22P34

High radiation fraction detachment with Ne seeding and edge magnetic island in new magnetic configuration in LHD

M. Kobayashi[1], T. Oishi[1], Y. Hayashi[1], K. Mukai[1], H. Takahashi[1], K. Tanaka[1], T. Kinoshita[2], M.Z. Tokar[3], B.J. Peterson[1], S. Masuzaki[1], the LHD Experiment group

1 NIFS, 2 Kyushu Univ., 3 Heinrich Heine University, Duesseldorf

An edge magnetic island has significant impact on the detachment onset as well as on the detachment stability due to its topological effects of O- and X-points, which alter growth rate of the thermal instability and the consequent impurity radiation pattern. The optimization of the edge magnetic island configuration for the detachment operation compatible with core plasma performance is being explored in LHD. New operation regime has been found, where divertor detachment with high radiation fraction of more than 90% is realized by combining edge magnetic island, Neon seeding, and ECRH. This was achieved with new magnetic field configuration, where the stochastization at the edge region is reduced as compared to the one studied before (higher stochastization) [1], in which the maximum radiation was limited to about 60%. The island was created by RMP of m/n=1/1 and ECH of ~ 3MW was deposited on central region. It is found that the radiation fraction increases stepwise as ~40% and ~90%, as the Neon puff amount increased. Profiles of Ne VI and VIII measured by VUV/EVU spectrometer show stepwise shift such that at 40% radiation the peaks of emission located at the outer edge of the island, and at 90% radiation they shift to inner edge of island (LCFS), showing strong correlation of the impurity radiation pattern with edge magnetic island structure.

Electron ITB, which is characteristic of the central heating with ECRH, is maintained even with the 90% radiation, and thus the pressure profile is peaked, too. During the 90% radiation, strong density increase is observed even with deuterium fueling turned off, indicating particle confinement improvement. This causes increase of Ne X emission, which might indicate impurity penetration, while the global confinement seems not degraded.

The divertor heat load decreases down to less than 10% of the attached phase in all toroidal section, in contrast to the configuration studied before (higher stochastization), where a certain amount of heat load remained with n=1 mode structure. At the moment we interpret this difference in the divertor heat load reduction as being attributed to the longer field line connection length in the edge island of the new configuration due to the reduced stochasticity, which allow impurity to distribute more uniformly around the plasma and thus to dissipate energy uniformly.

We have investigated NBI heating plasma (~10MW) with the new magnetic configuration by scanning Neon seeding amount. The results show stepwise increase of radiated power similar to the case with ECRH, but the maximum radiation was bounded at around 50%, that is, the radiation increases stepwise at 20%, 40% and 50%, then plasma collapses with larger amount of Neon seeding. The pressure peaking is observed during the 50% radiation phase, similar to the ECRH case. The divertor heat load decreases toroidally uniformly.

These results suggest that the central heating with ECRH as well as the degree of the stochastization at the edge island are of critical importance to stabilize the high radiation detachment and to obtain toroidally uniform diverter heat load reduction, while detailed assessment is ongoing.

[1] M. Kobayashi et al., Nucl. Fusion vol.62 (2022) 056006.

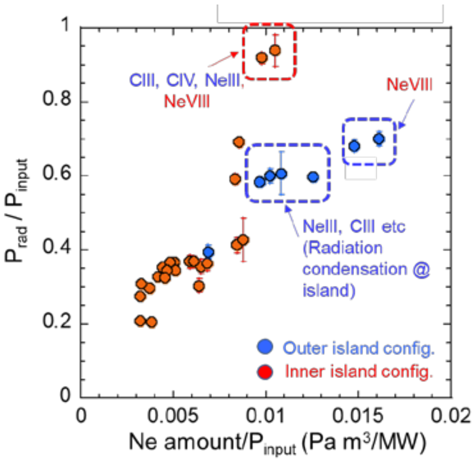

Fig.1: Radiation fraction as a function of Ne seeding amount for two magnetic island configurations at the edge.