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Light and metallic impurity identification in the 225 – 302 Å range from the SURVIE spectrometer in the WEST tokamak

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The WEST tokamak aims at testing actively cooled solid W monoblock Plasma Facing Units mounted in shape of a flat crown forming the lower divertor. These tests aim at long plasma discharges, with thermal loads of the same order of magnitude as those expected for the ITER vertical part of the lower divertor (10 MW/m^2). This solid W actively cooled lower divertor has been under test since December 2022. More than 60 seconds stable L-mode X-point plasma discharges have already been realised. The main gas used for WEST plasmas is deuterium. The plasma impurity content must be as low as possible because it dilutes the fuel and more importantly cools the plasma, decreasing its performances.
Two VUV spectrometers are used to characterise plasma contamination due to impurities coming from plasma facing components. One is equipped with two mobile detectors and dedicated to physics studies, the other one (called SURVIE) is a survey spectrometer equipped with a single fixed detector. Here the focus will be put on this latter spectrometer. Its spectral range is 225 – 302 Å. Its fixed line of sight crosses the plasma centre almost in the midplane
A thorough line identification of the VUV spectra has been performed since 2018 in various configurations : ohmic, with LHCD heating, with ICRH heating, with both LHCD and ICRH heating. These lines are identified mainly from the Kelly tables [1] and the NIST database [2].
At the start of the experimental campaigns, during ohmic phase, Chlorine (Cl XII to Cl XIV) as well as Oxygen (O IV), Titanium (Ti X, XVIII and XX), Nitrogen (N IV and V) and Boron (B V) lines dominate the spectra. Chlorine comes from a plastic plate which fell down behind a vacuum vessel protection panel and was never completely eliminated in the subsequent

campaigns. The presence of Nitrogen and Titanium is due to a number of limiter tiles made of BN fixed to the limiter frame by titanium rings. When the plasma leans on these tiles, consequently B, N and Ti lines appear.
An ohmic plasma including a large Argon injection allowed identification of Argon lines (Ar XIII, XIV and XV).
Then during plasmas heated by LH power only , it is observed that Copper (Cu XIII, XVIII and XIX) is dominant and lines from W VII-VIII to W XLV appear and increase with LHCD power.
In the case of ICRH power alone, silver lines (Ag XVI, XVIII and XIX) appear and increase with ICRH power. Silver is due to the Silver coating of ICRH antennae front face.
The lower ionisation stages of impurities give indications on the plasma edge temperature and sources, the higher ones on the impurity content of plasma core. From these two types of information, impurity transport can be evaluated.
Furthermore this line identification helps on the one hand to determine the impurity production processes and consequently to adapt the plasma's magnetic equilibrium; on the other hand it helps to assess the plasma conditioning state and performance.

References

1. R. L. Kelly, Journal of Physical and Chemical Reference Data Vol. 16 (1997) supplement N°1
2. https://www.nist.gov/pml/atomic-spectra-database

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