

## Inward Transport Induced by the Long Lived Mode in HL-2A H-mode plasma

J. Wu<sup>1</sup>, T. Lan<sup>1</sup>, J. R. Wu<sup>1</sup>, M. Xu<sup>2</sup>, L. Nie<sup>2</sup>, W. Chen<sup>2</sup>, L. M. Yu<sup>2</sup>, J. Cheng<sup>2</sup>, L. W. Yan<sup>2</sup>,  
X. R. Duan<sup>2</sup>, Y. Liu<sup>2</sup>, T. J. Deng<sup>1</sup>, H. Q. Xu<sup>1</sup>, S. Zhang<sup>1</sup>, Y. Yu<sup>1</sup>, X. Sun<sup>1</sup>, A. D. Liu<sup>1</sup>, J.  
L. Xie<sup>1</sup>, H. Li<sup>1</sup>, G. Zhuang<sup>1</sup>, W. D. Liu<sup>1</sup>

<sup>1</sup> *KTX Laboratory and Department of Modern Physics, University of Science and Technology of China, Hefei 230026, P.R. China*

<sup>2</sup> *Southwestern Institute of Physics, Chengdu 610041, P.R. China*

In the past two decades, the fluctuation induced inward flux was mainly studied in stellarators[1, 2] and less in tokamak[3, 4]. From the frequency resolved expression of fluctuation induced flux, the cross phase between electric field fluctuation  $\tilde{E}_\theta$  and pressure fluctuation  $\tilde{n}_e$  is the main term that changes the direction of turbulence transport flux[5] which is different from the zonal flow to suppress turbulence by reducing the amplitude of fluctuation level[6]. In HL-2A tokamak plasmas, the inward flux induced by the Long Lived Mode (LLM) has been firstly observed in spontaneous L-H transition by using Langmuir probe array. The LLM is a kind of energetic particle modes (EPs) excited by the resonance between internal kink mode and precessional motion of energetic trapped ions [7] or excited by energetic electron[8] in core region of HL-2A. In the edge region with strong  $\mathbf{E} \times \mathbf{B}$  shear, the radial flux induced by LLM is reversed to inward because the cross phase term  $\cos \alpha_{\tilde{E}_\theta \tilde{n}_e}$  becomes negative. By using the long-range correlation in radial direction between Langmuir probe and core soft X-ray signal, we find the poloidal electric field fluctuation  $\tilde{E}_\theta$  phase reversal is the main cause that leading to the inward transport. The other probe settled in the poloidal distance of 80 mm also observes the same inward flux phenomenon, which indicates the inward flux has a global characteristic. Furthermore, the inward flux may help to build the transport barrier and improve the confinement of turbulence transport.

### References

- [1] M. Shats. *et al Phys. Rev. Lett.* 79 (1997) 2690.
- [2] K. Toi. *et al Plasma Phys. Control. Fusion* 44 (2002) A237.
- [3] J. Boedo. *et al Nucl. Fusion* 40 (2000) 1397. Y. Xu. *et al Phys. Rev. Lett.* 97 (2006) 165003.
- [4] D. Kong. *et al Nuclear Fusion* 58 (2018) 034003.
- [5] P.W. Terry. *et al Phys. Rev. Lett.* 87 (2001).
- [6] H.G. Shen. *et al Phys. Plasmas* 23 (2016) 042305.
- [7] R.B. Zhang. *et al Plasma. Phys. Control. Fusion.* 56 (2014) 095007.
- [8] L.M. Yu. *et al Nucl. Fusion* 57 (2017).