§3. High-T_i Experiments in 13th Experimental Campaign on LHD

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The high-T_i mission experiments in 13th experiment campaign on LHD mainly consists of three topics, i) trial to expand the high-T_i regime of helical plasmas, ii) heat transport study of ion internal transport barrier (ion ITB) formation, and iii) study of impurity transport in ion ITB plasmas, in particularly, on the mechanism of impurity hole formation. In this report, the experiments performed in high-T_i mission on 13th campaign are reviewed.

For the first topic (high-T_i trial), the optimization of magnetic configuration and carbon pellet injection were tried. However, the high-T_i record of central high-T_i = 5.6keV cannot be updated. The reason for this is considered as the lower neutral beam power and less wall condition than those in last campaign. A new type of ITB formation was tried in the reversed magnetic shear configuration using neutral beam current drive. The tendency of ITB formation was observed in ion temperature profile. However the ion temperature region is still low ($T_i < 2$ keV).

For the second topic (ITB physics), the electrostatic potential profile measurement was carried out using heavy ion beam probe (HIBP) with normal magnetic field direction (ctr-NBI dominant condition). The weak negative radial electric field (E_r) was identified in the ion ITB core region (see Fig.1), where the ion heat transport is reduced with the factor of three. The observed E_r well agrees with neoclassical theory calculated by GSRAKE code. It is noted that the improvement of ion heat transport with the neoclassical ion root (negative E_r) is experimentally identified. The fluctuation measurement using phase contrast imaging (PCI) and reflectometry were also carried out, and the change of density fluctuation properties such as radial structure and the direction of poloidal rotation were observed. The ITG like fluctuation rotating in the ion-diamagnetic drift direction glows at the outside of the ITB foot in the transition to ion ITB phase. In the edge region, the fluctuation rotating in the electron-diamagnetic direction becomes small and the rotation reverses in the ion ITB phase. However, the causal turbulent suppression of the improvement of ion heat transport has not been identified yet.

For the third topic (impurity transport), the extremely hollowed profile of carbon impurity has been observed in the ion ITB core plasma, so far. The Z dependence was investigated using carbon pellet, helium gas puff and neon gas puff. It was observed that the impurity species with the larger Z shows the stronger hollowed profile in the ion ITB core. It is noted that the selective exhaust of heavy ions is a preferable to fusion reactor plasmas, which is not observed in tokamak plasmas, so far. The negative E_r observed by HIBP cannot explain the impurity hole formation in ion ITB plasma because of opposite direction of E_r driven impurity fluxes. The temperature screening effect due to the temperature gradient is too small to overcome the E_r effect evaluated by HIBP observation. Thus the mechanism of impurity hole formation is still an open question left for future study.

The proposed studies related to this group, for example, theoretical study on the scenario to further high-T_i regime, transient transport analysis of ion ITB plasma using Tespel injection, momentum transport analysis and so on, were also carried out in 13th campaign. The linkage and balance between the mission experiments and proposed experiment were valued, and the significant progresses were obtained in the electrostatic potentail measurement and impurity transport property in the 13th campaign.

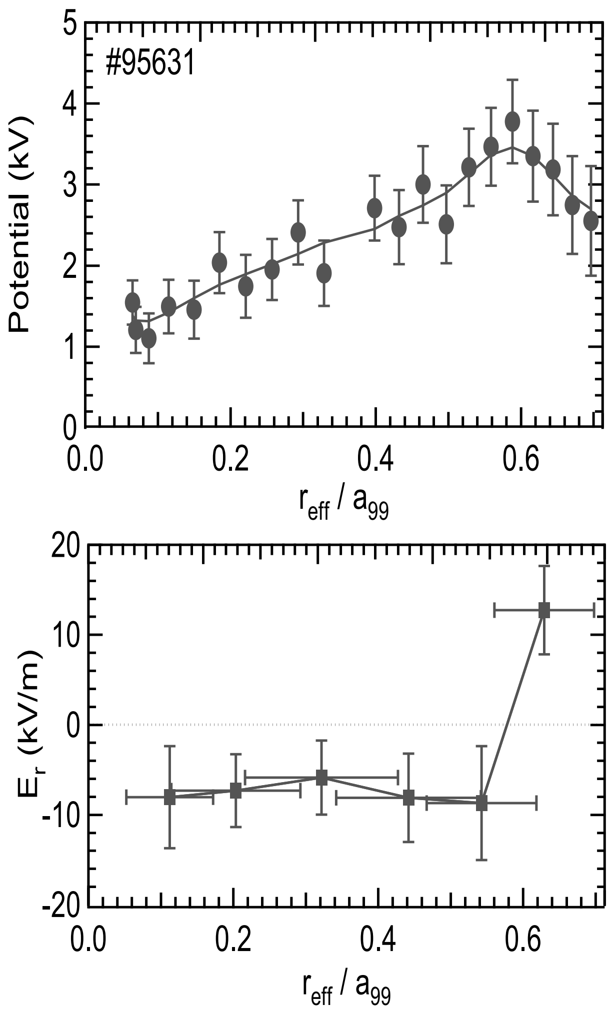

Fig. 1: (Upper) The potential profile measured by HIBP. (lower) The radial electric field E_r estimated by potential profile measured by HIBP.