Thesis subject proposal

Exploring Deep Neural Networks for Fusion Plasmas Spectroscopy

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Subject description: Artificial intelligence tools are taking an important place in plasma science [1] and particularly in plasma physics [2-4]. However, the integration of machine learning in the field of plasma spectroscopy is not well-developed despite some publications like those concerning 2D beam emission spectroscopy in the DIII-D tokamak for real-time inference of plasma dynamics [5], or neutral helium emission in linear plasma devices to predict plasma parameters using a support vector regression model (SVM) algorithm instead of the standard line ratio technique relying on collisional-radiative modelling [6-7], or a more recent work on the Balmer-β line (Hβ /Dβ) in the WEST tokamak [8].

As non-invasive method, emission spectroscopy is widely used for diagnostics of magnetic fusion plasmas. Several parameters are diagnosed, e.g, the densities and temperatures of the electrons and main plasma ions, the impurity densities, and the temperatures and concentrations of the hydrogen isotope neutrals. Concerning the hydrogen isotopes, the knowledge of the isotopic ratio D/(D+T) is of great importance since tritium inventory is mandatory in magnetic fusion devices operated with DT mixtures for obvious safety reasons. To infer the hydrogen isotopic ratio, we have built a predictive model based on the application of Dense Neural Network (DNN) algorithms to theoretical Balmer Hα/Dα line spectra generated for neutral temperatures and magnetic field strengths typical of tokamak edge plasmas [9-10]. More recently, the model was improved by the use of 1D Convolutional Neural Networks (1D-CNN) [11] to HD mixtures. In this thesis, it is proposed to develop predictive models based on different neural networks for more realistic conditions by considering DT as well as HDT plasmas but also to apply the models to experimental spectra from different tokamaks. We consider exploring experimental data measured in WEST (HD), JET (DT) and additionally JT-60SA through the EUROfusion WPTE involvement. Beyond their usefulness for future fusion devices like ITER, the development of predictive models will not be limited to Hα/Dα/Tα spectra but extended to H isotopes and impurity spectra.

The selected candidate will have the task to develop, test and validate computer programs coupling NN algorithms to spectra. Such programs should be more general to be extended to various diagnostics. Python and machine-learning skills as well as fusion plasma knowledges are greatly appreciated.

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