DRF: Thesis SL-DRF-20-0453

RESEARCH FIELD

Plasma physics and laser-matter interactions / Corpuscular physics and outer space

TITLE

Data-driven discovery approach to tackle turbulence in fusion plasma

ABSTRACT

In a magnetized fusion plasma, turbulent processes drive the heat and particle transport. Collective effects, charged particles and electromagnetic field makes turbulence in plasmas even more complex than in fluids. Data-driven discovery approach could be effective to extract new information because of the problem complexity and parameter diversity.

The first step was accomplished by building a database covering a decade of density fluctuation measurements by reflectometry on the Tore Supra tokamak [1]. Reflectometry is a radar-like technique able to access the density fluctuations with high sensitivity and good spatial resolution. This database enabled us to link modifications of the reflectometry spectra with the particle collisions rate and the hence the dominant turbulent instability [2].

This first objective is the extension of the database to the WEST tokamak. WEST is an upgrade of Tore Supra to test ITER-like divertor elements. The analysis technique, based on a decomposition of the fluctuation spectrum in several components, will be adapted to WEST configuration. The next step is to include more components and/or advance data-driven techniques like image recognition to identify automatically narrow components such as the quasi-coherent modes linked to a turbulent instability or the coherent modes due to magnetohydrodynamic (MHD) instabilities. The systematic analysis of these modes and their link with the confinement regime will be the PhD main objective. Trends obtained from the database will be confronted with simulations results performed with the support of the IRFM theory group. Application to the JET tokamak (European tokamak near Oxford, UK) is foreseen in particular to compare pure deuterium plasmas with deuterium tritium ones having fast alphas as a tritium campaign is planned at JET.

The student will be co-supervised by S. Heuraux, a University of Lorraine professor who is an expert on the simulation and interpretation of reflectometry measurement and R. Sabot, the responsible officer of the fluctuation reflectometer on WEST. S. Hacquin, an expert of reflectometry code will be the supervisor at JET. Collaboration with universities or IT companies specialized on data-driven analysis are also foreseen.

[1] Parametrization of reflectometry fluctuation frequency spectra for systematic study of fusion plasma turbulence, Y. Sun, et al, Rev. Sci. Instrum. 89, 073504 (2018).

[2] Experimental trends of reflectometry frequency spectra emerging from a systematic analysis of the Tore Supra database, Y. Sun, et al, Phys. Plasmas 26, 032307 (2019)

LOCATION

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