

Characteristic of an impurity hole in Large Helical Device

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An extreme hollow profile of carbon impurity (denoted as "impurity hole") is observed associated with the increase of ion temperature gradient after an impurity injection in the large helical device (LHD). The central carbon density drops due to a strong outward convection driven by an ion temperature gradient,

The profiles of ion temperature, toroidal rotation velocity and carbon impurity are measured with charge exchange spectroscopy using the charge exchange line of fully ionized carbon. The neutral beam injector which has a positive ion source (P-NBI) with the beam energy of 40 keV is used for the CXS measurement. Three NBI with a negative ion source (N-NBI) are injects the beam into the plasma tangentially, while the p-NBI injects the beam into the plasma perpendicularly with an on and off modulation of 5Hz.

The decrease of the carbon impurity is clearly observed on the discharge with single carbon pellet injection for high ion temperature operation. The carbon pellet was used for the supplying of the carbon impurity into the core of the plasma. The electron density increases rapidly just after the pellet injection, and then decreases with the time scale of a few 100 msec. The impurity profile suddenly changes to extreme hollow profile while the gradient of ion temperature grows higher in the decay phase of the electron density at the half of the minor radius of the plasma.

The radial particle flux and the density gradients of carbon and proton are calculated from the time slices of the carbon and proton density profiles. Profiles of the diffusion coefficient and convection velocity are evaluated from the dependence of particle flux normalized by the density on the density gradient normalized by the density during the decay phase of the density. The transport analysis of the carbon impurity gives a low diffusion coefficient and an outward convection velocity while an inward convection is predicted by the neoclassical theory at the half of the minor radius. The increase of the outward convection velocity of the carbon impurity associated with the increase of ion temperature gradient is observed.