

Impact of resonant magnetic perturbation on L-H transition dynamics in HL-2A and HL-3 tokamaks

Y. Zhang¹, M. Jiang¹, Z. B. Guo², P. H. Diamond³, W. X. Guo⁴, J. Q. Xu¹, N. Zhang¹, Z. Wang¹, Z. J. Li¹, Y. Zhou¹, A. S. Liang¹, T. F. Sun¹, R. Ke¹, S. B. Gong¹, X. X. He¹, W. Chen¹ and W. L. Zhong¹

¹ Southwestern Institute of Physics, Chengdu, China

² Peking University, Beijing, China

³ University of California San Diego, La Jolla, United States of America

⁴ Huazhong University of Science and Technology, Wuhan, China

e-mail (speaker): zhangyi@swip.ac.cn

This study investigates the effects of $n=1$ resonant magnetic perturbations (RMP) on L-H transition in both HL-2A and HL-3 tokamaks. Experimental results demonstrate that RMP application elevates the L-H transition threshold power and induces H-L back transition when the RMP coil current exceeds a critical value in H-mode. Particularly in HL-3 tokamak, the application of RMP inhibits the L-H transition at specific heating power. The electron density increases in the outer plasma region, while the electron/ion temperature decreases. Specifically, the flow shear in the edge region is substantially reduced. This reduction, combined with enhanced micro-instabilities driven by increased profile gradients, leads to enhanced turbulence levels. Consequently, the diminished flow shear becomes less effective in suppressing turbulence, providing a comprehensive explanation for the inhibited access to H-mode. Through a modified one-dimensional predator-prey model that incorporates the effects of RMP-induced radial magnetic perturbations, we have conducted a quantitative analysis of the turbulence and flow dynamics during the L-H transition process. Our

results indicate that as the strength of magnetic perturbation increases, the turbulence intensity increases and edge flow shear decreases, in agreement with experimental observations. Additionally, we found that the L-H transition power threshold increases almost linearly with the square of the radial magnetic perturbation intensity. These results enhance our understanding of RMP-induced changes in edge plasma transport, providing valuable insights for optimizing the operation of future tokamaks and improving the performance of fusion reactors.

References

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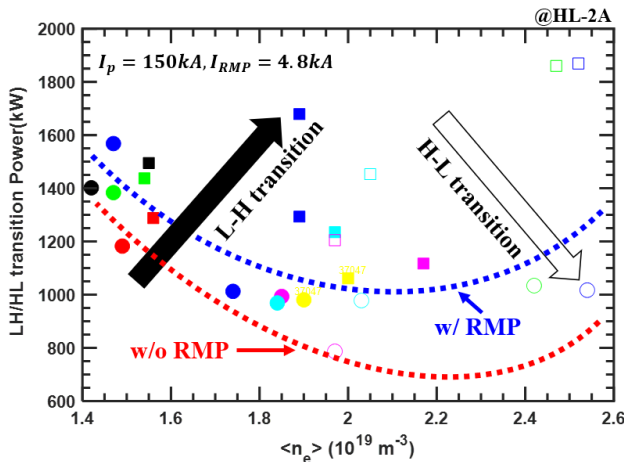


Figure 1. Increase of LH/HL transition power threshold with $n = 1$ RMP on HL-2A. Here the circle markers represent L-mode state and the square markers represent H-mode state. The blue dashed line estimates the LH/HL transition power, and the red dashed line denotes the LH transition power without RMP.

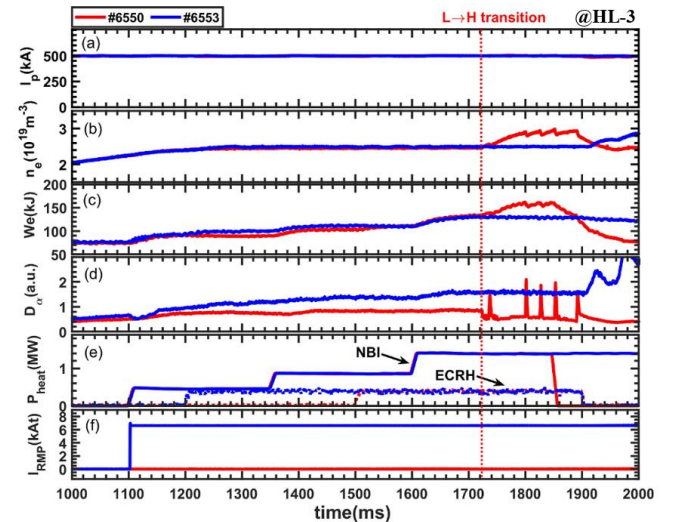


Figure 2. Time evolutions of the discharge parameters in shot 6550 and 6553 on HL-3, with (a) the plasma current I_p , (b) the line-averaged electron density n_e , (c) the stored energy W_e , (d) the D_α intensity in the divertor, (e) the NBI and ECRH heating power P_{heat} , and (f) the RMP current I_{RMP} . The red vertical dashed line marks the L-H transition time in shot 6550.