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Small amplitude limit-cycle oscillations in far and just before L-H transition plasmas

L.M. Shao[1], G.S. Xu[1,2], R. Chen[1], L. Chen[1,2], G. Birkenmeier[3,4], Y.M. Duan[1], W. Gao[1], P. Manz[3,4], T.H. Shi[1], H.Q. Wang[1], L. Wang[1], N. Yan[1], L. Zhang[1] and the EAST Team

[1] Institute of Plasma Physics, Chinese Academy of Sciences, Hefei 230031, China

[2] University of Science and Technology of China, Hefei 230031, China

[3] Max-Planck-Institut für Plasmaphysik, Boltzmannstr. 2, 85748 Garching, Germany

[4] Physik-Department E28, Technische Universität München, 85748 Garching, Germany

E-mail: shalom@ipp.ac.cn

Different from the widely known intermediate phase (I-phase [1]), small amplitude limit-cycle oscillations (SALCOs) at frequency of a few kilohertz can be observed before the low to high confinement regime transition (L-H transition) on EAST [2], NSTX [3] and JFT-2M [4]. SALCOs are mostly found in medium density L-mode plasmas independent of the plasma current, toroidal field, ion ∇B drift direction and heating methods. These oscillations located at the plasma edge are measured with the D-alpha filterscopes, Absolute eXtreme Ultra Violet (AXUV) diodes, Langmuir probe array at the targets and magnetic pick-up coils. With sufficient auxiliary heating, SALCOs can transit to H-mode or I-phase. Edge radial electric field (E_r, negative) measured by means of fast reciprocating probe inside the separatrix are observed to deepen after bursts of SALCOs.

In SALCOs far before the L-H transition no clear temporal ordering of edge $-E_\mathrm{r}$ and turbulence level is observed. However, just before the L-H transition, the phase of $-E_\mathrm{r}$ preceding turbulence level about 90° is found in the pulses of SALCOs. At the bottom of edge E_r well the turbulence level ahead of the negative floating potential perturbation about 90° in phase consistent with the model of zonal-flows and turbulence interaction [5] is measured in SALCOs both far and just before the L-H transitions. The poloidal magnetic perturbations of the pulses are up-down asymmetry and toroidal symmetry in the SALCOs. A physical mechanisms diagram of SALCOs is developed in this study: with input power close to the power threshold the ion heat flux propagates from the core to the plasma edge, leading to the steepening of edge pressure gradient and the increase of the turbulence level in the inboard E_r well. The increased turbulence level enhances the transport at the plasma edge and raises the zonal-flows at the bottom (outer board) of E_r well, which mitigate the turbulence later.

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