DRF: Thesis SL-DRF-20-0529

RESEARCH FIELD

Mathematics - Numerical analysis - Simulation / Sciences pour l'ingénieur

TITLE

Deep learning and artificial intelligence for numerical treatment and physics analysis of kinetic data: towards exascale fusion plasma simulations

ABSTRACT

Nuclear fusion aims at producing on Earth the energy of the stars, by confining the fuel (called plasma). However, a fusion plasma is a complex system, characterised by instabilities developing on disparate spatio-temporal scales which, in nonlinear regimes, can lead to turbulent transport. It is well-known that turbulence can limit the performance of fusion devices. Therefore, understanding, predicting and controlling turbulence and the induced transport and losses of particles is of prime importance for nuclear fusion and represents an extremely challenging research activity for the ITER project. In this context, numerical simulations are essential to support future experiments on ITER. One of the most efficient codes for core plasma turbulence simulations is GYSELA, developed for 15 years at IRFM/CEA and evolving nowadays towards the edge-core turbulence coupling in the presence of kinetic electrons, which requires the use of exascale computational power. To achieve this class of simulations, an efficient use of the generated data is mandatory, which motivates the proposed PhD thesis. The first goal is to develop Artificial Intelligence (AI) techniques based on neural networks to detect non-physical events leading to numerical crashes. The second goal is to rationalize the data-saving using both pattern-recognition methods to detect nonlinear physical events and neural networks to infer missing data. These first two goals will help rationalize CPU and memory consumption to prepare the GYSELA code for ITER-like exascale simulations. The third goal is to used AI techniques to improve the understanding of the physical mechanisms responsible for the de-confinement of particles induced by turbulence in fusion plasmas.

LOCATION

Institut de recherche sur la fusion par confinement magnétique
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