2022-2023
M2 Internship (3-5 months) / Stage de M2 (3-5 mois)

Applying Machine Learning to emission spectroscopy of fusion plasmas for diagnostics and predictions

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Research type: Theory/Numerical Modeling/Comparison with Experimental data

Subject description: Artificial intelligence (AI) and data science techniques are increasingly used in physics including magnetic fusion plasmas. For instance, the Machine Learning (ML) package Sickit-learn [1] was recently used for plasma parameter predictions in 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, neutral helium line intensities were treated using a support vector machine regression algorithm from sickit-learn to predict electron density and temperature values which were compared to values deduced from independent diagnostic techniques like Langmuir probes or Thomson scattering [2-3]. In this proposal, it is suggested to couple supervised Machine Learning techniques to spectroscopic data for the purpose of plasma diagnostics and predictions for future experiments. As a first step, the work will be focused on spectroscopic data of hydrogen isotopes from tokamaks combined with independent diagnostic systems for isotopic ratio determination. Because tritium inventory is mandatory in magnetic fusion devices operated with D-T mixture for safety reasons, the determination of the hydrogen isotopic ratio D/(D+T) is of great importance. In order to explore experimental data from D-T discharges carried out recently on JET as well a better preparation for future D-T discharges to be operated in fusion devices like ITER, it is necessary to determine the isotopic ratio H/(H+D) and D/(D+T) for H-D and D-T discharges. There are few methods to infer the hydrogen isotopic ratio like the residual gas analysis (RGA) [5] or the use of the Balmer-a line spectra [6-7]. The candidate will have the task to develop a computer program (in Python) allowing to fit experimental spectral measurements of the Hα/Dα line [8]. Hα/Dα/Tα line shapes reflect several recycling mechanisms and are affected principally by Zeeman and Doppler effects.

1. F. Pedregosa et al 2011 the Journal of machine Learning research **12** 2825
2. S. Kajita et al 2020 AIP Advances **10** 025225
3. D. Nishijima et al 2021 Rev. Sci. Instrum. **92** 023505
4. S. Kajita et al 2021 Plasma Phys. Control. Fusion **63** 055018
5. A. Drenik et al 2017 Phys. Scr. **T170** 014021
6. V. S. Neverov et al 2019 Nucl. Fusion **59** 046011.
7. M. Koubiti and R. Sheeba 2019 atoms **7** 23
8. M. Koubiti and M. Kerebel 2022 Appl Sci **12** 9891

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