2025-2026
M2 Internship (4-6 months)

Applying Deep-Learning (DL) to emission spectroscopy of fusion plasmas

Laboratory: PIIM, UMR7345, PATP team (Atomic Physics and Transport in Plasmas)
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Research type: Theory/Numerical Modeling/Comparison with Experimental data

Subject description: Artificial intelligence (AI) is increasingly used in physics including magnetic fusion plasmas. For instance, a Machine Learning (ML) algorithm [1] was used recently to predict the plasma parameters for PISCES-B and NAGDIS linear plasma devices [2-3]. Unlike the standard line ratio technique which relies on collisional-radiative modelling [4], in [2-3] no physical model is combined with the spectroscopic measurements. More precisely, using the intensities of few neutral helium lines the electron density and temperature were predicted by the ML algorithm and compared to their values measured by independent diagnostic techniques like Langmuir probes or Thomson scattering [2-3]. In this internship proposal, we suggest applying deep-learning techniques to line spectra of hydrogen isotopes in tokamak plasmas. We will apply in particular Dense Neural Networks (DNN) and Convolutional Neural Networks (CNN) to generated spectra of hydrogen isotopes for the aim of plasma diagnostics and predictions for future experiments. Our objective of applying DL techniques to the line emission of hydrogen isotopes in tokamaks is the prediction of the hydrogen isotopic ratio (defined as D/(D+T) for a D-T mixture) whose knowledge is of great importance for safety reasons and reaction performance control [5-7]. The algorithms can be also applied to impurity spectra to predict their plasma parameters such as the electron temperature. The candidate will have the task to develop a computer program (in Python) allowing to apply DNN and CNN algorithms to Hα/Dα/Tα line spectra generated by an existing code for various conditions in terms of neutral temperatures, neutral population densities, magnetic field strength and hydrogen isotopic ratio. Thanks to the involvement in the tasks of data analysis of the EUROfusion workplan Tokamak Exploitation (TE) for several tokamaks including JET, the candidate may also apply the trained deep-learning models to experimental data from devices like JET and/or WEST.

References

1. F. Pedregosa et al, the Journal of machine Learning research **12** (2011) 2825.
2. S. Kajita et al, AIP Advances **10** (2020) 025225.
3. D. Nishijima et al, Rev. Sci. Instrum. **92** (2021) 023505.
4. S. Kajita et al, Plasma Phys. Control. Fusion **63** (2021) 055018.
5. M. Koubiti and M. Kerebel, Appl Sci **12** (2022) 9891.
6. M. Koubiti, Eur. Phys. J. D **77** (2023)137.
7. N. Saura, M. Koubiti, S. Benkadda, Nuclear Materials and Energy **43** (2025) 101935.

This internship can be followed by a PhD thesis with funding by the doctoral school ED352