22P171-B

Transition processes of recombining plasma with pulse plasma flow

パルスプラズマ流入時における再結合プラズマの遷移過程

Takaaki Iijima, Naoki Mine, Akira Tonegawa, Kazutaka Kawamura and Kohnosuke Sato
飯島貴朗, 嶺直樹, 利根川昭, 河村和孝, 佐藤浩之助

Department of Physics, School of Science, Tokai University
411 Kitakaname, Hiratsuka, Kanagawa, 259-1292, Japan
東海大学　〒259-1292　神奈川県平塚市北金目411

The time evolution of electron density n_e, electron temperature T_e, electron velocity distribution function $\boldsymbol{f}_e(\upsilon)$, and hydrogen Balmer series spectra is found to depend on gas pressure in the recombination plasma with pulse plasma flow. The pulse plasma flux is generated by controlling the electric circuits of electrodes of plasma source. The negative spikes were appeared in the time evolution of the Balmer series spectra, which indicate on the transition from ionizing to recombining plasma.

1. Introduction

The research on the dynamic behaviors of plasma against the pulse plasma flow with bursts of heat and particles is a topic in space plasma, and fusion related edge plasma physics. In particular, the time-dependence of recombination processes with pulse plasma flow has become important for characteristics of plasma detachment, in which the transitions from recombination to ionization plasma have been identified in divertor region of fusion device.

The transient behavior of the recombination plasma with pulse plasma flow has been studied by observing the short double minimum (negative) spike in Dα/Hα emission from the plasma[1]. This response in Dα/Hα emission is explained by the electron temperature increase associated with pulse plasma flow with bursts of heat and particles along the magnetic field. However, it is required that experiments which will aid the understanding of the role of the high energy electron with pulse plasma flow are carried out.

In this study, we have carried out the experimental observation of the time evolution of electron density n_e, electron temperature T_e, electron velocity distribution function $\boldsymbol{f}_e(\upsilon)$, and hydrogen Balmer series spectra in hydrogen recombination plasma in a liner plasma device, TPD-SheetIV[2].

2. Experimental Apparatus and Method

Figure 1 show the schematic view of the TPD-SheetIV device and measuring system[2]. The plasma in TPD-SheetIV was divided into two regions: the sheet plasma source region and the experimental region. TTen rectangular magnetic coils formed a uniform magnetic field of 0.8 kG in the experimental region. The hydrogen plasma was generated at a hydrogen gas flow of 75 sccm, with a discharge current of 30-100 A. The neutral pressure P in the experimental region was

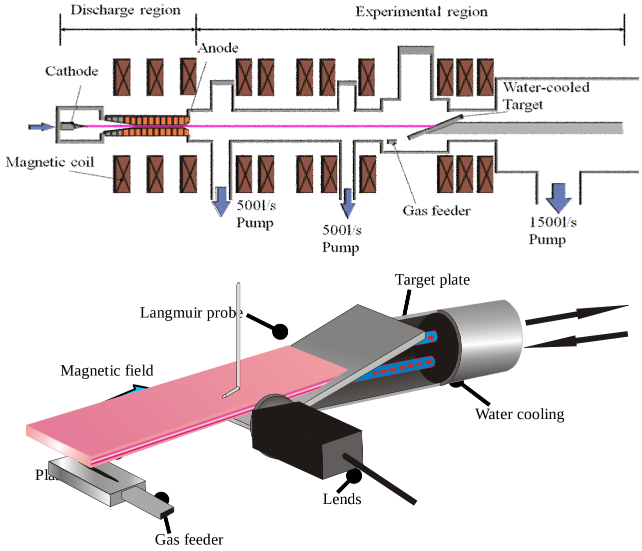

Fig.1　Schematic view of the TPD-SheetIV device and measuring system.

controlled between 0.01 and 2.0 Pa with a secondary gas feed. Electron density and electron temperature were measured using a planar Langmuir probe and double probe, which were located 3 cm in front of the oblique endplate.

The recombination plasma with pulse plasma flow was generated by controlling the electric potential of the next floating electrode of the anode in TPD-type plasma source. Pulse plasma flow generated by controlling the plasma source were introduced into hydrogen recombination plasma in the experimental region. The duration of the pulse plasma was 0.3ms and the frequency of cycle of the plasma was 50Hz. The time evolution of the emission intensity of the Balmer series spectra was observed with a spectroscope and a photomultiplier. The time evolution of electron density n_e, electron temperature T_e, electron velocity distribution function $\boldsymbol{f}_e(\upsilon)$ and hydrogen Balmer series spectra in hydrogen recombination plasma were measured using Langmuir probe, which were located 3cm in front of the endplate.

3. Experimental results

Figure 2 shows the typical time evolution of the electron temperature T_e and electron density n_e at a neutral gas pressure of 1.1 Pa (recombination plasma). The discharge current is 70 A in hydrogen plasma. Both T_e and n_e increase and peak after the pulse plasma flow is introduced. Figure 3 shows the time evolution of the electron velocity distribution function $\boldsymbol{f}_e(\upsilon)$ at a neutral gas pressure of 1.1 Pa. $\boldsymbol{f}_e(\upsilon)$ were obtained by derivative of the probe I_p-V_p curve. It is found that the high energy electrons around 40 eV appear in recombination plasma after the pulse plasma flow is introduced. Figure 4 shows the typical time evolution of the line emission intensities of Hα and Hε at a neutral gas pressure of 0.3 1.0 Pa. The Hα emission intensity increase and peak after the pulse plasma flow is introduced. On the other hand, the Hv5 emission intensity in recombination plasma is found to drop in time, indicating that recombination becomes weak. After the appearance of double minimum negative spikes at around 0.5 ms, the emission intensity starts to increase gradually. The ionization and recombination events are discussed by Collisional-Radiative (CR) model, taking into account of high energy electrons as shown in Fig.5. It is indicated that the recombination plasma decay for increase of ionization plasma during the pulse plasma flow.

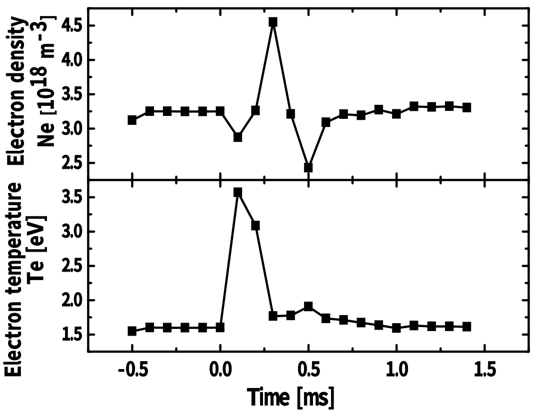

Fig.2 Typical tiame ebolution of the electron temperature and electron densityat a neutral gas pressure of 1.1 Pa.

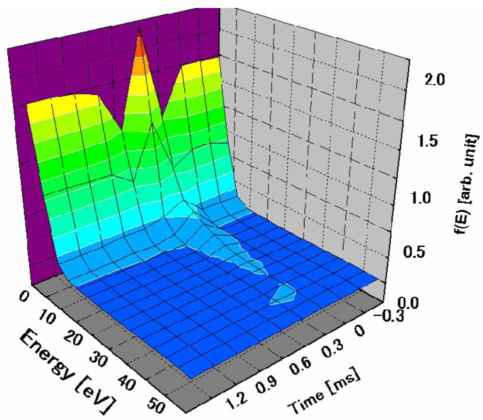

Fig.3 the time evolution of the electron velocity distribution function $\boldsymbol{f}_e(\upsilon)$ at a neutral gas pressure of 1.0 Pa.

4. Conclusions

The time evolution of electron density n_e, electron temperature T_e, electron velocity distribution function $\boldsymbol{f}_e(\upsilon)$, and hydrogen Balmer series spectra is found to depend on gas pressure in the recombination plasma with pulse plasma flow. The high energy electrons in the pulse plasma flow are influenced by the time evolution of the Balmer series spectra, which indicate on the transition from ionizing to recombining plasma.

References

[1] N.Ohno, et al. ,Nucl. Fusion 41(2001)1055.

[2] A.Tonegawa, J.Nucl.Mater.,313-316 (2003)1046.

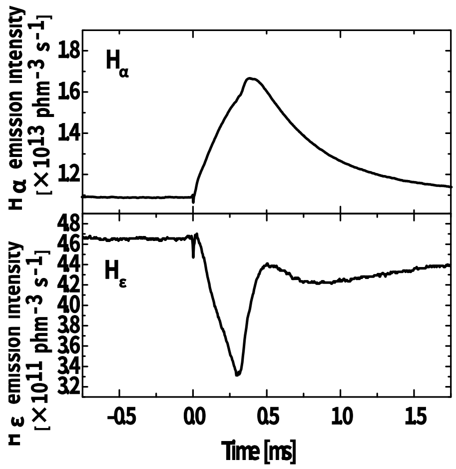

Fig.4 typical time evolution of the line emission intensities of Hα and Hε at a neutral gas pressure of 0.3 1.0 Pa.

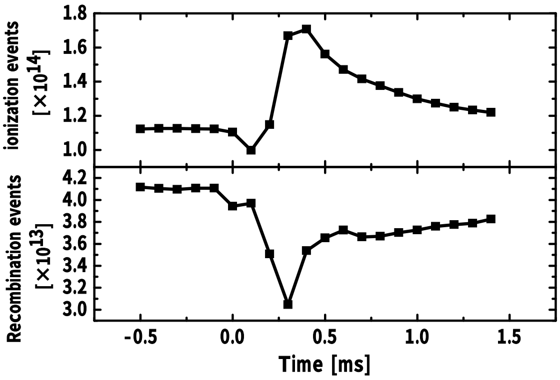

Fig.5 The ionization and recombination events are discussed by CR model, taking into account of high energy electrons.