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Machine learning applications to line spectra emitted by magnetic fusion plasmas

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Artificial intelligence is spreading across all science fields, including plasma science and plasma spectroscopy [1]. Various applications have shown promising results in combining diagnostic measures with machine learning techniques, particularly in tomographic reconstruction from sparse bolometric measures and early disruption detection [2,3]. In this communication, we present ongoing work on applying different machine learning algorithms to tungsten spectroscopy and Balmer lines of hydrogenic species (Hα/Dα and Dα/Tα).

For tungsten spectroscopy, we use the measurements of a W quasi-continuum emitted in the extreme UV (EUV) range, namely 45-65 Å. The measurements are performed with a grazing incidence spectrometer [4] with a mobile line of sight. We aim to establish an approximate mapping between the measured brightness spectrum of the tungsten quasi-continuum and the maximum electron temperature viewed by the line of sight during its scan. We present an end-to-end framework from the preprocessing of the emissivity lines to the maximum electron temperatures, explaining and comparing preprocessing and machine learning algorithms to achieve this goal. This study uses data from different discharges performed in the WEST Tokamak. It is found that when the investigation is focused on a series of very similar discharges, the spectrum shape is well correlated with the electron temperature in such a way that the temperature can be inferred from a measured spectrum and vice-versa with an uncertainty of about 150 eV over a broad temperature range. On the contrary, when the training set comprises plasma discharges in a variety of scenarios, the correlation is substantially weaker, an indication that « latent » parameters such as the specific heating scenario, the tokamak wall conditions and MHD also play a role. The first step to check this explanation will be to include in our analysis the electron density and temperature profiles along the line of sight.

On the other hand, we identified and dedicated 1D convolutional neural networks (CNNs) to predict the isotopic ratios of hydrogenic species from synthetic Hα/Dα and Dα/Tα), generated according to a theoretical model [5,6]. We show that the CNNs learn to predict the correct ratios from various lines and corresponding parameters While the training set is composed of synthetic lines corresponding to measurements parallel to the magnetic field, the CNNs can generalize their predictions to lines corresponding to various angles of measurements (from 0 to 90 degrees).

References:
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