Tungsten VUV spectroscopy in WEST tokamak 1-4 keV plasmas

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Since Tungsten (W) was chosen as the plasma-facing material in the future tokamak ITER, several magnetic fusion devices have been equipped partly (JET) or entirely (ASDEX-Upgrade) with W components. Among them, the WEST tokamak has a prominent place because of its capability to sustain 2-5 keV plasma discharges for minutes in a complete W environment.

WEST is equipped with two extreme UV spectrometers, one of which provides a wide variety of measurements thanks to its versatility. It covers the range 5-340 Å with two mobile detectors, each viewing a narrow interval (~20 Å at 15 Å, 60 Å at 310 Å) and a spectral resolution of ~0.2 Å. Its single line of sight can scan the lower half of the plasma with a minimum period of 4 s.

Spectra measured with this spectrometer are very complex due to the large number of spectral structures emitted by W. We have undertaken an extensive work of spectral line assignment using the HULLAC code and the NIST atomic database [1]. W^{25+} to W^{45+} ionisation stages have been identified. From four spectral lines from the higher stages we estimate the W density profile in the core plasma provided the electron temperature is high enough [2].

The strong and broad quasicontinuum (QC) at 45-65 Å has been extensively observed in magnetic fusion devices [3]. It has been attributed to W^{28+}-W^{45+} with additional lines from various ionisation stages. Up to now collisional-radiative modelling has not allowed to reproduce it in a satisfactory way, which suggests that the atomic structure of W or the radiative transitions and their probabilities are not well understood. A semi-statistical approach used in dense plasmas [4] has been applied with encouraging results, concerning both the ionisation degree of W and the quasicontinuum itself.

Given the complexity of this spectral feature, in parallel we have recently started to use artificial intelligence (AI) tools to investigate the relation between the spectral shape of the QC and the thermodynamic profiles of the plasma, in particular the electron temperature. The first step is to establish a relation between the spectrum and the maximum temperature along the line of sight. We have found that the temperature can be predicted with a very satisfactory accuracy (± 50 eV) in a boad range (300-3500 eV) if the AI algorithm is trained with plasma discharges performed on the same day. Plasma discharges performed several days from each other do not provide good results, possibly due to the changing vessel status. The next step is to investigate the possibility of extracting the whole temperature distribution from the QC analysis.

References

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