ECRH H-mode Experiments in the HL-2A Tokamak

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Heating in electron and ion channel plays different role in the scope of L-H transition [1]. In HL-2A tokamak 5MW ECRH system [2, 3] and 1.5MW NBI system have been equipped. The first H-mode on HL-2A was obtained in 2009 [4], with both NBI and ECRH. After that H-mode was also obtained with purely NBI. Although the total ECRH power is much higher than the NBI power, steady H-mode on HL-2A with purely ECRH has not been realised. However, clear evidence of limit cycle oscillation (LCO) and ELMy like phenomena on D_α signal in purely ECRH discharges has been observed, which indicates the plasma has entered into the intermediate phase (I-phase) toward steady H-mode.

Shot 21886 (B_t = 1.32T, I_p = 155kA, P_{ECRH} = 1.6MW) gives an example for such ECRH I-phase discharges. In the experiments, SMBI is employed to mitigate the density pump out effect [5, 6] during ECRH phase. Oscillation at frequency 2~3 kHz on D_α signal in t = 730~750ms and formation of edge density pedestal support the assertion of plasma confinement mode transition. However, the I-phase does not last long since the plasma density keep decreasing which improves the L-H transition threshold. Employing feedback control of density using SMBI to keep density constant, quasi-continuous LCO has also been clearly observed as in the case of shot 23065(B_t = 1.31T, I_p = 172kA, P_{ECRH} = 1.6MW, ne ~ $1.7\times10^{19}/m^3$). However, transition to steady ELMy H-mode has not yet been realised. The reason may be due to the enhancement of TEM instabilities and turbulence in ECRH phase.

References

[1] F. Ryter T. Pütterich, M. Reich, *et al.*, 2009 *Nucl. Fusion* **49** 062003
[2] M. Huang, J. Rao, B. Li, et al. 3MW ECRH system and experiments on HL-2A. *37th EPS conference*, Dublin, Ireland. 2010.
[3] M. Huang *et al*. Development of a 140 GHz steerable launcher for the HL-2A ECRH system. *Plasma Sci. Technol.* **15** (2013) 1247-1253
[4] X.R. Duan, J.Q. Dong, L.W. Yan, *et al.*, *Nucl. Fusion* **50**, 095011(2010)
[5] X.L. Zou, W.W. Xiao, S.D. Song, et al. Particle Transport Investigation in HL-2A Using ECRH and SMBI, *23rd IAEA Fusion Energy Conference*, Daejeon. (2012)
[6] C. Angioni, A.G. Peeters, X. Garbet, et al., *Nucl. Fusion* **44**, 827 (2004)