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Improved particle confinement in the L-H transition in the 3D magnetic field

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The spontaneous transition phenomenon like the L-H transition of the confinement is an important physics to explorer the fusion reactor [1]. For the L-H transition in tokamaks, the pedestal formation in the plasma edge is widely known, and the stored energy significantly increases with the pedestal formation. On the other hand, for the L-H transition in stellarators, although the spontaneous transition like the tokamak L-H transition is also observed in many experiments, the clear formation of the pedestal in the plasma edge was not observed. Also, only the particle confinement improves but the thermal confinement does not improve. It is very interesting because the transition phenomenon is very similar to the tokamak PEH-mode (Particle Enhanced H-mode) [2]. The PEH-mode appeared as the low energy branch of the H-mode with the resonant magnetic perturbation (RMP). That suggests the PEH-mode can be considered a branch of the H-mode in the 3D stochastic boundary. Also, in a stellarator experiment, it was found that the small density perturbation by the supersonic gas puffing can trigger the transition to the PEH-mode.

This study deals with new findings of the spontaneous transition are studied in the high-beta plasma of LHD. In previous studies [3], the transition happened in the quasi-steady state discharge without the active trigger. Recently, it found that the Super-Sonic Gas Puffing (SSGP) system can trigger the transition. If the SSGP injects in the quasi-steady state plasma with the constant density and heating power, the confinement transits spontaneously and then the plasma density sharply increases. Figure 1 shows a summary of the SSGP triggering L-H transition. At t = 4s, the SSGP injected. A special notice is that the confinement improvement occurs in two phases. In the first phase, the Hα / Dα signals drop, and these are quiescent. In this phase, the density sharply increases. However, in the second phase, the Hα / Dα signals behave ELMy. Also, the density fluctuation significantly changes in a boundary of two phases. Figure 2 shows the amplitude and spectrogram of the ion scale turbulence. For reference, the line averaged density, the Hα signal, the plasma stored energy are shown, respectively. In this study, we report two points, (i) how the improved confinement changes the MHD equilibrium and stability, and (ii) how the density and temperature fluctuations change in the boundary of two phases.

References
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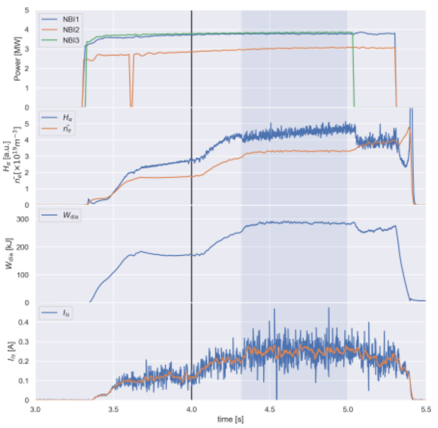

Figure 1 The time evolution of a shot for the SSGP triggering L-H transition. The heating power, the line averaged density/Hα signal, the plasma stored energy, and the divertor particle flux are shown, respectively.

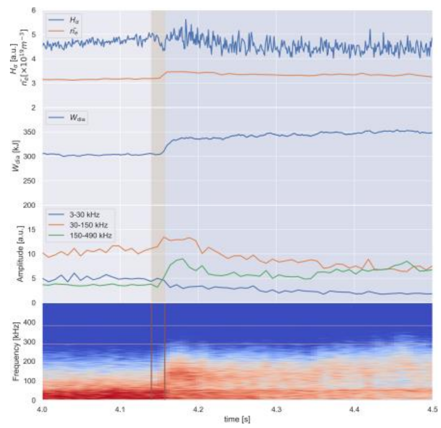

Figure 2 The time evolution of the ion scale turbulence amplitude and spectrogram. For reference, the line averaged density, Hα signal, and the plasma stored energy are shown, respectively.