2nd Asia-Pacific Conference on Plasma Physics, 12-17,11.2018, Kanazawa, Japan

Experimental investigation of the L-H transition dynamics

T. Kobayashi[1], K. Itoh[2,1,3], T. Ido[1], K. Kamiya[4], M. Sasaki[5,3], Y. Miura[6], Y. Nagashima[5,3], K. Ida[1,3], S. Inagaki[5,3], A. Fujisawa[5,3], and S.-I. Itoh[5,3,7]

[1] National Institute for Fusion Science, National Institutes of Natural Sciences, [2] Institute of Science and Technology Research, Chubu University, [3] Research Center for Plasma Turbulence, Kyushu University, [4] National Institutes for Quantum and Radiological Science and Technology, [5] Research Institute for Applied Mechanics, Kyushu University, [6] Japan Atomic Energy Agency, [7] Graduate School of Engineering, Chubu University

e-mail: kobayashi.tatsuya@LHD.nifs.ac.jp

Formation mechanism of the high-confinement mode (H-mode) in fusion plasmas has been intensively studied for the last two decades because of its prospective capability for achieving a high performance plasma. After the first discovery of the H-mode [1], the physical mechanism responsible for the edge transport barrier (ETB) formation has been continuously investigated [2,3]. Models focusing not only on the radial electric field formation but also on turbulent transport suppression by the radial electric field have been developed accordingly, and experimental validations have been promoted too. However, these are still challenging mainly because of an insufficient precision of the turbulence and electric field measurements. In this contribution, we attempt to solve these issues using a data set from JFT-2M. In some discharges, a heavy ion beam probe (HIBP) offered the direct measurement of the turbulence and the radial electric field with high spatial and temporal resolutions, which is one of the most ideal experimental data for the model validation. We address the following open questions remain unsolved: (i) how is the radial electric field excited and how is the turbulence transport quenched? (ii) how is the limit-cycle-oscillation (LCO), i.e., a sequential repetition of the L-H and H-L transitions, explained? and (iii) how is the geodesic acoustic mode (GAM), i.e., the oscillating global electric field structure excited?

Figure 1 shows the typical time evolution of the target discharge, in which a variety of events related to the turbulence and radial electric field dynamics are observed. The neutral beam power is set to be slightly above the threshold power of the L-H transition. The L-H transition occurs at 0.734 sec. as indicated by the dashed vertical line. At the L-H transition, the D_α emission intensity showing the outward particle flux decreases and the high frequency turbulence intensity is suppressed. The electrostatic potential at four different radii begin to deviate, showing a formation of the radial electric field. By using model formulae, it is found that the neoclassical bulk viscosity and the orbit loss are main contributors for the radial electric field formation [4-6]. The particle flux is directly evaluated from the fluctuation measurement, and the transport suppression at the L-H transition is observed. The particle flux is quenched by reducing the turbulence amplitude in the density fluctuation and the phase difference between the density and potential fluctuations [7]. Just before the L-H transition, the limit cycle oscillation as the ~4.5 kHz potential oscillation is observed. The LCO observe here is explained by the E_r-bifurcation model [8,9]. In the beginning of the L-mode discharge, the GAM is observed at ~15 kHz. The Reynolds stress is directly quantified and is found to be responsible for the GAM excitation [10]. In summary, the strong interaction between turbulence and electric field predicted by theories is experimentally confirmed.

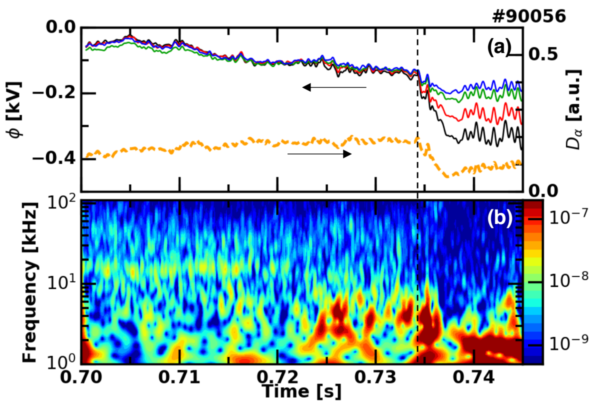

Fig.1 Time evolutions of (a) mean electrostatic potential signals measured by radially adjacent HIBP channels and D_α emission intensity and (b) power spectral density of the potential oscillation.

References

[1] F. Wagner et al., Phys. Rev. Lett. **49**, 1408 (1982).
[2] S.-I. Itoh and K. Itoh, Phys. Rev. Lett. **60**, 2276 (1988).
[3] K. Ida et al., Phys. Rev. Lett. **65**, 1364 (1990).
[4] T. Kobayashi et al., Nucl. Fusion **55**, 063009 (2015).
[5] T. Kobayashi et al., Sci. Rep. **6**, 30720 (2016).
[6] T. Kobayashi et al., Nucl. Fusion **57**, 072005 (2017).
[7] T. Kobayashi et al., Sci. Rep. **7**, 14971 (2017).
[8] T. Kobayashi et al., Phys. Rev. Lett. **111**, 035002 (2013).
[9] T. Kobayashi et al., Nucl. Fusion **54**, 073017 (2014).
[10] T. Kobayashi et al., Phys. Rev. Lett. **120** 045002 (2018).