§20. Effect of Low Order Rational Surface on H-Mode Characteristics

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In inward shifted magnetic configuration of LHD (R_{ax}=3.6m), edge transport barrier is often formed through L-to-H transition when neutral beam injection (NBI) absorbed power exceeds a certain level at lower toroidal magnetic field B less than 1.5T. ETB is usually formed in electron density profile, but not in electron temperature profile. Moreover, low frequency MHD modes having low toroidal mode number n=1 to 3 are immediately destabilized just after the development of steep pressure gradient in the plasma edge region that is always in the magnetic hill. These instabilities evolve nonlinearly and exhibit bursting characters which lead to excitation of ELM activities typically in Hα emission signal. The ELMs cease the considerable increase in electron density. However, this leads to the sudden saturation of the stored energy. This magnetic configuration has four obvious differences with that in tokamak: (1) the edge region is in the magnetic hill, (2) the magnetic shear in the edge region is always negative, (3) the lowest order rational surface $\iota/2\pi=1/1$ locates near the edge region, and (4) the thick region between the last closed flux surface (LCFS) and magnetic separatrix is filled with stochastic field layer.
When the magnetic axis position Rax is shifted outward further from 3.6m, the height of the magnetic hill gradually decrease, but never changes the sign, i.e, to magnetic well. The magnetic shear in the edge also gradually decreases, but still negative. On the other hand, the location of $\iota/2\pi=1$ is dramatically changed with the increase in Rax. For instance, the $\iota/2\pi=1/1$ location is at the normalized minor radius ρ=0.87, 0.90, 0.98 and 1.02 (outside LCFS) for the configurations of R_{ax}=3.6m, 3.75m, 3.85m and 3.9m, respectively. The thickness of the stochastic layer becomes the maximum in the configuration of R_{ax}=3.75m. When R_{ax} either increase or decrease from 3.75m, the thickness decreases.

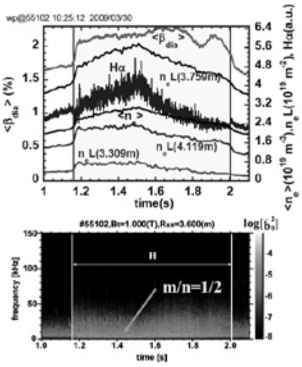

Fig.1 Typical ETB plasma obtained in the configuration of R_{ax}=3.6m. The lower trace indicates the spectrogram of magnetic probe signal. Edge MHD mode with m/n=1/2 is strongly destabilized in the H-phase.

Dependence of characteristics of H-mode and ELMs on R_{ax} were investigated. Very clear difference in H-mode character was observed in outward shifted configurations of R_{ax}=3.9m and 4.0m for the inward shifted one of R_{ax}=3.6m. The waveforms of the H-phase in the configuration of R_{ax}=3.6m are shown in Fig.1. Just after the transition, electron density near the edge suddenly jumps up, but magnetic fluctuation amplitude is enhanced by the transition. ELM activities appear on the Hα emission signal just after the transition. These characters are different with the characters in tokamak H-mode. However, when R_{ax} is set to be 3.9m, the H-mode goes into ELM free phase and suppressing incoherent magnetic

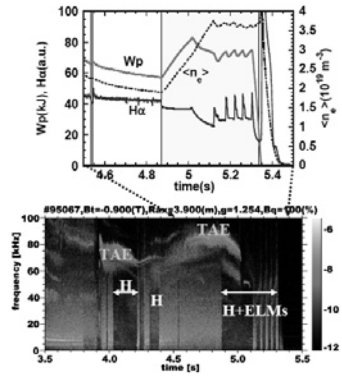

Fig.2 Time evolutions of the stored energy, line averaged electron density and Hα emission in the ELM free H-mode, where R_{ax}=3.9m. At t=5s, NBI power was stepped down.

fluctuations, as shown in Fig.2. During the ELM free, line averaged electron density rises linearly in time and the stored energy also increase dramatically untill the first giant ELM is triggered. This is very similar to an ELM free H-mode observed in tokamak. Density fluctuations measured by the phase contrast imaging of CO_2 laser and millimeter wave reflectometer are also clearly suppressed at the transition. The ETB is formed just inside the $\iota/2\pi=1$ rational surface, as seen from Fig.3. These results suggest the $\iota/2\pi=1$ rational surface may play an important role in triggering L-to-H transition and location of the ETB foot location.

In the next experimental campaign, the control of the density rise in the ELM free phase is planned to be done using resonant magnetic perturbations.

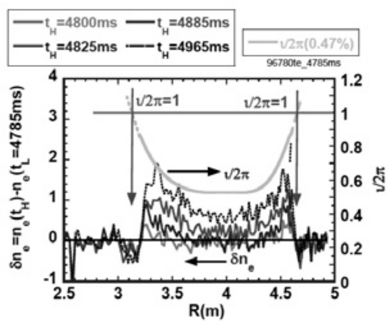

Fig.3 Density increase from the density just before the transition(t=4785ms) in another ELM free shot, where Rax=3.9m.