§11. Neoclassical Viscosity and Zonal Flows during the Ion-electron Root in the TJ-II and LHD

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The interplay between turbulent driven flows and 3-D effects could be explained on the basis of reduced neoclassical transport enhancing zonal-flow generation[1]. This finding shows the importance of zonal flows damping mechanisms via neoclassical processes. Experiments performed in the TJ-II stellarator have shown that Long-Range Correlations (LRC) in potential fluctuations (dominated by low frequency components and consistent with zonal flows) are present in the plasma edge, but not in the Scrape-Off-Layer (SOL) region, during the development of the edge shear flows and how these correlations are amplified either by externally imposed radial electric fields [2] or when approaching the L-H confinement edge transition [3]. Recent TJ-II studies have been focused on the measurement and calculation of mean flows and on the study of the dynamics of ZF-like structures in the vicinity of the so-called low-density transition (i.e. in the transition from the electron to ion root). We have provided a fundamental picture of the behaviour of the mean and oscillating flows during the transition through the vanishing of the neoclassical viscosity[4].

Heating power scan experiments [5] have been carried out in the Large Helical Device (LHD) to investigate the influence of the ion-electron root transition in plasmas fluctuations and radial electric fields. NBI heating scan can induce i-root (negative E_r) – e-root (positive E_r) transition in the plasma edge region at rather constant density while increasing ion temperature. During the change from the negative electric field to positive electric field, we observe the reduction of the turbulent density fluctuation. Also, the amplifications of low frequency fluctuation of both density and electric field are observed at just before and after the transition [6].

Fig. 1 and 2 show the time evolution of plasma rotation measured at different radial locations and the temporal evolution of Doppler reflectmetry signals at r_{eff}/a_{99}~1.05 respectively. At the transition time, low frequency (<20 kHz) fluctuations increase. Altough low frequency fluctuations are deveoped in the proximity of the transition point in agreement with previous TJ-II results, no evidence of LRC have been observed in LHD in the far edge region (r_{eff}/a_{99}~1.05). A research programme is in progress to explore LHD plasma edge region searching for LRC.

No change of root is predicted with NC calculations (with DKES and FORTEC-3D) using measured plasma profiles. From the slope of the radial neoclassical current vs E_r neoclassical viscosity in the range 1-10 kHz is predicted to exist before the root transition in LHD and to vanish during the transition, in consistency with LHD experimental findings

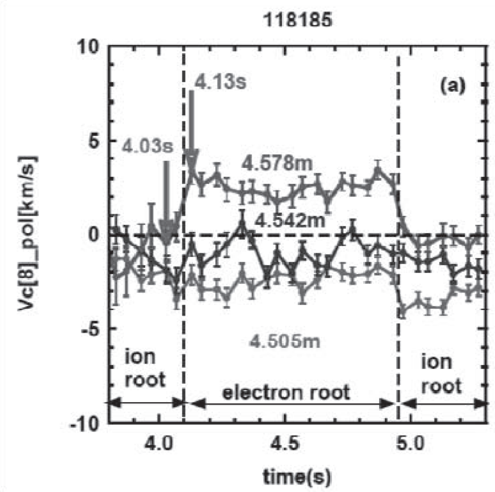

Fig.1 Temporal evolution of plasma rotation (poloidal) showing a reversal in the rotation from negative (ion root) to positive (electron root) in the plasma edge region (R > 4.54 m) in the plasma discharge 118185.

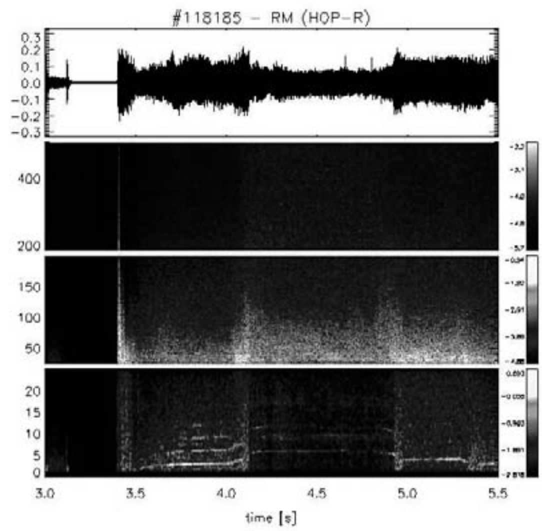

Fig.2 Temporal evolution of Doppel Reflectometry signals during the ion-electron transition (#118185). From upper raw signal, and spectrogram in kHz

1) T.H. Watanabe et al., Phys. Rev. Lett 100 (2008) 195002.
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3) C. Hidalgo et al., EPL 87 (2010) 55002.
4) J. L. Velasco et al., Phys. Rev. Lett. 109 (2012) 135003 / PPCF 55 (2013) 124044.
5) K. Tanaka et al., Plasma Fusion Res. 5 (2010) S2053
6) T. Tokuzawa et al., 4th Asia Pacific Transport Working Group (2014).