

# ENERGETICS

## AMMIN/DENERG - Integrated Edge-Core transport studies modeling in Tokamak Plasmas

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| <b>Funded By</b>                        | Dipartimento DENERG<br>Politecnico di TORINO [P.iva/CF:00518460019]                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
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| <b>Contact</b>                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Context of the research activity</b> | Fuel and impurities transport in a fusion reactor control the performance and may prevent reliable operations. Impurities are required to the total line radiation, favoring safe power exhaust. Species and concentration selection depend on their distribution in the different reactor regions (edge/core), and on the concurrent presence of elements produced by the reaction itself (Helium) or extracted from the wall via erosion processes. This proposal focuses on the development of theoretical modeling tools for the study of coupled edge and core plasma species transport in Tokamaks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Objectives</b>                       | <p>Understanding transport of fuel and impurities in a fusion reactor is critical to provide high performance, controlled and reliable operations. It is now widely accepted that some level of plasma impurities will be required to handle satisfactorily the power released by the <math>\alpha</math> particles produced by D-T fusion reactions, aiming at enhancing the total line radiation. Selection of the proper chemical species, together with their concentration, depends on their distribution in the different reactor regions (edge/core), and on the concurrent presence of elements produced by the reaction itself (Helium) or extracted from the wall via erosion processes. Transport processes details will then dramatically influence plasma radiation and, ultimately, the possible solution of the so-called Power Exhaust problem, i.e. the ultimate handling of the plasma released power.</p> <p>The scientific community developed accurate transport models for the edge plasma (e.g. the SOLPS-ITER code) and in the center (ASTRA). However, a reliable integrated tool covering both regions does not exist. We aim at closing this gap, leveraging on the more than 20-years' experience of the proposing group with the SOLPS-ITER code and the recent experience gained on the ASTRA code within an ongoing collaboration with IPP-Garching. The latter will support the project by providing continuous support on ASTRA.</p> <p>While the scientific community counts on well-established tools for transport modeling in the plasma core and edge separately, self-consistent models covering the whole plasma chamber are still experimental, with an estimated TRL around 3. This stems from important differences in the two regions. On the one hand, physical parameters differ by several orders of magnitude,</p> |

resulting in different physical phenomena taking place in the different regions. On the other, while the core is mostly one-dimensional, the edge is at least two-dimensional. We aim at closing this gap by coupling the SOLPS-ITER code, reference in the community for edge studies, with ASTRA, focusing on core transport. The project will have three steps, which can be roughly identified with the three years of the PhD program:

1. The successful candidate will be educated to the usage of the ASTRA code at PoliTo. Later on, he will deepen the physical aspects of the model and the potential applications in collaboration with IPP-Garching.

2. The successful candidate will develop and test the coupling procedure, also leveraging the strong expertise available at PoliTo on the SOLPS-ITER code. Then, a copy of the produced software will be installed in an HPC device, aiming at testing its reliability in an environment not fully controlled by the user and optimizing performances.

During the third year, a set of experimental data will be gathered and used to validate the tool. We aim at providing an analysis of a low-field and a compact experiment. This will prove the tool reliability in the environment typical of advanced modeling activities, placing it at an estimate TRL level 6.

**Skills and  
competencies  
for the  
development of  
the activity**

The successful candidate should have a good knowledge of basic plasma physics and Power Exhaust techniques in tokamaks. Experience with the ASTRA and or SOLPS\_ITER codes will also be a bonus, as well as with PYTHON and FORTRAN. He/She should be willing to work in a dynamic international environment, and to spend significant periods in foreign laboratories. He/She will also be requested to proactively identify early problems during the research project, suggesting and implementing solutions.