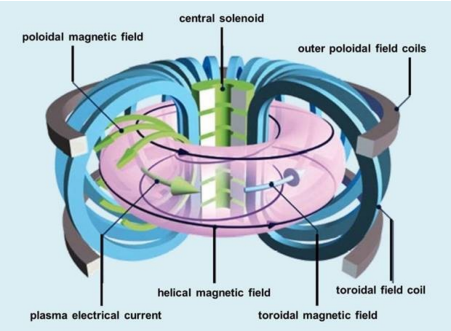
Master project:
AI in Plasmasimulations

This internship addresses the simulation of plasma systems using techniques of physics informed neural networks (PINN) and geometric flows. For the intership, you will implement a semi-Lagrangian PINN [1] for the Vlasov Poisson equation:

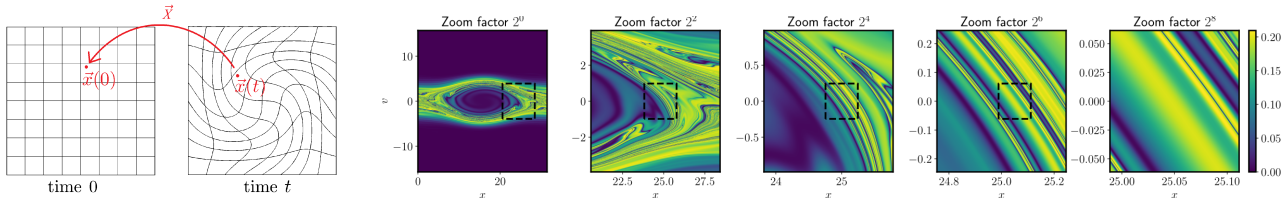
$$\partial_t f + v\partial_x f + \frac{q}{m} E \partial_v f = 0\,, \qquad \partial_x E = 1 - \int f \,\mathrm{d}v\,. \tag{1}$$

In a first step you will implement the approach using the `pytorch` software framework `SCIMBA` [2, 1]. And in the second step, apply this same methodology to the characteristic map.



[Image courtesy of EUROfusion]

The characteristic mapping method [3] is a semi-Lagrangian method that evolves an underlying grid (shown in fig. 1a) in time. This newly developed method allows studying fine-scale structures of turbulence shown in fig. 1b.



(a) Characteristic Map

(b) Zoom into two-stream instability

Figure 1: Visualizing the idea of CMM for the two-stream instability in plasma.

Who? This internship targets physicists or engineering science students in their master's with a background in AI and who are comfortable with programming in Python.

Workplan:

The tasks for this project can be divided into the following points:

- Reproduction of the results in [1]
- Combination with existing framework [3].
- Simulation of non-linear Landau damping and validation.

Contact Person:

Philipp Krah:	`philipp.krah@cea.fr`
Kevin Obrejan:	`kevin.obrejan@cea.fr`
Kai Schneider:	`kai.schneider@univ-amu.fr`
Olivier Laffite	`lafitte@math.univ-paris13.fr`

References

[1] Emmanuel Franck, Victor Michel-Dansac, Laurent Navoret, and Vincent Vigon. Neural semi-lagrangian method for high-dimensional advection-diffusion problems. *Computer Methods in Applied Mechanics and Engineering*, 448:118481, 2026.

[2] Scimba development team. Scimba. `https://www.scimba.org/`, 2025. Version 1.0.0; Python library for Scientific Machine Learning for PDEs.

[3] Philipp Krah, Xi-Yuan Yin, Julius Bergmann, Jean-Christophe Nave, and Kai Schneider. A characteristic mapping method for vlasov–poisson with extreme resolution properties. *Communications in Computational Physics*, 35(4):905–937, June 2024.