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# Theory-based Modeling of the Effect of Neutral flux on Pedestal Density Width

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The width of the edge transport barrier(ETB) that sustains H-mode plasmas is a critical paramter for the reactor relavent next step tokamaks. Using the theory-based transport models, ETB simulations are carried out with B2 solps 5.0[1] package focusing on the effect of the neutral fluxes in the main chamber on the pedestal structure. Recently, in DIII-D and in JET, the density width has been correated with to the penetration length in the edge plasma[2]. In ASDEX Upgrade, on the other hand, no clear variation in the width of the density width has been reported[3]. In this work, therefore, this issue is investigated with the theory-based transport modelling, changing the incomming neutral fluxes in the main chamber. For the transport models, the electrostatic multi-mode model(MMM)[4] and the electromagnetic drift-Alfven(DA) turbulence[5] are considered and the corresponding transport coefficients(D, chi_e, chi_i) are used for the solps simulations. In the MMM model, ITG/TEM modes and resistive and kinetic balloning modes are included and in the DA model, the drift-Alfven mode is considered. The effect of eingen-mode structure of the ideal Ballooning instability is not considered in this work. To determine the ExB shearing rate, the neoclassical radial electric field(Er) in the ETB is calculated with the coupled NCLASS[6] routine. The magnetic geometry used in the work is the double-null configuration of The KSTAR tokamak which is under construction in Korea.

The details of the simulations are as follows. For the boundary conditions at the core boundary, the NBI heat and particle flux are used. To study the effect of the main chamber wall clearance, the three computational meshs are used, with R_wall-R_sep are 2, 5, and 8 cm. The radial electric field($E_r$) is calculated following the neoclassical radial momentum balance, $E_r = \frac{T_i}{e}\left(1.0\frac{d\ln n_e}{dr} + \chi\frac{d\ln T_i}{dr}\right) - b_x\left\langle V_{\parallel}B\right\rangle$, where $V_{\parallel}$ is the velocity of ion parallel to the external magnetic field and <...> is the flux surface averaging. The r is the radial cordinate. $T_i$ and $n_e$ are the ion temperature and the electron density. $\chi$ is the ratio of neoclassical viscosity coefficient and is calculated with NCLASS routine, covering the wide range of collisionality in the ETB. For typical plasma in the ETB, the V_par term is negligible compared to the gradient terms and is neglected in this work. The transport reduction model in the ETB due to ExB shearing rate is considered with the following formula, $D_{\perp}^{ETB}(\chi_{e,i}^{ETB}) = \frac{D_{\perp}^{turb}(\chi_{e,i}^{turb})}{1+\omega_{ExB}^2/\omega_c^2}$, where D, $\chi_{e,i}$ are the radial diffusion coefficient and the electron and the ion thermal difusivities in the ETB, $\omega_c$ is the critical shearing rate from the turbulent model(about ~1e6 $VT/m^2$), $\omega_{ExB}$ is the ExB drift shearing rate(=$\frac{dv_{ExB}}{dr}$). The q_edge is 3.5 and the magnetic shear is from 2.5-5.0. The Scrape-off layer is modeled with the constant transport coefficients(~4 $m^2/s$) and the constant decay length boundary conditions at the main chamber wall. In case of mmm model, D is reduced by factor of two, for D from the resisitive ballooning mode is overestimated in the model.

The plasma profiles in the ETB are compared for the L-(2MW input pwer) and H-(4MW input power) modes in fig.1, using the DA turbulence transport model. The H-mode transition is, largely, due to the steeper $T_i$ gradient from the high input power which generates the larger $E_r$ and $\omega_{ExB}$. The width of pedestal is about 1.5cm for $\omega_c$ =1.e6. The transport reduction in the ETB is well reproduced with this model but the relatively higher $\chi_i$ is predicted compared to $\chi_e$ . However, the Ti and Te profiles are similar due to the energy loss in the electron channel from the neutral ionization process.

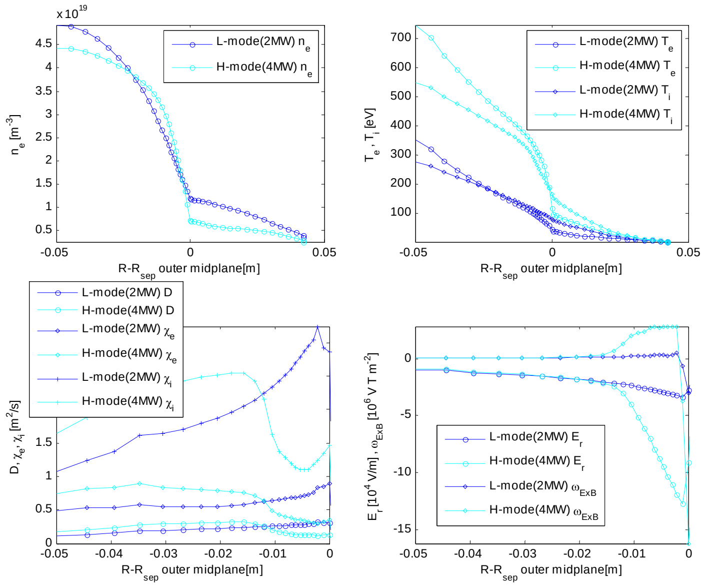

*Fig.1. L- and H- modes comparison with DA transport model*

In fig. 2. the dependence of the pedestal width on the wall crearance is shown for DA model. For the narrower wall clearance, the main chamber wall recycling is increased and the ETB is narrowed at the same time and the transport reduction from ExB is decreased. The density is increased due to the large main chamber neutral flux for the narrow mesh case. For the narrower wall clearance, Te and Ti presdestal is very weak due to the strong ionization process and

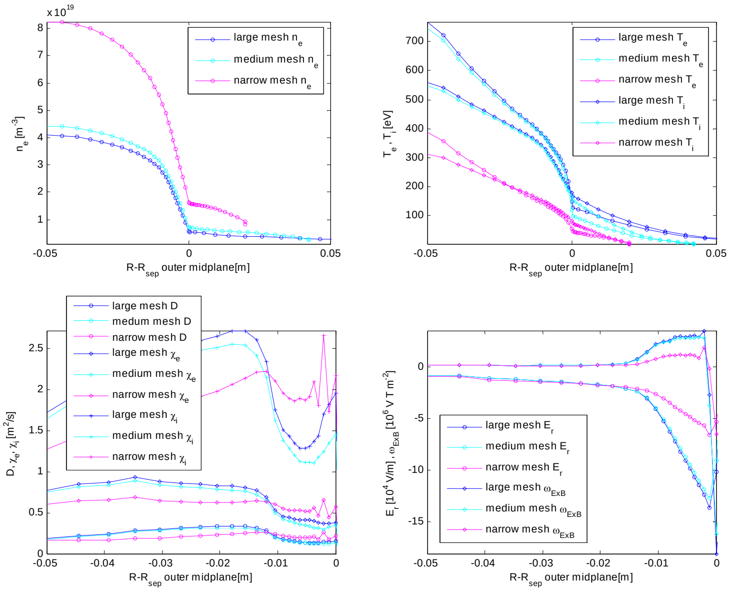

*Fig.2. The dependence of the pedestal width on the wall-clearance with DA transport model*

heat transfer between the electrons and the ions. For the comparison with experimental data, the determination of the wall clearance and the main chamber recycling process is necessary.

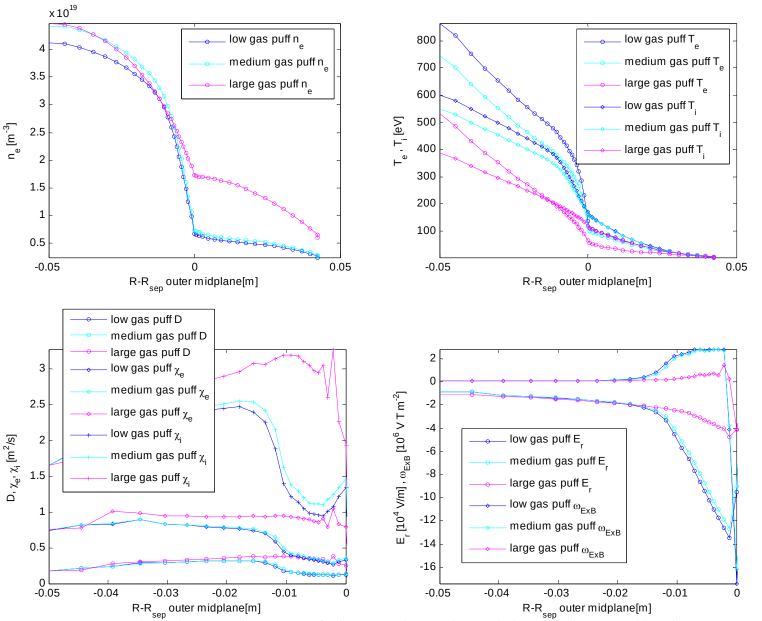

*Fig.1. The dependence of the pedestal width on the wall-clearance with DA transport model*

In fig.3, The dependence of the pedestal width on the the main chamber gas puffing is shown. The lower the gas puff, the width of ETB is larger and this behavior is explained with the similar argument as the case of the wall clearance. Sumarizing the results, ETB is simulated with the theoretical transport model(DA turbulence) and the ETB structure is well reproduced. As the main chamber wall recycling is increased, the pedestal width is decreased due to the increased ionization sources and density(further detail will be presented in the poster). The comparisons with the experimental data will be of great interest.

## References

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