# §4. Impurity Transport Analysis in the Plasma Periphery for the Closed Helical Divertor Configuration

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The Closed Helical Divertor (CHD) was constructed for peripheral plasma density control and efficient particle pumping. The CHD consists of three components: slanted divertor plates, a dome structure, and target plates. The neutral particle transport analysis using a simulation code (EIRENE) has showed that the density of neutral hydrogen molecules in the inboard side for the CHD is enhanced by more than one order of magnitude compared to that for the open divertor. It also predicts that the total ionization source in the ergodic layer for the CHD is about 50% of that in the open divertor case under a same main plasma condition, indicating that the peripheral plasma density is effectively controlled for the CHD.

A next concern for the CHD is impurity contamination in the plasma periphery. In order to check the performance of impurity retention in the divertor region, the density profile of neutral impurity (carbon) atoms is calculated by the simulation code including the effect of physical/chemical sputtering. The calculation of the three-dimensional profile of the neutral impurity density shows localization of the neutral carbon atoms ($C^0$) behind the dome structure, indicating retention of the impurity atoms in the divertor region. The calculated total ionization source rate of the carbon atoms for the CHD is comparable to that for the open divertor, which suggests that the carbon source is not the divertor plates but the vacuum vessel. The total ionization source rate without the sputtering in the ergodic layer is about 25% of that with the sputtering. It shows that the CHD configuration itself is not effective in reducing the impurities in the ergodic layer.

Another concern is impurity transport from the divertor region to the main plasma because of the short connection length of the magnetic field lines on divertor legs (a few meters). Plasma temperature gradient on the divertor legs in high neutral density (high recycling) cases can induce the thermal force which pushes back impurity ions to the main plasma. It may cause impurity contamination and deteriorate energy confinement property by radiation cooling. Impurity ion transport is basically determined by the balance of the following two forces: 1. Thermal force due to the temperature gradient along magnetic field lines, 2. The friction force due to interaction with the plasma flow from the main plasma. The ratio of the thermal force on the friction force ($R$) is a critical factor to determine impurity transport. When $R$>-1, impurity ions are swept back to the divertor plates by the plasma flow, For $R$<-1, impurity ions are transported to the main plasma by the temperature gradient effect. The parameter $R$ is calculated in different neutral density cases. This plasma parameter profile along magnetic field lines on divertor legs are obtained by a one-dimensional plasma fluid analysis. Figure 1 gives the profiles of the plasma parameters ($T_i$ and $n_e$) along five representative magnetic field lines connecting the divertor plates in the CHD region in various neutral density cases. The profiles of the parameter $R$ are also indicted, which shows that $R$ is more than -0.15 even in the case where significant temperature gradient is formed near the divertor plates. It means that impurity transport to the main plasma is effectively suppressed by the plasma flow on divertor legs.

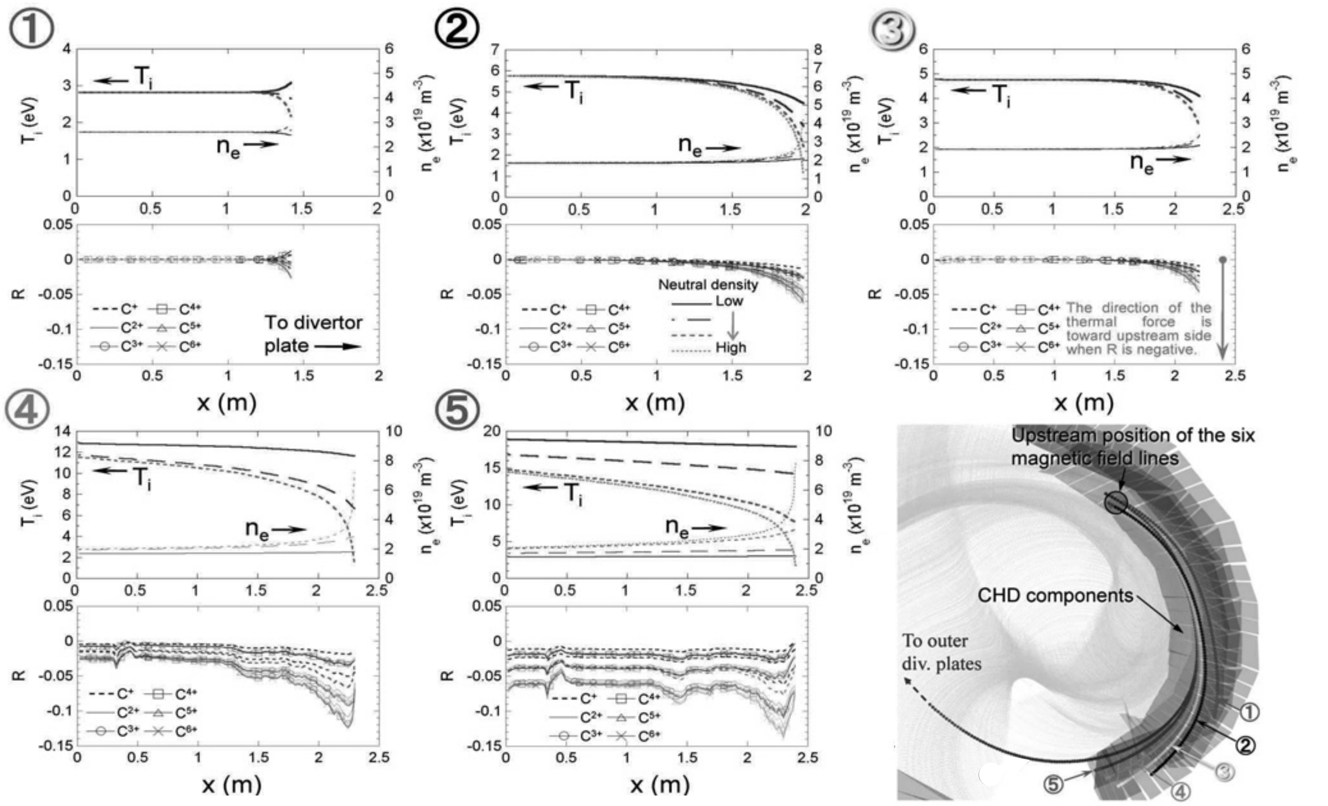


Fig. 1 Calculations of the profiles of the plasma parameters and the parameter $R$ along the five magnetic field lines.