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** See annex of J. Pamela et al, "Overview of Recent JET Results and Future Perspectives", Fusion Energy 2002 (Proc. 19th IAEAFusion Energy Conference, Lyon (2002).*

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Measurements of radial brightness profiles of Fe, Ni and Ge spectral lines emitted by FTU ohmic plasmas have been compared in a previous work with impurity transport simulations using state of the art data for the ionisation S and recombination a rates [1]. The F-like to B-like charge states could not be simulated unless the relevant α/S ratios were multiplied by a factor of two. It was found equivalent to modify either the first or the second parameter, but for the reasons given in [1], the increase of recombination (mainly dielectronic, DR) rates was preferred. In FTU ohmic plasmas the mentioned charge states are located at intermediate radii, so that the core ionisation states are not much affected by the discussed uncertainty. For Mo, the F-like to B-like charge states peak on axis if the central electron temperature T_e is larger than 3-4keV. It is important therefore to verify if the mentioned α/S correction is necessary in this case too. The Mo atomic data recently used for FTU simulations [2] have been updated to include the recently evaluated DR rates for recombining H-like to Ne-like ions [3].

Spectroscopic data from both JET and FTU are considered. Along with low resolution 100-300Å (SPRED) spectra, L-shell (35-50Å) Mo spectra -and for JET also the 65-95Å region including both M-shell Mo and Ge lines - are recorded.

The JET data are obtained from two Laser Blow-Off (LBO) injections from a composite Mo-Ge target into a 3MA, 6keV L-mode plasma with 8MW ICRH. The FTU data are from an evolving supplementary heated (1.5MW LH and 0.4MW ECRH) 0.5 MA plasma with a maximum T_e of ~6keV. The impurity transport parameters (diffusion coefficient D(r) and inward convection velocity V(r)) are deduced from the time histories of both the spectroscopic lines and of the central brightnesses of the Soft X-rays (SX). Then, L-shell relative brightnesses are considered for the evaluation of the plama core Mo ionisation degree.

There was no unanimous agreement in previous LBO simulations over the choices of the boundary condition (source function), of the incoming neutral flux. Since the number of Mo and Ge lines available is quite large, we have chosen to follow Ref. [4]: the lowest ionisation stages observed (Mo XXIV-XXV and Ge XXI) are simulated adjusting the source function (a triangular pulse followed by an exponentially decaying tail) ; then, D(r) and V(r) are progressively varied to obtain the best simulation of the time histories. To simulate closely the outflow of as many as possible ionisation stages, the simulation requires a time-dependent V(r).

In figure 1, D(r) and V(r) are shown for the Mo simulation of the LBO injection. They show the presence of both a peripheral barrier at the plasma edge (produced by reducing D and by increasing V near the LCFS ar r ~ 1.20m) and of an improved confinment core region. Critical for the first point is the simulations of Mo XXXI 116Å and Mo XXXII 128Å signals and for the second the simulation of the relatively long decay of the of F-like Mo XXXIV 37.6Å line (blended with a O-like line). The simulation of the Ge brightnesses requires a slight increase of the D-values found for Mo in the central region and at the peripheral barrier. Examples of normalised brightness simulations are given in Fig.2. The relative amplitudes of the lines from different ionisation stages depend on the transport parameters and on the atomic rates. Figure 3 presents normalised, simulated and experimental L-shell Mo spectra, 200ms after the LBO injection. Clearly the simulated spectrum (green) shows a Mo ionisation degree much higher than that observed ; thus, either the ionisation rates are over-estimated or the recombination rates (mainly DR) are under-estimated. By multiplying, as in Ref. [2], by a factor of two the F-like to B-like DR rates, the Mo central ionisation degree is reduced and the fit (red) is improved The brightness absolute values are modified, but the comparison of the normalised brightnesses (like the one of fig.2) is practically not affected by the change of the DR rates.

The considered FTU shot has been simulated between 80 and 570 ms (fig.4), when one or both supplementary heatings are applied, with a few brightness comparison in fig.4. A constant D(r)=1 m 2 /s is required to simulate the SX peak between 320 and 360 ms due to a Mo LBO (the SPRED time resolution is insufficient to observe the corresponding peak on the Mo XXXII line). An impurity peaking towards the center is observed, since V(r) linear in the outer region (~7 m/s at the last mesh), has to be increased in the core so that it reaches at r = 0.12m 8m/s with both heatings on and 5.5m/s with a single heating on.

In figure 5 the same comparison as in Fig.3 is presented for two experimental (blue) L-shell Mo spectra (time averages 0.22-0.32s, upper and 0.4-0.5s, lower) with corresponding $T_e(0)$ ~6 and ~3.5keV. The wavelength range 46-50Å is now not-shown, because the lines of B-like and Be-like charge states are too weak to be identified unambiguously. The two best fits (green and red curves, respectively, without and with 'α/S correction') do not yield as clear-cut a result as in the case of the JET spectra.

CONCLUSIONS

The JET and FTU data have first been analysed to deduce the impurity transport parameters. The successive analysis of the JET L-shell Mo spectra has indicated the necessity of modifying the state of the art Mo atomic rates. On the other hand, no similar clear-cut conclusion could be drown from the FTU data analysis.

ACKNOWLEDGEMENTS

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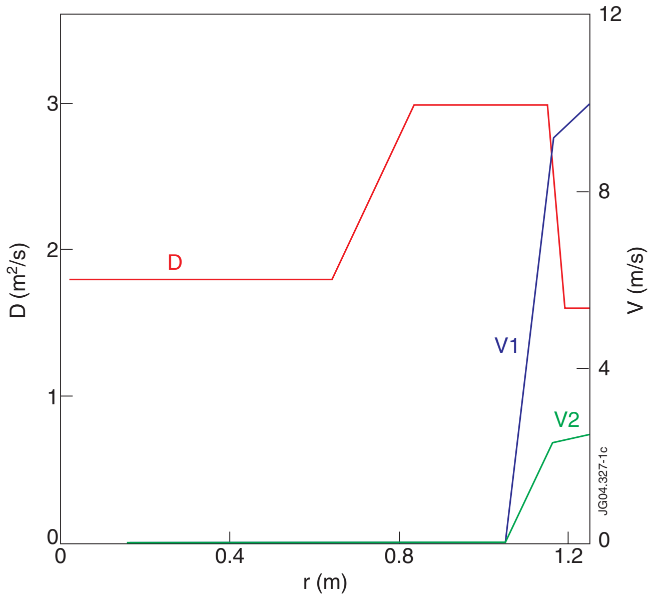

Figure 1: D(r) and V(r) profiles. The latter are progressively decreased during the outflow (shown are the limit profiles: V1 up to 100ms and V2 between 300 and 600ms) Inward velocities are positive.

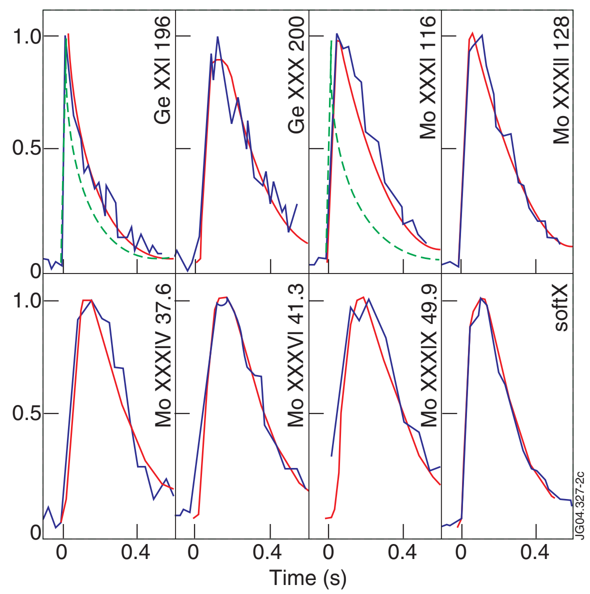

Figure 2: examples of experimental (blue) and simulated (red) brightnesses (l in Å). The green lines show the Mo XIII and Ge XV lines, that practically follow the incoming neutral flux at the last mesh. The time-dependent V(r) profiles (see Fig.1) are obtained using the SX brightness as reference line.

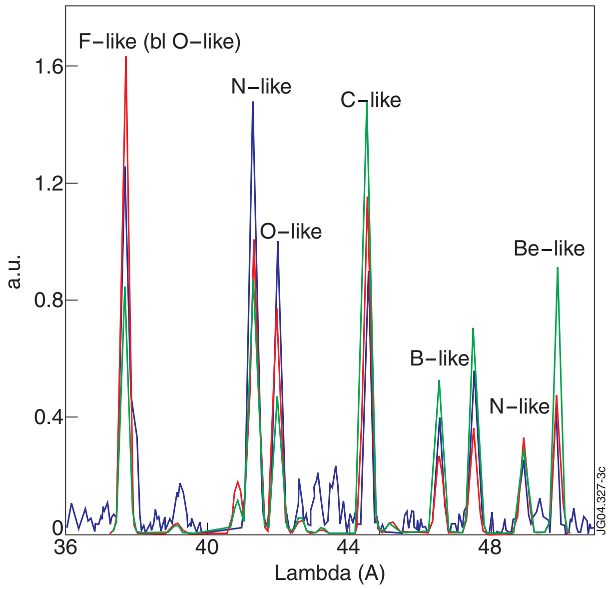

Figure 3: Experimental (blue) and simulated (green and red) experimenal spectra (200ms after the LBO, $T_e(0)$ ~6keV). See the text for color explanation. For normalisation a χ^2 minimisation on the strongest lines is done.

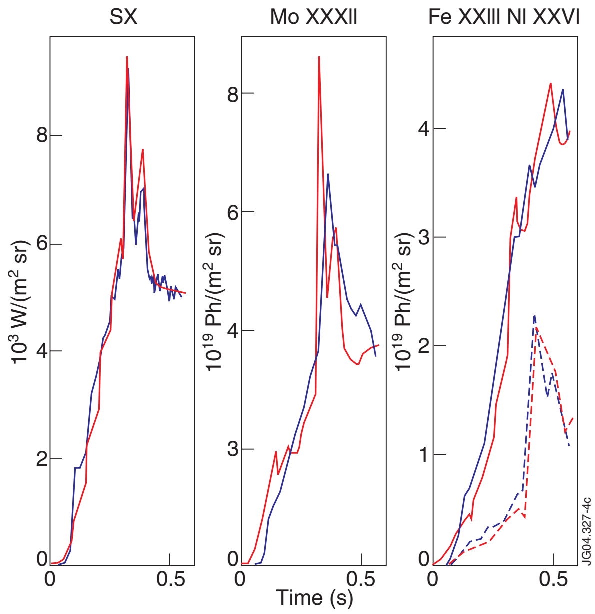

Figure 4: Experimental (blue) and simulated (red) brightness of central SX and one line per considered impurity (Mo XXXII 128Å, Fe XXIII 133Å, Ni XXVI 165Å, the last dashed). All absolute values are normalized to the visible bremsstrahlung.

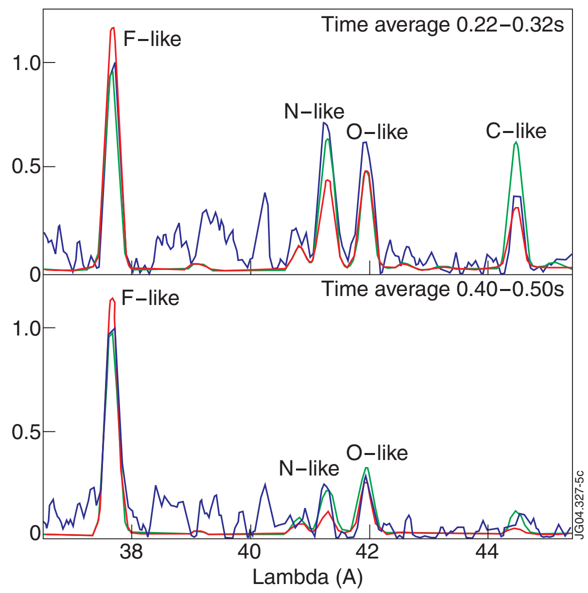

Figure 5: Experimental (blue) and simulated (green and red) FTU averaged spectra (corresponding top and bottom $T_e(0)$ ~6 and ~3.5keV). Colors same as in Fig.4. For normalisation see Fig.3.