Study of impurity tungsten transport and suppression in EAST Tokamak

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The impurity in fusion plasmas is generally produced by an interaction between edge plasmas and plasma facing components in the vacuum vessel, e.g., divertor plates, first wall and radio-frequency antennas. Impurity accumulation in core plasma can dilute the density of fuel ions, cool down the plasma, degrade the confinement performance and even result in plasma disruption. In particular, accumulation of heavy impurities such as tungsten (W) can breaks the energy balance through the huge radiation loss in the core region since the radiation loss power is a function of the atomic number. Since W divertor plates are used in ITER, suppression of W concertation in core plasma has become one of the most critical technique challenges for the steady-state operation.

ITER-like tungsten divertor has been used in EAST. Even wall conditioning methods, such as Lithium coating, are applied, plasma disruptions caused by impurity W accumulation also frequently happen during the EAST experimental campaign. The disruption not only degrade the first wall condition, but also threaten the device safety. Suppression of impurity W in the core region also becomes one the most important issues for achieving long-pulse operations in EAST. In this study, therefore, both on-axis electron cyclotron resonance heating (ECRH) and resonant magnetic perturbation (RMP) are applied to suppress impurity W accumulation in EAST. Impurity transport is also studied under the conditions of ECRH and RMP.

In EAST, space-resolved extreme ultraviolet (EUV) spectroscopy and X-ray crystal spectroscopy (XCS) have been developed to observe the spatial distribution and temporal behavior of core impurity emissions [1]. Recently, in order to obtain the W concertation in EAST plasma, absolute intensity calibration is conducted for the XCS system. Besides, Abel inversion technique is also developed for obtaining the radial profile of W^{44+} ions concentration [2]. In this study, the radial profiles of W LXV (3.9095 Å) emissions are used to analyze the W behavior in the core region.

Firstly, the effects of on-axis ECRH on W emissions are studied with the help of EUV and XCS systems. As shown in Fig.1, the W concentration dramatically decrease as ECRH applied. Then, the behavior of W emissions is also study under the condition of applying both on-axis ECRH and RMP. It is observed that the impurity W concentration in the core region of EAST plasma can be further reduced as RMP is supplied [2]. The impurity suppression efficiency of RMP is also studied against the RMP strength and RMP mode number.

The impurity transport behavior is also studied with one-dimensional impurity transport code STRAHL [4]. As the on-axis ECRH heating is applied, the diffusion coefficient in $0<\rho<0.6$ region are enhanced significantly. However, the value of inward convective velocity decreases at the same time. When the RMP is further applied, the inward convective velocity further decreases and even turns outward in the region of $\rho > 0.5$. It is thought that the on-axis ECRH and RMP increase the turbulence intensity in the core region, which changes the diffusion coefficient and the convective velocity of W ions. The reverse of the convective velocity may also contribute to the suppression of W concentration in core impurity density.

References

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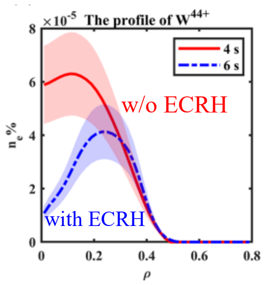

Fig. 1 The concentration profile of W^{44+} ions shows dramatic decrease in the core region as ECRH is applied.