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First Results from B2SOLPS5.0 Plasma Edge Modeling for the MAST Spherical Tokamak

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Introduction

Modeling of the edge plasma for the MAST spherical tokamak was performed with the B2SOLPS5.0 code with drifts and currents for L-mode regimes. Two shots were analyzed: shot 5498 corresponds to a quasi single-null (SND) divertor configuration (distance between two separatrixes 8 mm), while shot 7138 (distance between two separatrixes 1 mm) corresponds to a quasi connected double-null divertor configuration (CDN).

Simulation results

The transport coefficients used in the simulations are chosen to match the experimental data and are given in table 1. They are independent on radius and poloidal angle. The anomalous viscosity coefficient $\eta = nm_iD$. The plasma density, the ion and electron temperatures at the inner boundary are also given in table 1. These temperatures were chosen to provide the experimental heat flux (P_{LOSS}) from the core divided equally between the electron and ion channels. The gas puff $\Gamma = 6.0 \cdot 10^{21}\ particles/s$ for both shots was imposed at the outer midplane. Calculated and measured profiles of electron temperature and ion saturation current along the plates are shown in Figs.1-2 for shot 7138. The comparison between the (TS) data and calculated density and electron temperature profiles at the inner mid-plane for shot 5498 is shown in Fig.3.

Table 1 cross field transport and core parameters used in the simulation

Shot	D m^2s^{-1}	κ_e/n_e m^2s^{-1}	κ_i/n_e m^2s^{-1}	$n_e\|_{core}$ $10^{19}m^{-3}$	$T_e\|_{core}$ eV	$T_i\|_{core}$ eV	P_{LOSS} kW
5498	1.5	2.5	2.5	1.8	90	100	420
7138	1.0	2.5	1.5	1.8	120	188	500

Since the position of the separatrix is not exactly defined the calculated curves were shifted to match the experimental ones. The matching of the slopes of calculated and observed profiles is reasonable. The D_α signal in the equatorial mid-plane for the same shot is shown in Fig. 4. The corresponding profiles for shot 7138 are very similar.

As seen from the comparison, the simulation reproduces the experimental data. The accuracy is determined by the restrictions of the fluid model for neutrals used in B2SOLPS5.0 similar to other tokamaks, e.g. ASDEX Upgrade. In particular, flux-limiting corrections in perpendicular neutral heat and particle fluxes are important for MAST. Note, however, that there is no much flexibility in choosing the transport coefficients since the matching to all experimental data imposes rather severe restrictions on their values. As in the experiment, the main energy flux goes to the outer divertor plates. The ratio of energy flux to the outer plates and the energy flux to the inner plates is 2.5 for shot 5498 and 2.7 for shot 7138. This ratio could be amplified if the ballooning nature of the transport coefficient was assumed.

The radial electric field profiles at the outer mid-plane are shown in Figs. 5-6 for two shots. In the core region the radial electric field is close to the neoclassical electric field, as in ASDEX-Upgrade [1]. The value of the electric field in MAST is significantly smaller, while the shear of the poloidal $\boldsymbol{E}\times\boldsymbol{B}$ drift is of the same order due to the smaller toroidal magnetic field at the outer mid-plane. In the scrape-off layer the poloidal $\boldsymbol{E}\times\boldsymbol{B}$ drift is nearer to the poloidal sound speed than in ASDEX Upgrade especially at the outer part of the SOL. The parallel velocity at the outer mid-plane is negative (in the co-current direction), its poloidal profile is shown in Fig. 7 for shot 7138.

Conclusions

1.First simulations of spherical tokamak MAST were performed with B2SOLPS5.0 code.

2.Results of the simulations are in reasonable agreement with probe measurements of the electron temperature and saturation current at the divertor plates, with the radial profiles of D_α signal at the outer mid-plane and with the mid-plane density and electron temperature profiles obtained from a Thomson scattering (TS) system.

3.The core radial electric field in the vicinity of the separatrix is close to the neoclassical value, as obtained previously for ASDEX Upgrade.

References

1. V. Rozhansky et al Nucl. Fus. **42** (2002) 1110.

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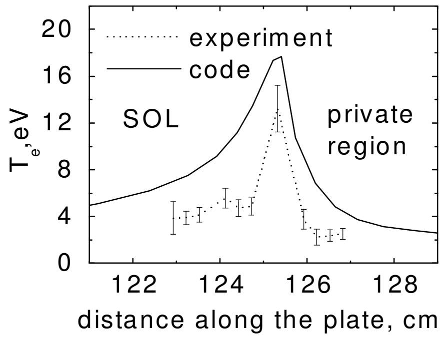
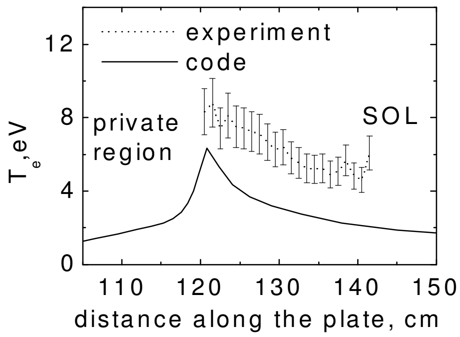
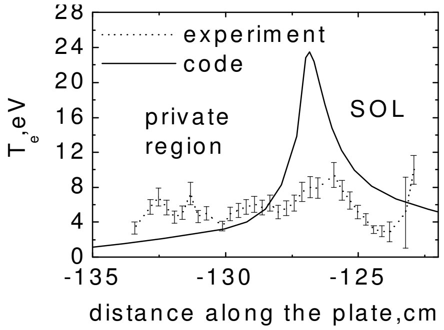
Fig.1. Electron temperature profiles along the divertor plates. Comparison of B2SOLPS5.0 results with probe measurements for shot 7138.



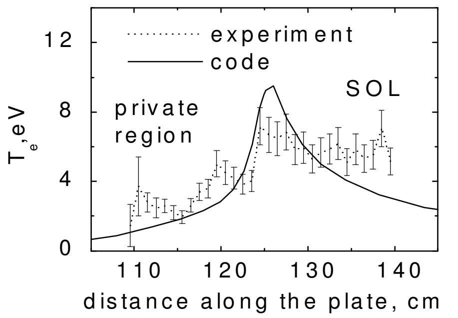
(a) Inner upper plate



(b) Outer upper plate

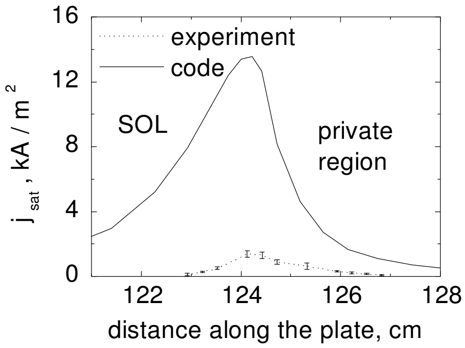


(c) Inner lower plate

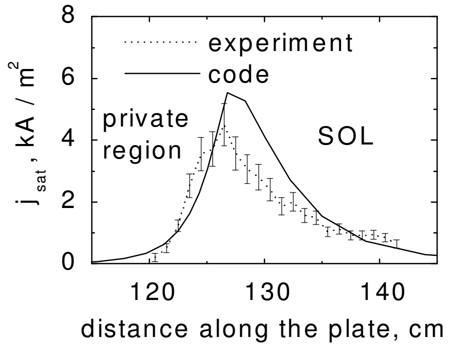


(d) Outer lower plate

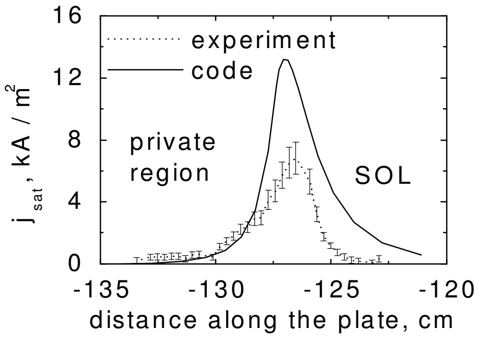
Fig.2. Ion saturation current profiles along the divertor plates. Comparison of B2SOLPS5.0 results with probe measurements for shot 7138.



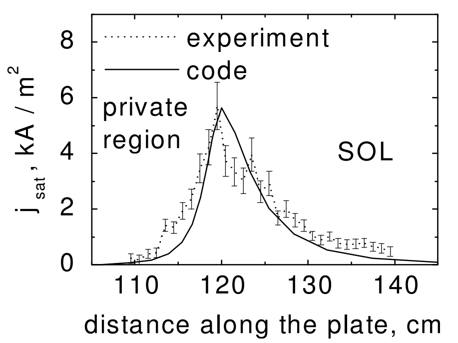
(a) Inner upper plate



(b) Outer upper plate



(c) Inner lower plate



(d)Outer lower plate

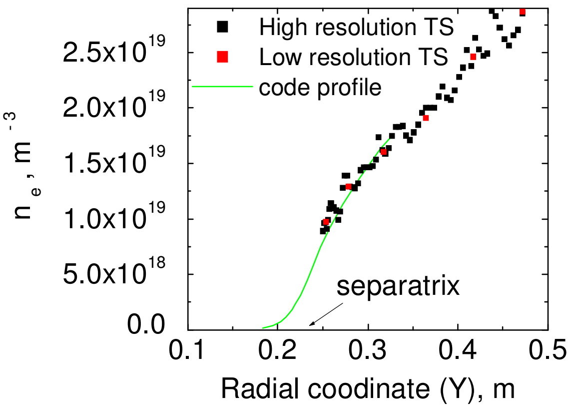


Fig.3 (a). Comparison of calculated density profile and TS data at the inner midplane for shot 5498.

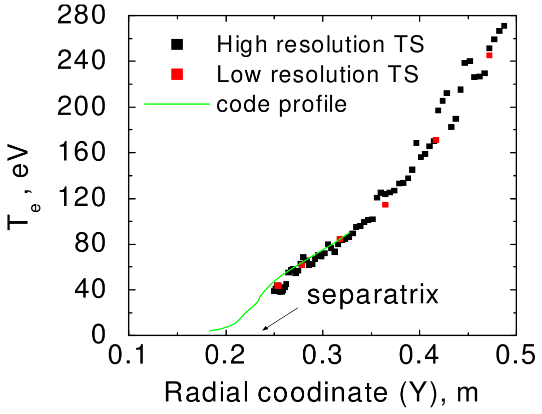


Fig.3 (b). Comparison of calculated electron temperature profile and TS data at the inner midplane for shot 5498.

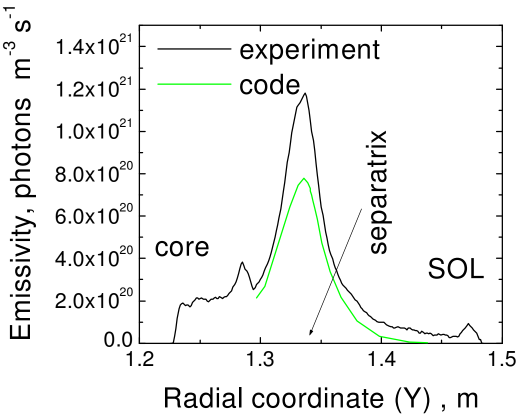


Fig.4. Radial profile of D_α emission at the outer midplane. Code calculation for shot 5498.

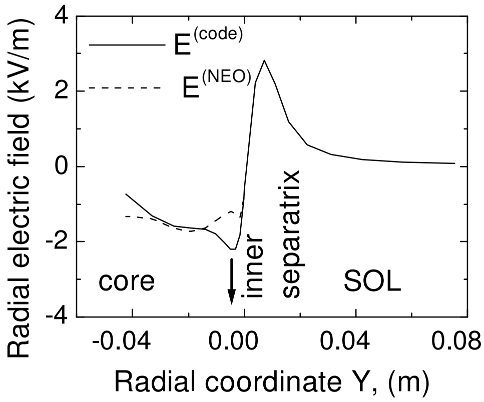


Fig.5. Radial electric field profile for shot 7138.

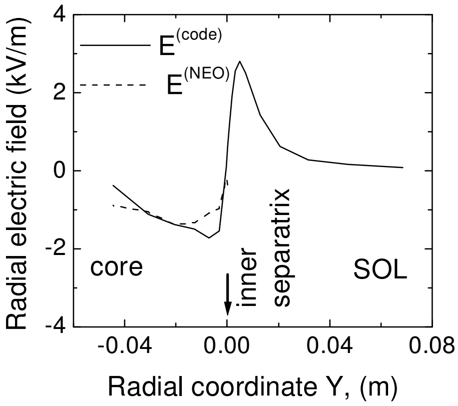


Fig.6. Radial electric field profile for shot 5498.

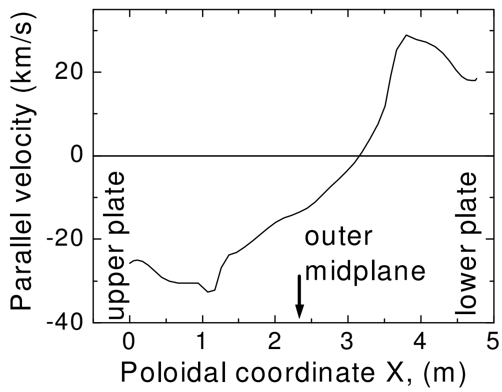


Fig.7. Poloidal profile of parallel velocity in the outer SOL for shot 7138.