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WEST impurity spectra variation through ohmic reference pulses during C9 campaign in the 225-302 Å range

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Since December 2022 WEST has tested actively cooled solid W monoblock plasma facing units mounted on 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). Deuterium plasma durations of more than 360 seconds have been obtained in a stable L-mode X-point configuration. The plasma impurity content must be as low as possible to minimise main ion dilution and radiation cooling, both deleterious for performances of a future burning plasma.

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 is equipped with a single fixed detector dedicated to monitoring impurities along a campaign and from campaign to campaign. Here the focus will be put on this latter spectrometer which spectral range is 225-302 Å and acquisition time is 11 ms. 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 heating. These lines are identified mainly from the Kelly tables [1] and the NIST database [2] and with the HULLAC code [3] for validation. We present here our line identification work for Ne. It was injected in the X-point region for X-Point Radiator studies [4] during the previous (C8) campaign.

During the last experimental campaign C9 (January-April 2024), we performed monthly an identical ohmic pulse scenario ("reference pulse") in lower X-point configuration at the start of a session. Here we compare the spectra observed during the stationary phases of the February, March and April reference pulses.

First, the brightnesses deduced from the spectra decreases from month to month both for lines and for the background. The strongest contribution to the latter is a W quasi-continuum. Although the radiated fraction during ohmic pulses remains stable [5], we see Cl and O lines diminishing along the campaign and boronisations. This brightness decrease is confirmed by the Zeff and the total radiated power decrease from pulse to pulse. There are also qualitative differences: for example the March spectra do not show Copper and Nitrogen lines while these latter largely dominate the April spectra.
The detailed study of the "reference pulses" show that differences exist in plasma parameters: over the three months, the central temperature decreases from 1.4 keV to 1.1 keV and the distance from the plasma separatrix to the closest LH antenna changes from a few millimeters to several tens of millimeters. When the central plasma temperature is lower than 1.5 keV then radiation increases with temperature. Here the background level changes by a factor 2.5 and 4.5 which shows that other parameters play a role. The comparison with the visible spectra measured on the lower divertor shows clearly that the lower divertor is not the main source of impurities. More probably the main contributor is the closest LH antenna where Copper elements face directly the plasma.

Second, the April spectra show clearly the legacy of the previous session: X point radiator with N_2 gas injection. To conclude, the impurity 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:
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[4] N. Rivals et al. « Experiments and SOLEDGE3X modeling of dissipative divertor and X-point Radiator regimes in WEST » PSI 2024-to be published in Nucl. Mat. and Energy
[5] A. Gallo et al. « Wall conditions in WEST during operations with a new ITER grade, actively cooled divertor » PSI 2024-to be published in Nucl. Mat. and Energy
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