# Transport Simulations for the Scrape-off Layer and Divertor Plasmas in KSTAR Tokamak

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## Abstract

Two-dimensional simulation results are presented for the transport of plasma in the edge scrape-off layer region of KSTAR discharges by using B2.5 code. The code uses the classical model for parallel transport along the magnetic field and includes the cross-field drifts together with anomalous radial transport. The effects of drifts on particle distribution and divertor power dispersal are investigated and discussed. It is found that the drifts give rise to density spreading near the divertor, resulting in the reduction of heat load to the divertor.

*Key words:* transport simulation; divertor plasma; drifts

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## 1. Introduction

The control of power and particle exhaust in tokamak edge region is one of the important issues in tokamak physics. The large power loss onto plasma-facing materials such as divertors is a critical obstacle to the progress of tokamaks toward a fusion reactor. To resolve this problem, the edge plasma transport should be understood in advance because the heat removal on the divertor through dispersive loss mechanisms such as radiation is mainly governed by the distributions of the background plasmas.

In this study, we investigate the characteristics of the edge plasma transport in KSTAR discharges by using the B2.5 code, focusing on the effect of cross-field drifts on the plasma transport near the divertor. The drift is believed to affect significantly plasma performance, e.g. it leads to edge turbulence reduction in the pedestal-gradient regions and causes asymmetries in the divertor plasmas. Our results emphasize the importance of drifts in divertor power dispersal and reduction.

## 2. Model descriptions

The model of the B2.5 code uses classical processes of parallel transport along the magnetic field and cross-field drifts caused by $\nabla B$, electric field, viscosity, collision, and inertial forces[1]. It also includes anomalous radial transport by using assumed transport coefficients. It solves the set of the fluid equations describing particle, parallel momentum, charge, and energy conservations. A self-consistent electrostatic potential is calculated from charge conservation.

## 3. Results

The simulations are carried out in double-null KSTAR geometry, whose major and minor radii are 1.8 and 0.5 m, elongation and triangularity are 2 and 0.8, and toroidal B field is 3.5 T, respectively. The input power and the plasma density at the core

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boundary are given as 4 MW and $3 \times 10^{19}$ $\mathrm{m}^{-3}$. We use L-mode like transport coefficients, 2 and 4 $\mathrm{m}^2/\mathrm{sec}$ for anomalous particle and thermal diffusivities. To investigate the drift effects, we obtain the results for the three cases. No drifts, only diamagnetic drifts, and all drifts are switched on, in cases I, II, and III, respectively.

In Fig. 1, the density profiles of $D^+$ near the bottom divertors are presented for the cases I and III. The arrows in Fig. 1 (b) represent for the $\mathbf{E} \times \mathbf{B}$ drifts. The result for the case I shows the highly-peaked density in front of the divertors, which are dispersed to a broader region by the drifts in case III, as shown in Fig. 1 (b). The $\nabla B$ drifts occur in the downward direction, leading to the higher density at the lower side and density spread in the inboard divertors. The $\mathbf{E} \times \mathbf{B}$ drifts induce more dispersed density distribution and reduce in-out asymmetry caused by the $\nabla B$ drift.

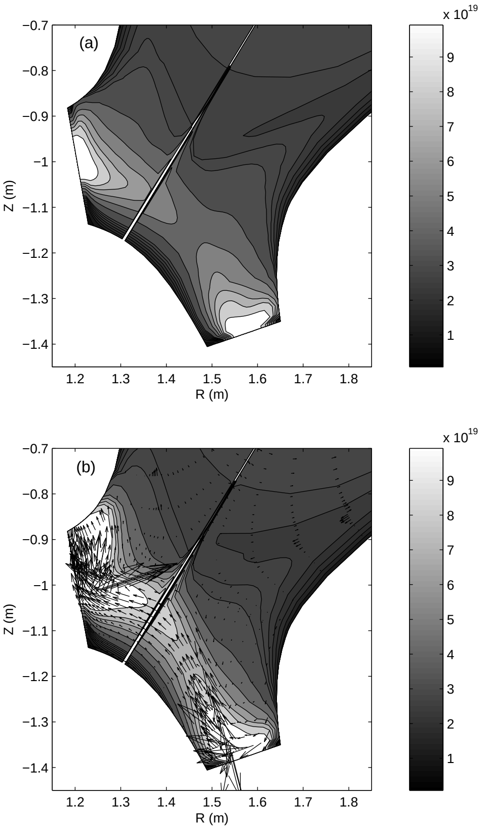

Fig. 1. Density profiles in (a) case I and (b) case III. The arrow in (b) stands for $\mathbf{E} \times \mathbf{B}$ flux.

Figure 2 shows heat fluxes to the bottom divertors. Since the electron temperature near the divertors is a few eV, the high density at this region leads to large volume recombination process and the high neutral density. As a result, the high density plasma is spread by $\nabla B$ and $\mathbf{E} \times \mathbf{B}$ drifts, and thus diminishes divertor power load through volume recombination, charge exchange and radiation losses, as shown in Fig. 2.

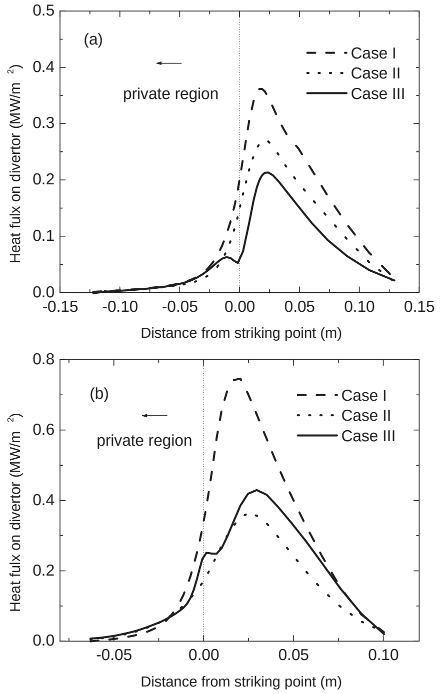

Fig. 2. Heat fluxes to (a) inboard and (b) outboard divertors in bottom region.

## 4. Summary

Two-dimensional simulations by using B2.5 code show that the cross-field drifts can affect significantly the edge plasma transport. The $\nabla B$ and $\mathbf{E} \times \mathbf{B}$ drifts disperse density distribution near the divertor, leading to divertor heat load reduction.

## Acknowledgements

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## References

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