§22. Confinement Improvement in High-Ion Temperature Plasmas in LHD

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High-ion temperature plasmas above 10 keV have been obtained with negative-ion-based NBI heating in LHD. Since the hydrogen injection energy is higher than 150 keV, the electron heating is dominant in hydrogen discharges. In order to enhance the ion heating power effectively, high-Z discharges with Ar or Ne seeding are utilized [1]. Low-density and high-Z plasmas, where the beam absorption power is enhanced and the ion density is reduced, are realized by suppression of the dilution with wall-absorbed hydrogen with intensive Ne and/or Ar glow discharge cleaning. As a result, the central ion temperature ($T_i$) is increased with an increase in the density-normalized ion heating power, and reaches 13.5 keV.

Considering that the increase in the central $T_i$ is not saturated with the ion heating power, the anomalous transport, which causes the power degradation of the temperature, would be suppressed in the high-ion temperature plasmas obtained in the high-Z discharges. As shown in Fig. 1, the central $T_i$ is increased with an increase in the electron temperature ($T_e$) gradient in an outer plasma region of around $\rho=0.8$, and no definite correlation is observed between the central $T_i$ and the $T_e$ gradient in a core region of round $\rho=0.6$. The neoclassical ambipolar calculation considering multi-ion species indicates the generation of strong positive radial electric field ($E_r$) in the outer region for the high-ion temperature plasmas. In the CXRS measurement, positive $E_r$ is observed in the outer region and the positive $E_r$ is increased as the density decreases. Correspondingly, a little rise of the local $T_i$ there is also observed. These results suggest the improvement of the ion transport in the outer plasma region due to the electron root, and that should lead to the central $T_i$ rise.

When the centrally focused ECH is superposed on the high-Z NBI plasma, central $T_i$ rise is observed [1]. Then, the $T_e$ profile shows the electron ITB, in which the $T_e$ gradient is steep in a core region of $\rho=0.4-0.5$. The neoclassical calculation shows the formation of positive $E_r$ in the core region. In the case of the non-high-Z plasmas, positive $E_r$ is observed in the core region with the superposition of the ECH in the CXRS measurement.

As shown in Fig. 2, positive $E_r$ is observed in a core region for an electron ITB plasma in the non-high-Z discharges generated with a combined heating of NBI and ECH, and a little increase in the $T_i$ is recognized. In the electron ITB plasmas the improvement of the electron transport has been confirmed [2], and the core $T_i$ and the $T_e$ gradient are both increased without saturation as the density-normalized electron heating power increases. Considering the above mentioned results, the ion transport should be improved due to the electron root in the high-ion temperature plasmas.

References