Machine learning prediction of the electron density and the electron energy distribution function from the optical emission spectra

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Non-invasive diagnostics are invaluable to plasma applications such as semiconductor manufacturing, thrusters, or nuclear fusion, where the plasma should not be disturbed or cannot be easily measured with probes. Optical emission spectroscopy (OES) is a widely used non-invasive diagnostic that can be used to measure the plasma behavior in these applications. However, determining the plasma characteristics from the wealth of information contained in emission spectra is not an easy task. In this study, machine learning (ML) was used to determine the electron density (n_e) and the electron energy distribution function (EEDF) from the optical emission spectra. The ML models were trained on spectral line intensities calculated from a collisional-radiative model (CRM), with a varied combination of n_e and EEDF as the input parameters [1,2]. The n_e and EEDF used in the study include those calculated using a Particle-in-Cell/Monte-Carlo-Collisions (PIC/MCC) simulation [3]. The study was done on a capacitively coupled argon plasma with a pressure ranging from 2-100 Pa. Different ML models were used for the prediction, including Kernel Regression for Functional Data (KRFD) [4,5], an artificial neural network (ANN), and Random Forest.

In this presentation, details of the ML study and its resulting predictions will be discussed, along with the limitations encountered when using this method. Moreover, prediction results for experimentally-measured spectral intensity lines will also be presented.

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