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CALL FOR APPLICATIONS 2025 – FELLOWS

Supervisor	Ugo Boscain
Supervisor page	https://www.ljll.fr/~boscain/
Host Institution	Sorbonne Université https://www.sorbonne-universite.fr/en
Research Lab	Jacques Louis Lions Laboratory https://www.ljll.fr/en/
Research Team	Control, optimization, and inverse problems https://www.ljll.fr/en/theme-controle-optimisation-problemes-inverses/

Project Title

The Mathematics of Stellarators

Project Description

Fossil fuels (oil, gas, coal) currently account for 85% of the world's primary energy sources, despite the greenhouse effect caused by CO_2 emissions from their combustion. Controlled thermonuclear fusion presents a promising alternative for sustainable energy.

To achieve nuclear fusion in toroidal configurations, it is necessary to design strong magnetic fields with a "twist" on the plasma surface and more generally in the plasma domain. The twist is necessary to compensate for a drift force arising when a particle is moving in a nonconstant magnetic field.

There are two main technological approaches to creating this twist. In a tokamak, the twist is produced by generating a current within the plasma itself. This design is relatively straightforward, but it can only operate in pulses, which leads to significant plasma instability. In contrast, a stellarator achieves the twist without inducing any current, relying instead on a much more complex shape and magnetic field structure. While stellarators are easier to operate (they can in principle achieve steady-state operation), their design is considerably more challenging to realize.

The design of both tokamaks and stellarators still faces numerous problems, many of which are highly complex from a mathematical and automatic control perspective. These challenges are becoming increasingly critical for the success of magnetic fusion. Addressing them requires a transdisciplinary approach, connecting fields such as dynamical systems, KAM theory, shape optimization, control of partial differential equations, and feedback control.

The main objectives of the project are:
1. Understand the Drift in Strong Magnetic Fields
2. Investigate the Link Between Chaotic Behavior and KAM Theory

Description of the Host Research Lab

The Jacques-Louis Lions Laboratory is the largest applied mathematics laboratory in France and one of the leading ones worldwide for education and research in the field. Its research focuses on the analysis, modeling, and high-performance scientific computing of phenomena described by partial differential equations. With about 100 permanent or emeritus faculty members, researchers, engineers, and administrative staff, as well as a similar number of PhD students and postdoctoral researchers, the LJLL collaborates with the industrial sector and other scientific disciplines across a broad range of applications: fluid dynamics; theoretical physics, mechanics, and chemistry; control, optimization, and finance; medicine and biology; signal and data processing.

To submit your application, please send an email with the required documents to
msca-pf@sorbonne-universite.fr