PhD proposition. First, PhD student will study the stability/turbulent areas in the parameter space (plasma pressure and boundary conditions) by experimental acquisition of plasma parameters with Langmuir probes, fast camera and optical tomography. Second, new innovative experimental configurations will be studied to better control the plasma azimuthal differential rotation: concentric grids controlling ionizing electrons injection and cold/hot cathodes placed at the end of the plasma column.

Finally, a comparison of experimental results with theory will allow a better understanding of ExB plasma rotation physics to ultimately propose an experimental setup with a Keplerian plasma rotation. The importance of this part will be modulated, according to the student's motivation for theoretical work.

The project, being within the framework of AMIDEX ("Excellence initiative" of Aix-Marseille University) project "Table Top Accretion Disks", is 100% funded.

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