§7. Application of Resonant Magnetic Perturbation for long pulse discharge in LHD

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Appling Resonant magnetic perturbation forming m/n=1/1 island can enhance edge particle diffusion in LHD. This effects becomes clearer with increase of collisionality [1,2]. We have applied these results to long pulse discharge and improved the controllability of density feedback. Figure 1 shows one example of comparisons of discharge behaviour with and without RMP. Plasma is produced by 77 and 154GHz ECRH, then sustained by 38.47MHz ICRH. Main species are helium and hydrogen are fuelled as a minority species for ICRH[3]. RMP forms m/n=1/1 island by externally applied vertical filed. As shown in Fig.1, there is a clear difference of time traces of densities, namely the plasma being terminated by radiation collapse without RMP, while being sustained as planned with RMP as, evidenced in (a). In this way, the application of RMP has been clearly shown to improve controllability of the electron density. For this identical feedback target signal, line-averaged electron densities were almost the same until 18.5 s, while they were changed completely differently with and without RMP after t=18.5 s. From t=15 s to t=20 s, the densities increased in both cases while the target density was meant to keep them constant at $1.4x10^{19}$ m^{-3} thus helium fueling being reduced after t=15 s. Although densities were almost the same before t=18.5 s, profiles of both electron density and temperature were different. In a laser scattered signals of density profiles measured using YAG Thomson scattering, one recognizes a flattening at around ρ=0.9 in the smoothed profile shown by thin lines in Fig.2 (a) and (d) for the case with RMP Also, electron density profiles are more peaked with RMP at same averaged density. The electron temperature profile shows clearer flattening as shown in Fig. 2 (b) and (e) for the case with RMP and that the island width is smaller at earlier phase at t=11.05s, then, it becomes larger at later timing t=17.05. Before t=18.5s, radiation profiles are almost identical with and without RMP as shown in Fig.2 (c) and (f). After t=20 s, the target signal was to reduce thus resulting in the external fueling becoming zero as shown in Fig 1 (b). Finally, electron density becomes around factor two lower and electron temperature becomes around factor two higher at t=23.05s with RMP than the case without RMP as shown in Fig. 2 (g) and (h). With this scenario, however, the electron density continued to increase without RMP after target density is reduced. For this case, the plasma reached to radiation collapse with a resultant discharge termination. On the other hand, the radiation collapse was avoided for the case with RMP resulting in the density behavior following the target density as shown in Fig. 1. (a). These are increase of diffusion coefficients with increase of the collisionality. After t=17.05s, with RMP, particle transport is bad enough to prevent radiation collapse and good enough to follow feedback target. These results suggest that there are optimum tuning of applying field strength for plasma condition. The application of ramping up of RMP field achieved control of radiation profile from peaked one to hollowed one at higher density (~$3x10^{19}m^{-3}$) than the results in this report[4]. The cause of the improvement of controllability was not clear due to change of impurity source profile or impurity transport. In this report, the operation scenario was made due to the past transport study[1,2]. Also, radiation profile is kept hollowed profile as shown in Fig.2, (c),(f) and (i), the behavior of impurity is different and effects on particle and possibly impurity transport in low collisionality likely play a main role.

1) Tanaka. K., Plasma Fusion Res. **8** (2013) 2402141
2) Tanaka. K., NIFS Annual report 2012-2013
3) T. Mutoh et al., Nucl. Fusion 53 (2013) 063017
4) Nakamura. Y., Nucl. Fusion 43 (2003) 219

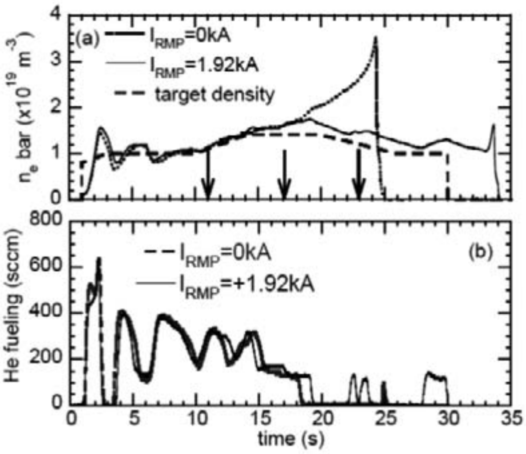

Fig.1 Time histories of (a) line averaged densities, (b) helium fueling rates, and profiles of electron densities

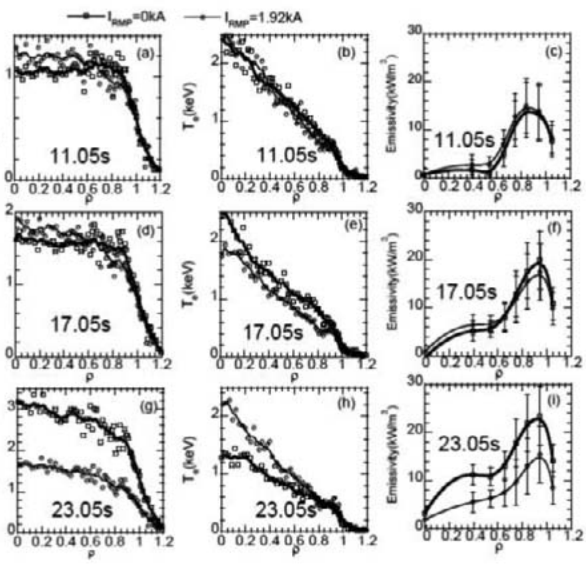

Fig.2 profiles of electron densities (a,d,g), electron temperatures (b,e,h) and Radiation emissivity(c,f,i)