Contribution ID: **137** Type: **Poster**

Investigation of Detached Recombining Plasmas in a Linear Device Pilot-PSI and its impact on Plasma Detachment in Fusion Devices

Friday 21 October 2016 14:00 (4h 45m)

Handling enormous plasma heat load to divertor is essential to the achievement of high fusion gain. The electron-ion recombination (EIR) process is required to reduce particle flux, leading to reduction of heat load due to the surface recombination. Further, in the ITER research plan, initial studies of H-modes are planned in helium plasmas because the predicted H-mode threshold power in helium plasma is lower than that of hydrogen [1]. Therefore, it is necessary to conduct plasma detachment experiments under the high density helium plasma condition that is relevant to detached divertor operations in ITER.
Electrostatic probe and Thomson scattering (TS) measurements were performed in detached recombining plasma (DRP) in a linear plasma device, Pilot-PSI. Pilot-PSI [2] can produce high density helium plasma above 10^20 m^-3 in steady state. The electron temperature (T_e) measured by using electrostatic probe showed a good agreement with TS measurement without any anomaly of probe characteristics, observed in other linear devices [3, 4].
The particle and heat fluxes at the target dramatically decreased with neutral pressure (P), while they were almost constant at the upstream. When P ~ 15 Pa, the peak particle flux decreased from 10^24 to 10^22 m^-2s^-1 and heat flux from 7 MWm^-2 to 0.1 MWm^-2 along the magnetic field in DRP region with a length of ~ 0.5 m. The EIR process contributed to the strong reduction of the particle and heat fluxes, due to the reduction of T_e from 3 eV to 0.2 eV. This experimental result indicates that narrow DRP region determines the heat load to the divertor plate associated with EIR process. It can be also said that the stable control of the DRP region is quite essential in future fusion devices.

This work was supported by JSPS KAKENHI Grant Number (25289337). This work is partially supported by NIFS/NINS under the project of Formation of International Network for Scientific Collaborations and NIFS Collaboration Research Program (NIFS14KUGM094).

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Paper Number

EX/P8-44

Country or International Organization

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Session Classification: Poster 8

Track Classification: EXC - Magnetic Confinement Experiments: Confinement