Transport modeling of the Globus-M tokamak edge plasma.

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The reduction of heat loads to the material walls and divertor targets is the key issue of a future tokamak reactor. Recently a heuristic drift-based model of heat transport at the tokamak edge plasma was introduced [1], and then tested versus data from large machines like ASDEX Upgrade and JET [2]. The corresponding scaling predicts the power scrape-off width in the ITER H-mode to be 1 mm, which is critical for ITER operational performance.

In this report we present transport study of the edge plasma of Globus-M spherical tokamak, which has smaller values of plasma current and power – the main parameters scrape-off width depends on according to Goldston's scaling [2]. Consequently, with the Globus-M data the Goldston's scaling can be verified against data in wider range of tokamak operational parameters.

For analysis chosen were the NBI-heated shot #29076, $I_{pl}^{29076}=185$ kA, and the OH shot #30095, $I_{pl}^{30095}=170$ kA, (both in double-null divertor topology with active lower X-point) so we can study the power dependence of SOL width λ_q. Unfortunately, the more important plasma current (I_{pl}) scan still was not performed on Globus-M.

The transport processes were modeled by coupling of 1D core and 2D edge transport codes (namely ASTRA and B2SOLPS5.2) [3]. This coupling procedure, briefly described in [3], results in continuous self-consistent profiles of density, temperature, particle and heat fluxes from the magnetic axis up to divertor targets. Values of anomalous transport coefficients were fitted in order to reach satisfactory agreement between calculated profiles and experimental data, coming from Thomson scattering, Langmuir probes, infrared camera and Doppler reflectometry. According to previous results of Globus-M transport modeling [4], anomalous ion heat conductivity was set to zero being much less than the neoclassical one.

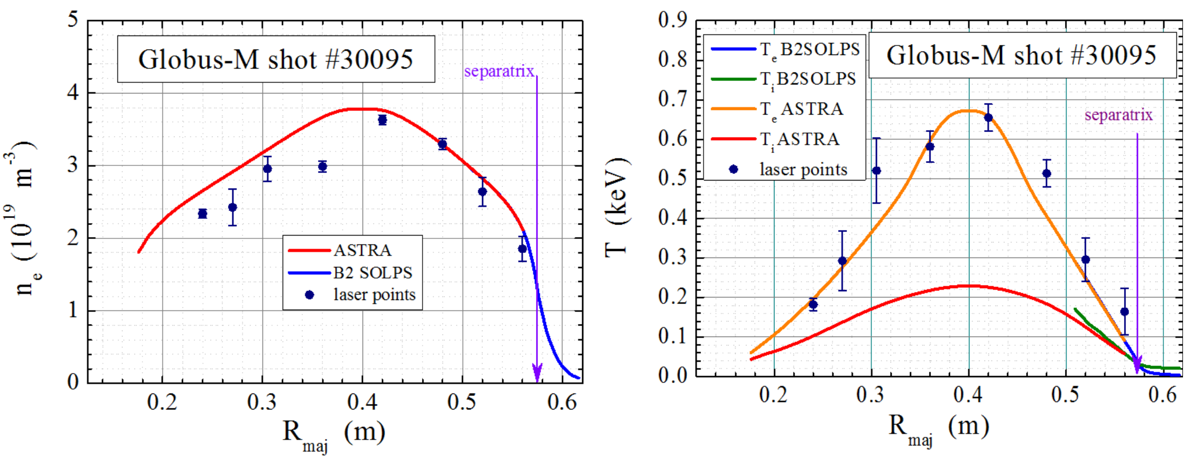

Figure 1. Calculated profiles of density and temperature at outer midplane.

Results of such an integrated modeling for the ohmic shot #30095 are presented in

Figures 1-5. One can see the reasonable agreement between calculated and measured [5] profiles both in the core and on the low field side (LFS) bottom target. In Fig. 5 the best exponential fit to the calculated temperature profile with decay length $\lambda_q^{(fit)}=11$ mm and an exponential curve with decay length by scaling [1] $\lambda_q^{G}=8.1$ mm are plotted.

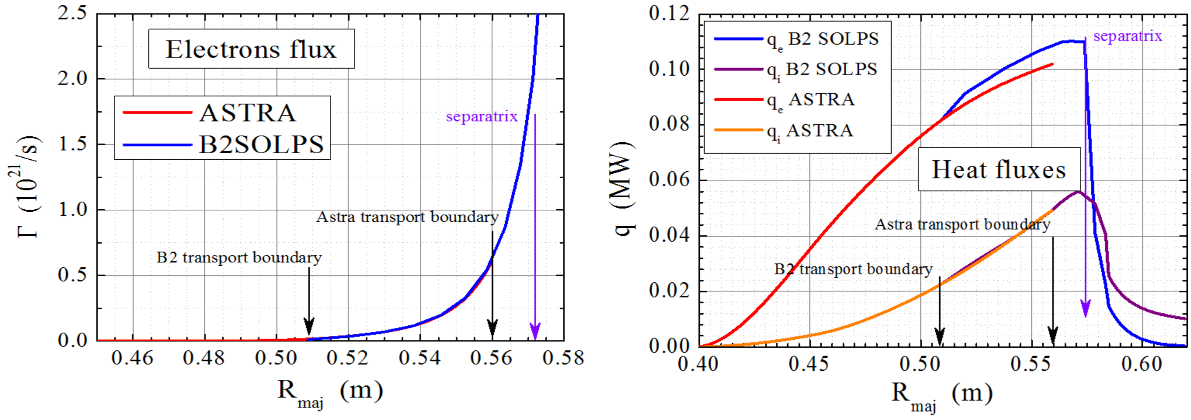

Figure 2. Calculated profiles of particle and heat fluxes.

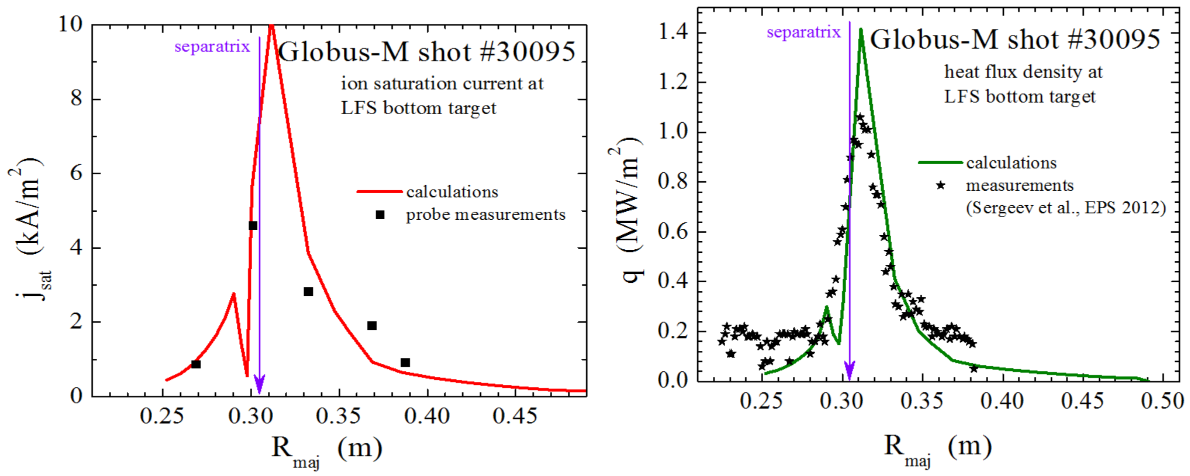

Figure 3. Calculated ions saturation current and heat flux density at outer bottom target compared with experimental data [5].

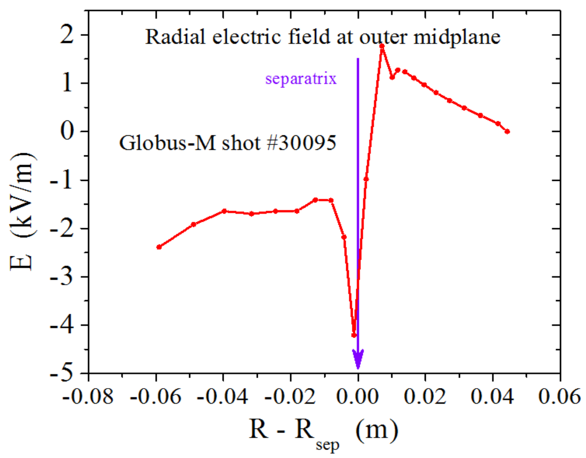

Figure 4. Radial electric field at outer midplane.

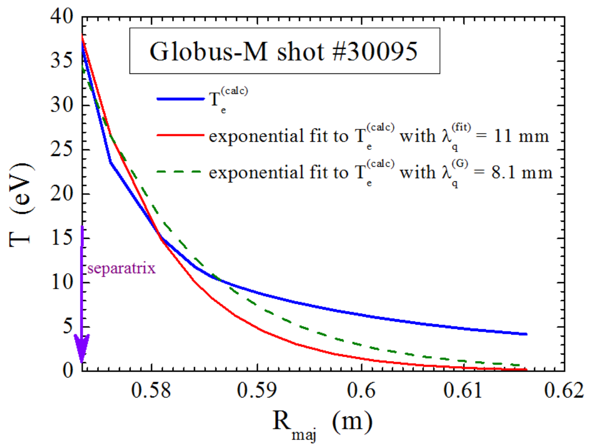

Figure 5. Calculated electrons temperature decay at outer midplane and comparison to Goldston's scaling [1] with $\lambda_q^{G}=8.1$ mm.

More interesting is the NBI-heated discharge #29076, because of the clearer evidence of L-H transition. Results of modeling are presented in Figures 6-9. One can see that values of heat flux density and ion saturation current increase with higher discharge power, while the reduction of characterizing width of these profiles is not so significant.

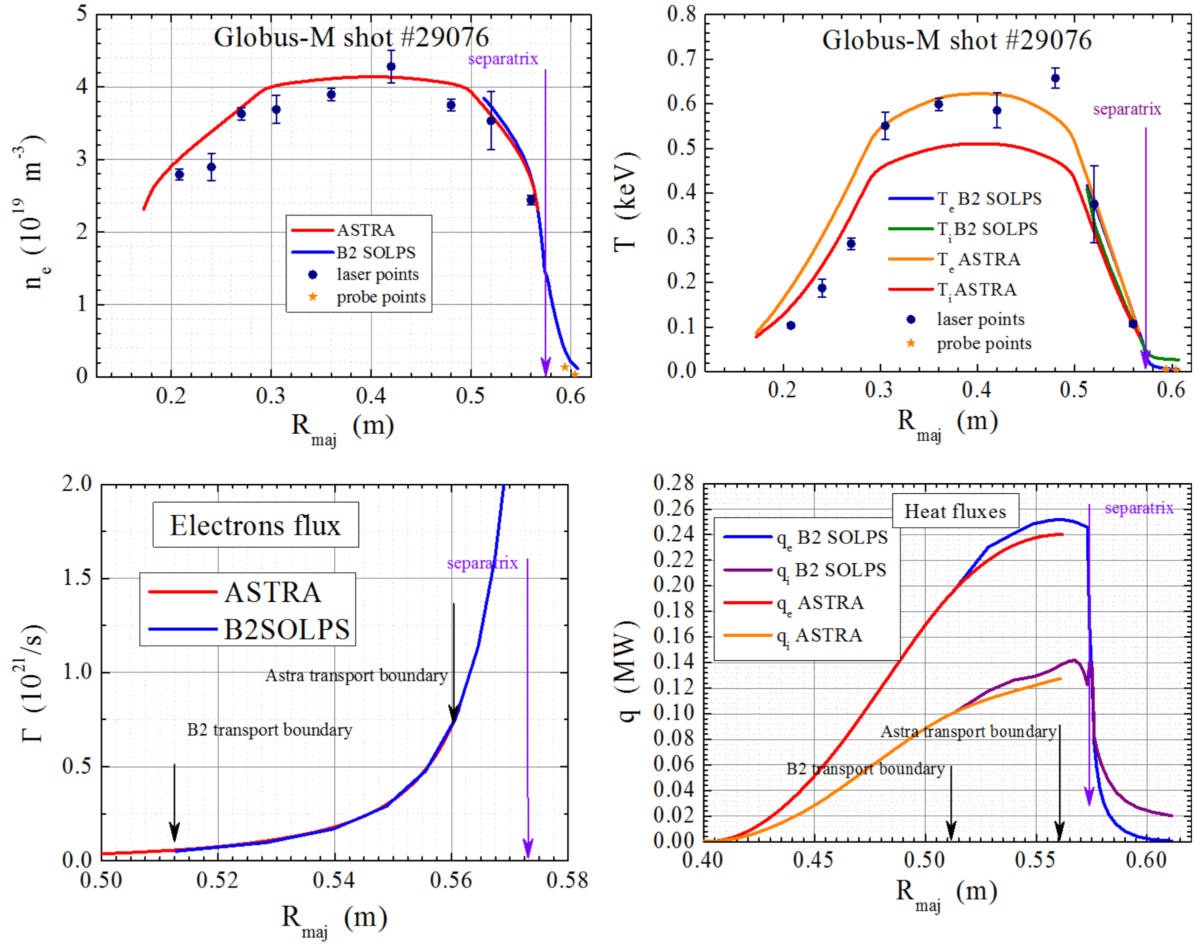

Figure 6. Calculated profiles of density and temperature at outer midplane.

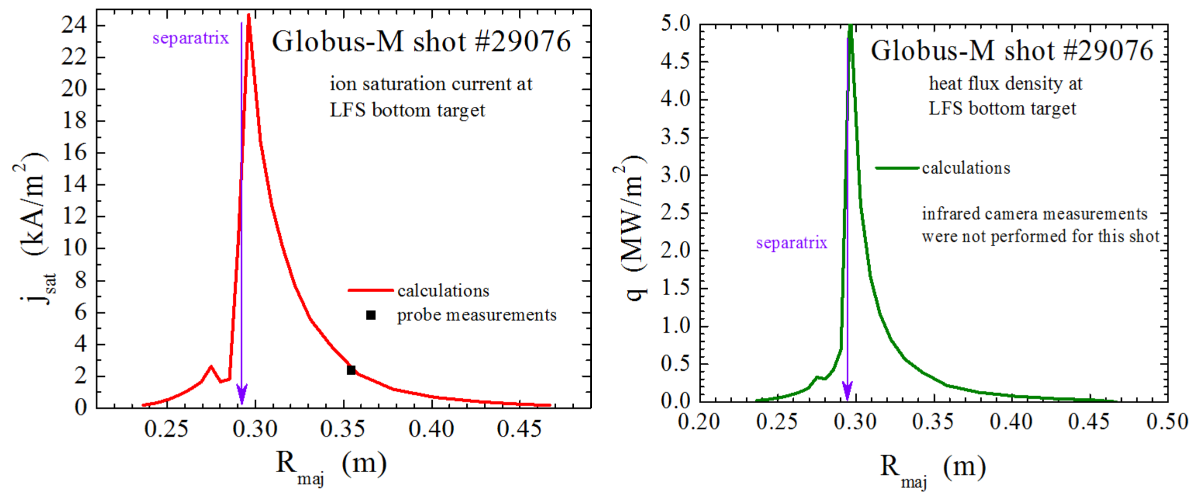

Figure 7. Calculated ions saturation current and heat flux density at outer bottom target .

The comparison to Goldston's scaling, which gives for the SOL width $\lambda_q^G = 7.1$ mm for the parameters of Globus-M shot #29076, is presented in Figure 9.

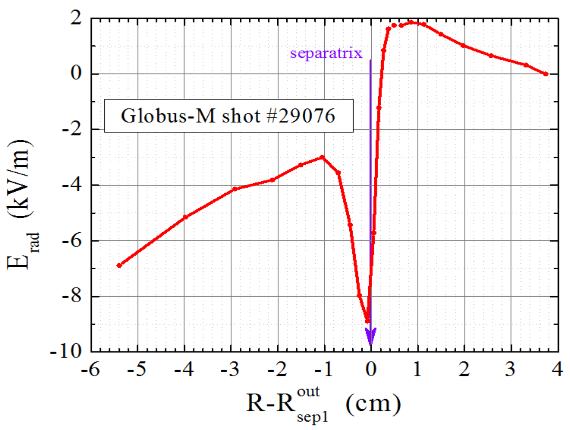

Figure 8. Radial electric field at outer midplane.

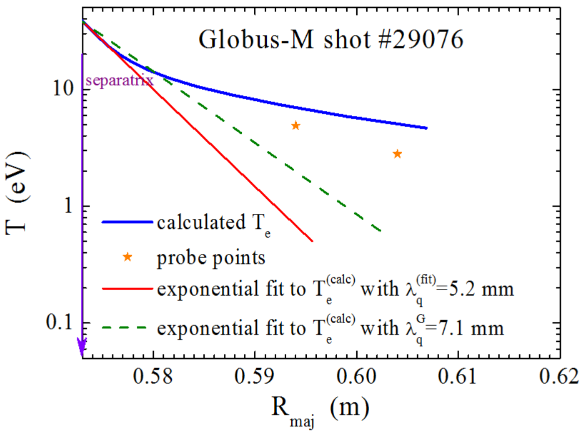

Figure 9. Calculated electrons temperature decay at outer midplane and comparison to Goldston's scaling [1] with $\lambda_q^G = 7.1$ *mm*

In Figure 10 predictions of Goldston's scaling [1] versus measured SOL width λ_q for several tokamaks are plotted. The asterix on this viewgraph represents result of modeling of the NBI-heated disharge in the Globus-M tokamak (instead of the experimentally measured width we plot the width as deduced from modeling, the ohmic case demonstrated the good agreement between both justifying this approach).

Thus we can conclude that the coupling scheme of ASTRA and B2SOLPS5.2 transport codes with self-consistent account of such important processes as NBI heating, neoclassical ions heat transport, drifts and currents, neutral atoms distribution, can reproduce experimental data with reasonable accuracy. The SOL width eliminated from such a modeling satisfactorily agrees with the prediction of Goldston's scaling [1].

Further studies of the edge transport and SOL width measurements are planned for future Globus-M experimental campains.

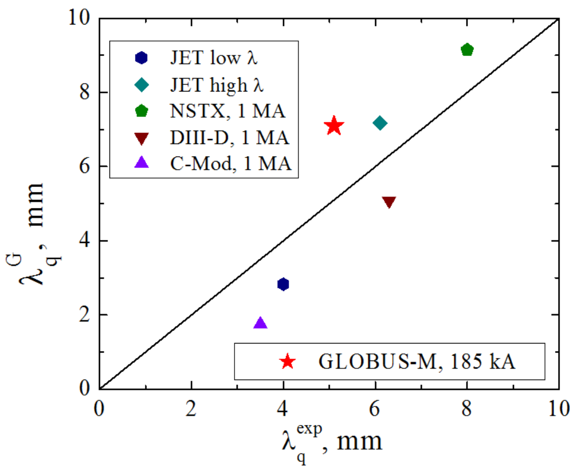

Figure 10. Comparison of Goldston's [1] scaling predictions with measured SOL width.

Acknowledgements

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