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Experimental study of the interaction between oscillation flows and turbulence across a transition to H mode in edge plasma

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It is important to study L-H transition mechanisms to provide a predictable power threshold for a successful operation of fusion reactor. Recently, much experiment observations indicate that the turbulence driven zonal flow can directly trigger the LH transition, which is in good agreement with the theoretical prediction of the predator-prey model based on the nonlinear interaction between the zonal flow and turbulence. However, a few experimental results point out that the zonal flow has a less effect on the L-H transition. These different experimental results implied a rather complicated nonlinear process in the L-H transition dynamics. Here we extend the previous study of the oscillation dynamics to the interaction between turbulence and oscillation flow in edge plasmas, which can further improve our understanding of the H -mode physics. In this work, we study the intimate interaction between oscillation flows and turbulence across a transition to H mode in edge plasma of HL-2A tokamak. The probe array data measured at the pedestal (Δr=-10 mm) shows that the oscillation appears in electron temperature, density, radial electric field, pressure gradient fluctuations, and the E x B shear flow leads to the turbulence, consistent with the previous observation of J-LCO with the higher pressure gradient across the L-I-H transition. The pedestal pressure gradient was dramatically modulated by the oscillation flow and then an electromagnetic fluctuation with the center frequency ~12 kHz was excited, which has a strong coupling with turbulence and finally the mode energy was dissipated by the resistance thermal effect. The enhanced sheared flow, dominated by the neoclassical pressure gradient, exceeds a threshold value and then speeds up the positive feedback loop rotation to achieve the H mode transition. The more detail study on the nonlinear interaction between oscillation flows and turbulence will be presented in future.

7. List of related published papers 7.1 J. Cheng, J.Q.Dong, K.Itoh, et al., Dynamic of low-intermediate-high confinement transition in toroidal plasma, Phys. Rev. Lett. 110, 265002 (2013). 7.2 J. Cheng, J.Q.Dong, K.Itoh, et al. Low-intermediate-high confinement transition at HL-2A, Nucl. Fusion 54, 114004 (2014). 7.3 J.Cheng, J.Q.Dong, L.W.Yan, et al., Roles of turbulence-pressure gradient induced flows in triggering H-mode at marginal heating power on HL-2A tokamak, Europhysics Letters 116, 15001 (2016). 7.4 J.Cheng, Y. Xu, C.Hidalgo, et al., Role of a MHD mode crash in triggering H-mode at marginal heating power on the HL-2A tokamak, Physics Letters A, 380, 3897 (2016) 7.5 Y. Xu, J.Cheng, J.Q.Dong, et al., Dynamic of low-intermediate-high confinement transition on HL-2A, Plasma Phys. Control. Fusion 57, 014028 (2015) 7.6 L.W.Yan, J. Cheng, J.Q.Dong, et al. The effect of BAE on L-I-H transition in HL-2A tokamak, Nucl. Fusion 53, 093008 (2015). 7.7 K.J.Zhao,J.Cheng,P. H. Diamond, et al., Sawtooth-triggered limit-cycle oscillations and I-phase in the HL-2A tokamak, Nucl. Fusion 53, 123015 (2013).