HIGH DENSITY AND HIGH TEMPERATURE PLASMAS IN LARGE HELICAL DEVICE

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Abstract. For the realization of the fusion reactor, it is necessary to confine high density and high temperature plasma for a time, which is well known as the Lawson criterion. To improve the plasma or confinement performance, vigorous experiments have been performed in the Large Helical Device (LHD) in National Institute for Fusion Science, which is the largest superconducting heliotron device with R = 3.9 m r = 0.6 m, B_t = 3 T. Recently a promising confinement regime called Super Dense Core (SDC) mode was discovered. An extremely high density core region with more than ~ 1×10^{20} m^{-3} is obtained with the formation of an Internal Diffusion Barrier (IDB). The density gradient at the IDB (ρ = 0.6) is very high and the particle confinement in the core region is ~ 0.2 s. It is expected, for the future reactor, that the IDB-SDC mode has a possibility to achieve the self-ignition condition with lower temperature than expected before. The IDB-SDC mode is also favorable from the engineering point of view since one can moderate demands for heating devices and plasma facing components. In order to achieve the IDB-SDC mode, the central fuelling with the pellet injection and the low recycling condition are essential. A repetitive pellet injector was newly developed to continuously feed the particle source to the central region. For the recycling control, the effective divertor system should be employed to control the edge plasma. Conventional approaches to increase the temperature have also been tried in LHD. For the ion heating, the perpendicular neutral beam injection effectively increased the ion temperature more than 10 keV with the formation of the internal transport barrier (ITB). In the core region, the heat conductivity is improved to the neoclassical level, while no clear ITB for electron was seen. Another interesting phenomenon called "impurity hole" was observed inside the ITB. During the high ion temperature discharge, the impurity density in the core region becomes low and its profile becomes hollow. The impurity atoms are pumped out, in spite of the negative electric field (ion root) inside the ITB. In the lecture, the mechanism of the impurity hole will also be discussed, together with the theoretical background and numerical results.

References

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