Simulation study of the tungsten impurity transport in the scrape-off layer with electric drift effects

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In the future fusion reactor, tungsten (W) is considered as the preferred candidate of the plasma-facing material, due to its high conductivity, low sputtering yield as well as the low tritium retention. However, due to the high atomic number, the W could lead to significant radiation inside the core plasma, which means the concentration of W impurity in the core plasma has to be lower than $\sim 10^{-5}$ [1]. In the present tokamak device, the divertor configuration is generally adopted, where the plasma leaving the confined region will flow towards the divertor targets in the so-called scrape-off layer (SOL) along the open magnetic field line. As a result, the region having intensive plasma-surface interaction can be placed in a certain distance from the confined region, which implies the contamination of the core plasma with the impurity sputtered from the plasma-facing surface is reduced. In the divertor configuration, the W sputtered from the divertor target will be ionized in the divertor region, then transport along the SOL and reach the core plasma by cross-field transport from the main SOL around the confined region. Considering the extreme low limit on the W concentration inside the core plasma, it is of great importance to understand the transport of W impurity in the SOL.

DIVIMP [2] is a Monte Carlo code for simulating the impurity transport in the edge plasma. The transport of W impurity can be simulated on the background plasma, which could be obtained from 2-D fluid codes such as SOLPS-ITER [3]. It should be noted that the W impurity is considered as the trace impurity, which is assumed to have little influence on the background plasma (due to its low concentration). Along the field line (poloidal direction), the impurity ions is simulation in a manner of velocity diffusion, which is affected mainly by the friction force (due to the background plasma flow) and the temperature-gradient force (towards the high temperature side with lower collisionality, i.e. the upstream). While in the radial direction, the perpendicular transport is simulated in a manner of cross-field diffusion.

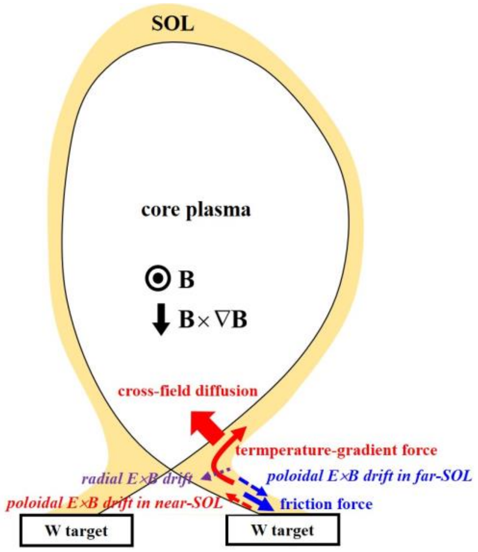

Figure 1. Sketch of the effects on the impurity transport in SOL.

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Recently, it is recognized that the electric ($E \times B$) drift has considerable effect on the SOL plasma transport [4 and reference therein]. It is also expected that the effect would be stronger for the impurity ions with high charge number. In this conference, we will report our recent work on the effect of electric drift on the impurity transport in the SOL [5]. As mentioned above, the background plasma with/without drift effect are simulated by SOLPS-ITER. The W transport is then simulated by DIVIMP. The electric drift of W ions are introduced as the poloidal and radial velocities calculated according to the electric field distribution obtained in SOLPS-ITER simulation. Therefore, it allows to study the indirect effect via background plasma and direct effect on the W ions, as well as the synthetical effect of electric drift in detail. It founds that the influx of W impurities into the confined region as well as the W concentration can be dramatically increased due to the effect of electric drift.

Keywords：impurity transport; tungsten; $E \times B$ drift; SOLPS-ITER; DIVIMP.

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BIOGRAPHY

Shifeng MAO has completed his PhD in 2009 from University of Science and Technology of China and continue his Postdoctoral studies there. He is now the associated professor in School of Nuclear Science and Technology, University of Science and Technology of China. He has published more than 80 papers in reputed journals.