Influence of recombination front region on plasma detachment in a linear divertor plasma simulator


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Various researches on plasma detachment are currently underway through complementary studies with magnetically confined fusion devices, linear diverter plasma simulators[1], and numerical simulations in order to control heat and particle loads on plasma-facing components. It has been investigated in the linear divertor plasma simulator NAGDIS-II that recombination front (RF) region, in which volume recombination strongly occurs in a detached plasma, has strong influence on the characteristics of plasma detachment. Detailed observation of plasma profiles and dynamical behaviors around the RF was conducted using newly developed two-dimensional driving Langmuir probe (2-D LP) as well as a laser Thomson scattering (LTS) diagnostics[2]. The LTS system, developed with international collaboration of DIFFER, is enable to measure electron temperature ($T_e$) less than 0.5 eV. LTS data can be utilized to calibrate 2-D LP data. Plasma fluctuations near RF were measured with a microwave interferometer (MI).

In a detached plasma, axial and radial profiles obtained with the 2-D LP show monotonically decreasing electron density ($n_e$) and $T_e$ along the central region of plasma column. On the other hand, in the peripheral region of the plasma column, $n_e$ peaks near the RF, which means a strong local cross-field transport from the central to peripheral region exists near the RF. Plasma instability accompanied with strong $n_e$ fluctuation was observed by MI near RF[3]. The instability leads to the enhancement of the cross-field plasma transport near RF in a detached plasma. The local enhancement of the cross-field plasma transport also changes the plasma flow pattern, showing that inverse plasma flow along the magnetic field at the peripheral region of plasma column appeared[4].

We have also investigated the effects of magnetic field structure on RF by simulating magnetically expanding and contracting plasmas[5]. The total ion particle flux measured with a large-diameter target plate dramatically changed under the detached plasma condition compared to that in attached plasma. Under the detached plasma condition, the magnetically expanding plasma clearly exhibited a significant degradation of detached plasma formation.