

Modelling of the density modifications in front of the LH launcher during gas injection in ITER

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In the JET tokamak, it was demonstrated that injecting gas in the outer mid-plane (OMP) can result in a peripheral plasma density increase, which improves the Lower Hybrid (LH) wave coupling. Gas puffing proved to be useful in JET particularly in cases with a relatively large distance of about 10 cm between the LH grill mouth and the plasma [1]. It was shown by EDGE2D modelling that the increase in the Scrape-off-Layer (SOL) density and the consequent LH wave coupling improvement can be explained by ionisation of the SOL neutral due to heating by the LH wave [2]. In contrast to the computational grid for configurations considered in [2] that have a SOL width of about 10 cm (Fig. 1, right) at the OMP, ITER relevant magnetic configurations, with the 2nd

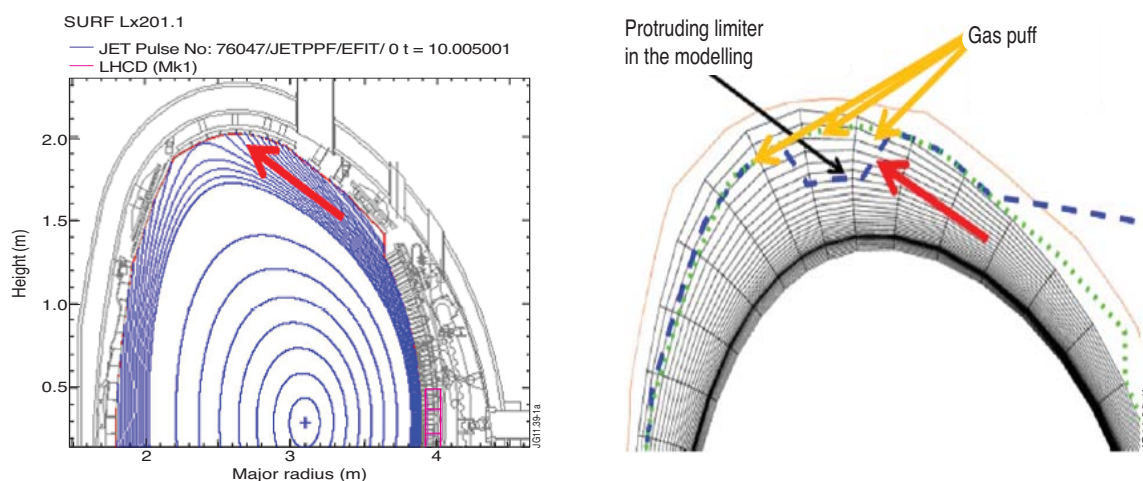


Fig. 1. Left: Iter-like geometry with the 2nd X point near to the top. Right: Wide OMP SOL grid of the shot #66972 with the top limiter. Top gas puff location in the modeling is indicated by yellow arrows. Red arrows indicate flows to the wall (left)/top limiter (right).

* See the Appendix of F. Romanelli et al., Proceedings of the 23rd IAEA Fusion Energy Conference 2010, Daejeon, Korea

X point at the top, have only a several cm wide SOL in the OMP (Fig. 1, right). The EDGE2D computational grid is restricted to a rather narrow OMP SOL layer in these ITER relevant configurations, which excludes the study of processes more distant from the separatrix using EDGE2D. In the modelling, we have attempted to overcome this problem by introducing a limiter (particle sink) protruding radially down from the top, cf. the dashed blue line in Fig. 1. Then, the locations radially near to the grill mouth are connected to the wall (particle sink), similarly to the above mentioned ITER-like configuration with a 2nd X-point at the top. A comparison of the computed plasma density for a top gas puff of $1.e22$ el/s (black solid line), the same puff rate injected from the OMP, similar to GIM6 in [2] (green dashed line), and no puff (red dotted line) is shown on Fig. 2.

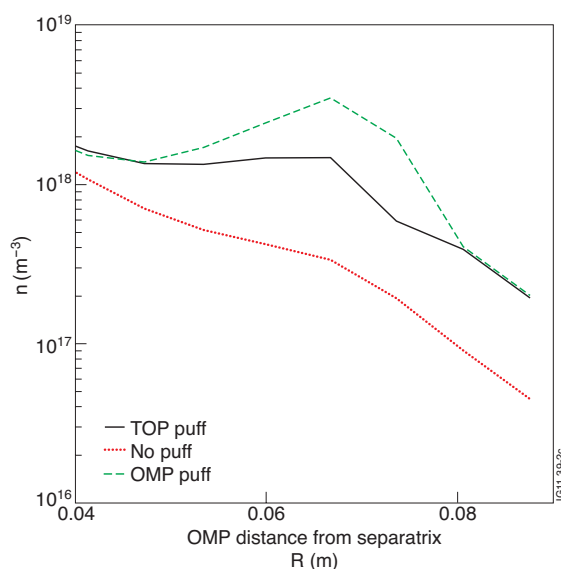


Fig. 2. Comparison of the top and OMP gas puff efficiency for the configuration with the top limiter as shown in Fig.1.

It is assumed that 150 kW of the LH power is dissipated in the radial layer between 5 and 8 cm in front of the grill mouth. It means that the grill mouth is assumed to be located at about 8 cm from the separatrix at the OMP. It is obvious that the top gas puff is much less efficient than the OMP gas puff for density enhancement in the OMP near the LH grill mouth and for the corresponding coupling amendment. This is consistent with the results obtained in JET experiments where the effect of top gas injection on the LH coupling was assessed [3]. Fig. 3 indicates how much the top puff has to be enhanced in order to obtain similar OMP density values as for the OMP puff of $1.e22$ el/s. It is seen from Fig. 3 that it is necessary to enhance the top puff three times, in order to obtain similar OMP density as with the OMP puff.

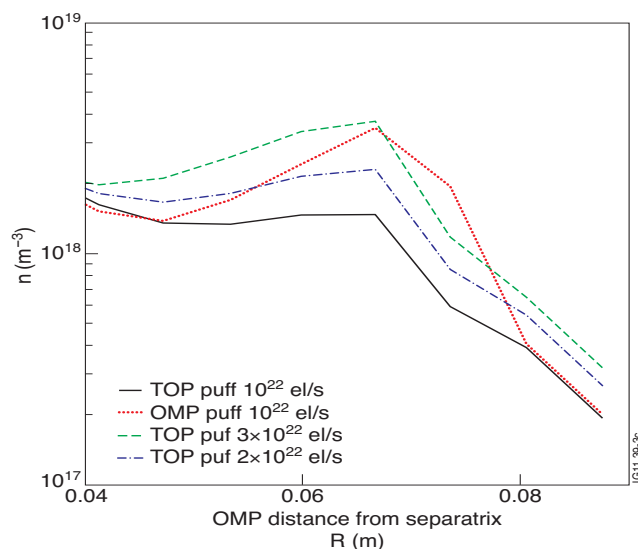


Fig. 3. Comparison of various values of the top gas puff in ITER-like configuration with the OMP gas puff: top puff $1.e22$ el/s - black solid line; $2.e22$ el/s - blue dot-dashed line; $3.e22$ el/s green dashed line; OMP puff $1.e22$ el/s - red dotted line.

We also shifted the top gas puff locations to both sides from the top of the configuration, with no significant difference in the gas puff efficiency for the OMP density increase.

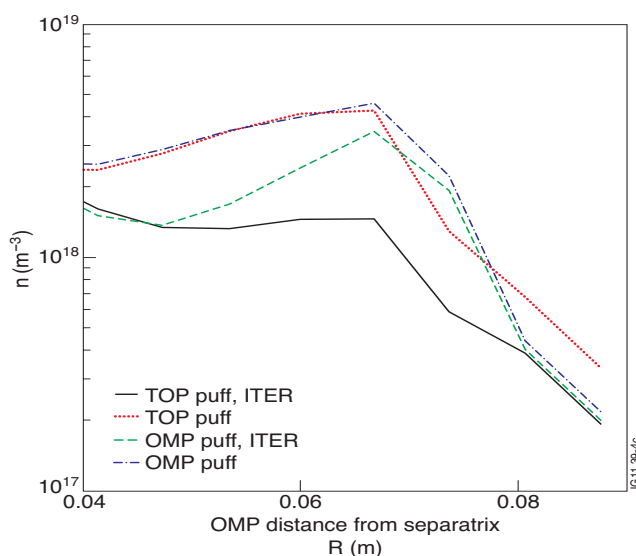


Fig. 4. Comparison of the OMP density increase for top and OMP gas puff in configurations with (ITER-like configurations) and without the top limiter.

As Fig. 4 demonstrates, this large difference between the top and OMP gas puff efficiency is specific for the ITER-like configurations with the 2nd X point near to the top of the machine. The black solid line and the green dashed curves show top and OMP puff of $1.e22$ el/s in ITER-like configuration with the top limiter, while the red dotted and the blue dot-dashed curves show top and OMP puff of $1.e22$ el/s in the configuration with no top

limiter. Obviously, the configuration with the top limiter (i.e. ITER-like configuration) has lower gas puff efficiency than the configuration with no top limiter, and the top puff is very inefficient in ITER-like configurations. The modeling also shows (Fig. 5) that the top puff enhances at the top the far SOL density a bit more than the OMP puff, both in the configurations with and also without the top limiter. This is consistent with the density enhancement measured at the top by the Li-beam [3] (two grid steps to the right from the top limiter, Fig. 1), while the LH coupling remained bad, i.e., the OMP density was not enhanced sufficiently for the coupling amendment, even if the top far SOL density increased.

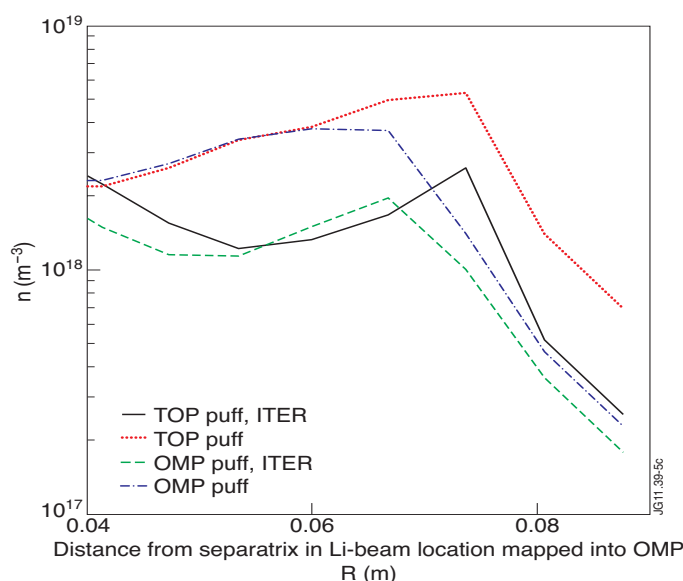


Fig. 5. Comparison of the density increase at the top (in the Li-beam location) for the top and OMP gas puff in configurations with (ITER-like configurations) and without the top limiter.

Similarly as in Fig. 4, the black solid line and the green dashed curves show top and OMP puff 1.e22 el/s in ITER-like configuration with the top limiter, while the red dotted and the blue dot-dashed curves show top and OMP puff 1.e22 el/s in the configuration with no top limiter. In conclusion, the modeling shows that much higher gas puff rates for the top gas puff are needed for an appropriate LH coupling improvement in ITER relevant configurations.

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