§25. Detailed Dynamics of Internal Transport Barrier Formation in Low Temperature CHS Plasmas

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Energy and particle transport in a toroidal plasma is a very important and challenging issue in magnetic confinement fusion research. There is general consensus that transport of high temperature toroidal plasmas is governed by plasma turbulence. Therefore, correlation measurement among plasma fluctuations is crucial to clarify underlying physics mechanisms in turbulent particle and heat transport of a toroidal plasma. However, the correlation measurement is extremely difficult in high temperature plasma. The Langmuir probes (LPs) are the most promising tool for the correlation measurement, but are only applicable to low temperature and low density plasma. In CHS, we are attempting to study a possibility to simulate plasma transport in high temperature plasma with low temperature one, by adjusting various dimensionless plasma parameters [1]. We have found that this new approach is very promising [2]. Recently, detailed dynamics of internal transport barrier formation of which similar event is often observed in high temperature plasma have been investigated in low temperature and low density plasmas produced at very low toroidal field B_t (<0.1T).

In a low density hydrogen plasma produced by launching about 15 kW microwaves at B_t=0.0613T, line averaged electron density $\langle n_e \rangle$ rapidly increases up to ~ 1.1×10^{17} m^{-3} and gradually decreases down to ~5×10^{16} m^{-3}. During the decay of $\langle n_e \rangle$, electron temperature Te linearly increases till the transition. Plasma collisionality decreases continuously toward the transition and reaches the boundary between 1/ν and plateau regimes. When $\langle n_e \rangle$ decreases to ~ 7-8x10^{16} m^{-3}, electron density n_e in the core region (ρ<0.45) suddenly increases and that in the outer region suddenly decreases, as shown in Fig.1, where these data were taken shot by shot basis for many reproducible shots using LP. This transition in electron density n_e clearly indicates the formation of internal transport barrier (ITB). The formation of ITB is also observed in electron temperature Te, but is not significant. The ITB observed in Te is inside ρ≤0.3 and the size is smaller than that of ITB in n_e. Note that after the ITB formation the decay of $\langle n_e \rangle$ becomes slow, and $H\alpha$ emission slightly decreases. These results suggest the reduction of particle transport. It is interesting how the radial electric field Er behaves across the transition. Figure 2 shows the space potential Vs derived from measured floating potential V_f and electron temperature Te as $Vs=V_f+\zeta Te$, here $\zeta\approx3$ for hydrogen plasma. Before the transition, Vs profile in the core region of ρ<0.5 is flat, which means Er ~0 there. Across the transition, Vs profile changes to a centrally peaked one, which means that large positive Er of ~600 V/m is generated in the region of ρ<0.5. This positive Er corresponds to large poloidal rotation velocity of ~10 km/s because of very low B_t. However, the velocity shearing rate in these plasmas is less than 10^5 s^{-1} and is not significant. Relationship between the ITB transition and most relevant quantities such as Er, Er-shear and fluctuation characteristics should be clarified in future studies. This result again suggests that this new approach using low temperature plasma based on the *non-dimensional similarity hypothesis* is very promising.

[1] K. Toi, S. Kawada, G. Matsunaga et al., in Proc. 29th EPS on Plasma Phys. Control. Fusion (Montreux, 2002), Paper No. P-4.061.
[2] K. Toi et al., J. Plasma Fusion Res. SERIES Vol.6, 516.

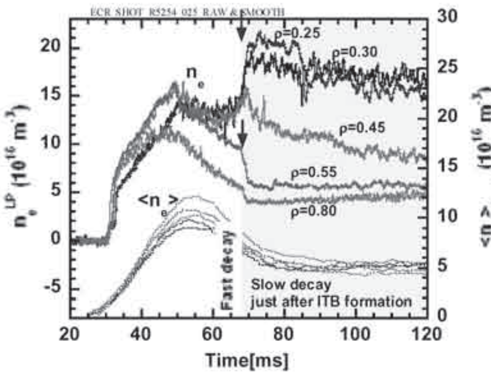

Fig.1 Time evolutions of local and line-averaged electron densities, where the transition occurs at t~69ms. The vertical arrows indicate the transition. The decay in $\langle n_e \rangle$ after the transition slows down.

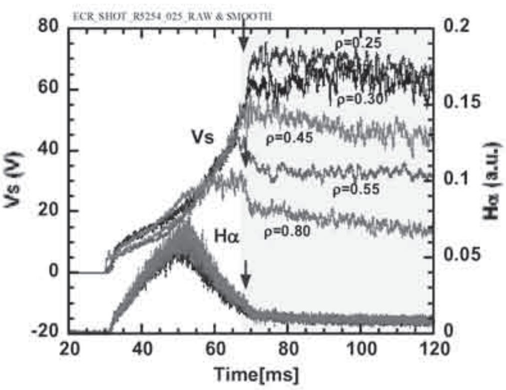

Fig.2 Time evolutions of space potential Vs and $H\alpha$ emission.