7th Asia-Pacific Conference on Plasma Physics, 12-17 Nov, 2023 at Port Messe Nagoya

Influence of dynamic pressure induced by transient recycled neutral flux on reduction of pulsed particle load in the linear plasma device Magnum-PSI

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Detached divertor operation is an essential scenario to reduce the divertor heat load and to protect plasma facing components in fusion devices. Because in conventional tokamaks transient heat loads are released from the confinement region due to edge localized mode (ELM), both steady-state and transient heat loads are required to be handled in scrape-off layer (SOL) and divertor region. The interaction between the detached plasma and the transient heat load should be investigated under the high density and high particle flux condition which is similar to the divertor plasma in ITER. The linear plasma device Magnum-PSI enables this experiment because of its high performance for steady state plasma generation with particle flux up to 10^{25} $m^{-2}s^{-1}$[1] and pulse plasma production. In the present study, the impacts of a pulsed plasma input into the detached plasma on the particle load were investigated and discussed from the experiments and modeling in Magnum-PSI.

Figure 1 schematically shows the experimental configuration used in the present study. Steady-state plasma is generated by a cascaded arc source. In parallel with this, a capacitor bank system transiently increased the discharge power for ~ 1 ms, leading to increase in the electron temperature, T_e, and electron density, n_e, in the plasma source region [2]. The steady-state and transient pulsed plasmas were measured using a Langmuir probe and target plate. Laser Thomson scattering (TS) measurements and optical emission spectroscopy (OES) were performed during the steady-state phase. The dynamic response of the steady state plasma in front of the target plate was measured by the ion saturation current, I_{sat}, with the Langmuir probe and target current, I_{target}, with a negatively biased target plate.

Figure 2 shows the time evolutions I_{target} in various neutral pressure, p_n, conditions. The low and high p_n cases are separately shown on the figures 2(a) and (b), respectively. The trigger timing of the pulse corresponded to a time, t, of 0 ms. The time width of the pulsed plasma should be ~ 0.8 ms because waveforms of the discharge power show that under the all p_n conditions. However, as shown in figure 2(a), the particle flux was not maintained for ~ 0.8 ms at the target plate. The waveforms of I_{target} indicate that the pulse duration detected at the target decreased with a drop in p_n. Similar tendency was not observed by the Langmuir probe located at 200 mm upstream. Because the first parts of the pulsed plasma were observed, their last ones were considered to be partially suppressed in front of the target plate. In high p_n cases, on the other hand, I_{target} in all cases were maintained at least for ~ 0.8 ms as shown in figure 2(b). The waveforms of I_{target} were mitigated by increasing p_n. The reduction in I_{target} in the high neutral pressure cases might be due to the enhancement of a plasma-neutral interaction.

Regarding the low p_n cases, because the mean-free path of the charge exchange was shorter than that of the n-n elastic scattering, the impact of the recycled neutral flux on the pulsed plasma suppression by the transient enhancement of the plasma-neutral interaction was speculated. Modeling was performed by coupling the LINDA (LINear Divertor Analysis) code [3] with a neutral transport code [4]. The modeling results showed that the dynamic pressure induced by the transient recycled neutral flux in the opposite direction from the target caused a sufficient momentum loss to stagnate the pulsed plasma.

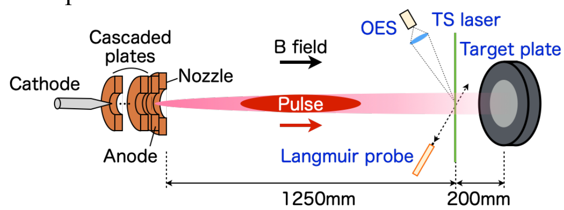

Figure 1. Schematic of experiments in Magnum-PSI.

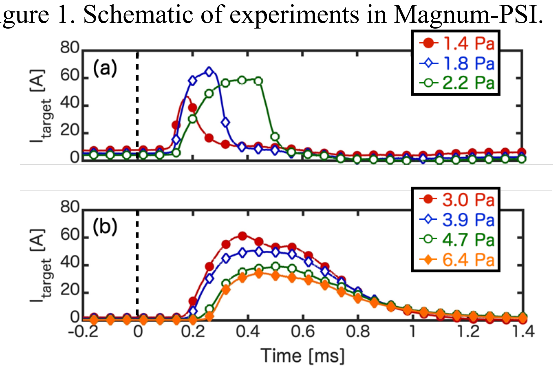

Figure 2. Time traces of I_{target} during the pulsed plasma.

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