Contribution ID: **46** Type: **not specified**

Measurements of the W concentration in the low- and mid-temperature range

Tuesday, 30 March 2021 10:45 (30 minutes)

Tungsten is one of the most important impurities in the magnetic confinement fusion plasma. It is a deleterious impurity, because its radiation is a large part of the radiative loss from core and pedestal plasma, diminishing the plasma performance and destabilizing the pulse. In the core the main radiation of tungsten is in SXR region, whereas the more long-wavelength structures radiate in VUV from the external regions (or even from the core, during the low-power pulses). The SXR is used for tungsten concentration estimation in the high-temperature core plasma (see e.g. [1]) but the concentration of tungsten in lower temperature regions are not so obtainable.

In both JET and ASDEX the XUV region around 5 nm, where the model spectrum has been calculated by Pütterich et al [2], makes possible an estimation of tungsten density in 1.5-2 keV temperature region. This means upper pedestal regions in high-power pulses or plasma cores in low intensity ones (e.g. the ones used to study L-H transitions in JET). There is another very well visible tungsten feature in VUV, roughly in 15-30 nm region, which could be used for estimating tungsten density in temperatures of 1 keV and below. The problem is, that it still cannot be reproduced using any kind of model spectra, at least not sufficiently to make any tungsten density estimations based on it. It is still one of the main tungsten signals (real time as well) used in JET, and is used to study tungsten behaviour (e.g. [3]). Due to the lack of atomic data, it cannot be used for more, and it's especially important in tritium/DT campaigns, when it is frequently the only tungsten signal apart from SXR obtainable, due to restrictions in spectroscope utilization.

Recently, also lower ionization stages of tungsten were observed in JET [4], – lines of W VI to W XIII, with the most visible being W VII lines of 21 and 26 nm. As more and more tungsten erosion studies show that the eroded tungsten, visible as W I radiation, is screened and redeposited, therefore not entering the deeper plasma at all, this W VII lines could be an estimation of SOL tungsten, the one that is more readily entering and exiting the fusion plasma core. Unfortunately, whereas the temperatures estimated using their intensities look realistic for where they are emitted from, the estimated densities are way too high. This suggests some problems with atomic parameters for those lines (ADAS database, [5]). Having better atomic parameters would greatly enhance utility of those signals for tungsten erosion and impurity source studies.

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[5] A. R. Foster, PhD Thesis, University of Strathclyde, 2008.

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Session Classification: EXP/1 fusion devices