§8. Observation of Low Diffusivity of Impurity Transport inside the Neoclassical Transport Barrier (ITB) in CHS

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In the Compact Helical System (CHS), the plasmas with neoclassical ITB are established in the ECH+NBI discharges where a thermal transport barrier results in a high central electron temperature of ~3keV. In order to study the particle transport inside the barrier, the diffusion coefficients for titanium impurity are evaluated both for the plasmas with and without neoclassical ITB as the indication of particle transport. Since the energy peak of impurity K-α lines depends on the impurity transport as well as electron temperature, the diffusion coefficients of impurity can be derived from the energy peak with the transport analysis based on the electron temperature measured [1].

Figure 1(a) shows the radial profiles of energy peak of titanium K_α lines for plasmas with and without neoclassical ITB measured with the soft x-ray CCD camera [2, 3]. For the case of plasma with neoclassical ITB, the energy peak shows good agreement with the calculation using MIST code with a low diffusion coefficient of 0.002m^2/s for ρ<0.7. The energy peak of the titanium K-α lines shifts from 4.73 keV to 4.64keV along the plasma radius where the electron temperature changes from 3 keV to 1.0 keV. On the other hand, a diffusion coefficient profile consistent to the plasma without neoclassical ITB is 0.12m^2/s just for the region near plasma center. The diffusion coefficient evaluated from the energy peak of titanium K-α lines in the plasma without neoclassical ITB is consistent with the particle transport coefficient estimated from the density profile in CHS (D~0.4 m^2/s at ρ=0.7).

How high the impurity ions are ionized is determined by the balance of time required for the ionization and particle confinement time. The MIST code gives the diffusion coefficients consistent with the peak energy of K-α lines. The energy peak of titanium K-α lines decreases as the diffusion coefficient exceeds 0.02m^2/s as shown in Fig. 1(b). The peak energy for the plasma with neoclassical ITB (solid line) is larger than that without neoclassical ITB (dashed line). The change of electron temperature alone can not explain the difference of peak energy of 4.73 keV (with neoclassical ITB) and 4.68 keV (without neoclassical ITB). The diffusion coefficient evaluated from the energy peak is <0.02m^2/s inside the transport barrier in plasmas with neoclassical ITB while it is 0.1-0.18m^2/s for the plasmas without neoclassical ITB. The two hatched areas indicate the error bar of peak energy of titanium K-α lines measured.

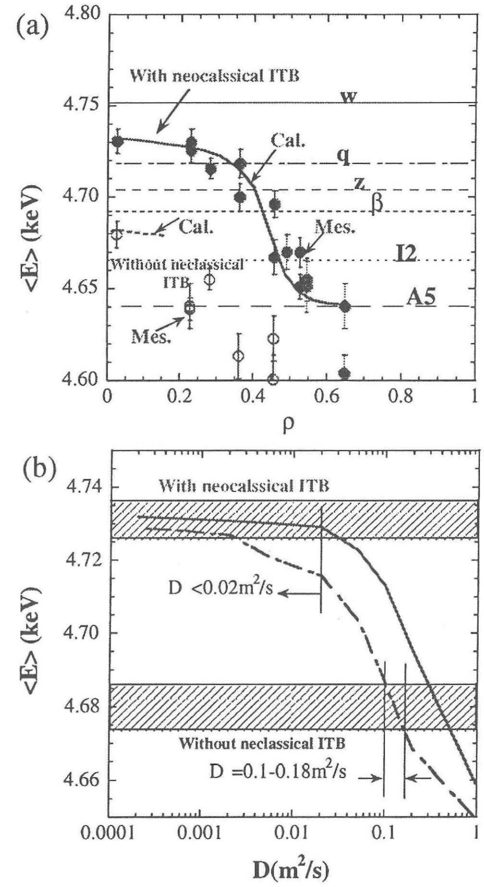

Fig1. (a) The energy peak of the titanium K-α lines as a function of radius measured and that calculated with MIST code with the diffusion coefficient with D_{core}=0.002m^2/s for ρ<0.7 and D_{edge}=1m^2/s for ρ>0.7 and D_{core}=0.12m^2/s for ρ<0.7 and D_{edge}=1m^2/s for ρ>0.7 for plasmas with (solid line) and without (dashed) neoclassical ITB, respectively. Horizontal lines indicate the energy of individual lines of K-α. (b) The energy peak of the titanium K-α lines as a function of diffusion coefficient of impurity transport for plasmas with (solid line) and without (dashed) neoclassical ITB, respectively.

References

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