Time-dependent of recombining Plasma with Pulse Plasma flow

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Introduction

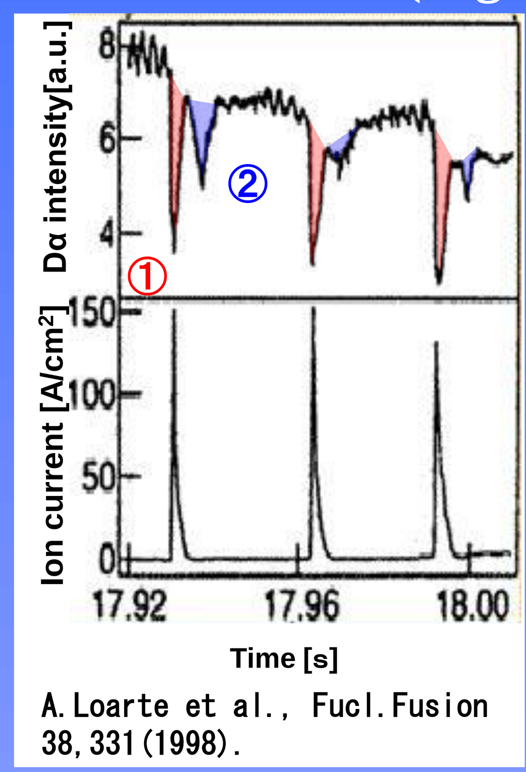
The research on the dynamic behaviors of plasma against the pulse plasma flow with bursts of heat and particles is a topic in space plasma, and fusion related edge plasma physics. In particular, the time-dependence of recombination processes with pulse plasma flow has become important for characteristics 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. 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 ne, electron temperature Te, electron velocity distribution function $f_e(\upsilon)$, and hydrogen Balmer series spectra in hydrogen recombination plasma in a liner plasma device, TPD-SheetIV.

Time-dependent of emission intensity with Plasma flow

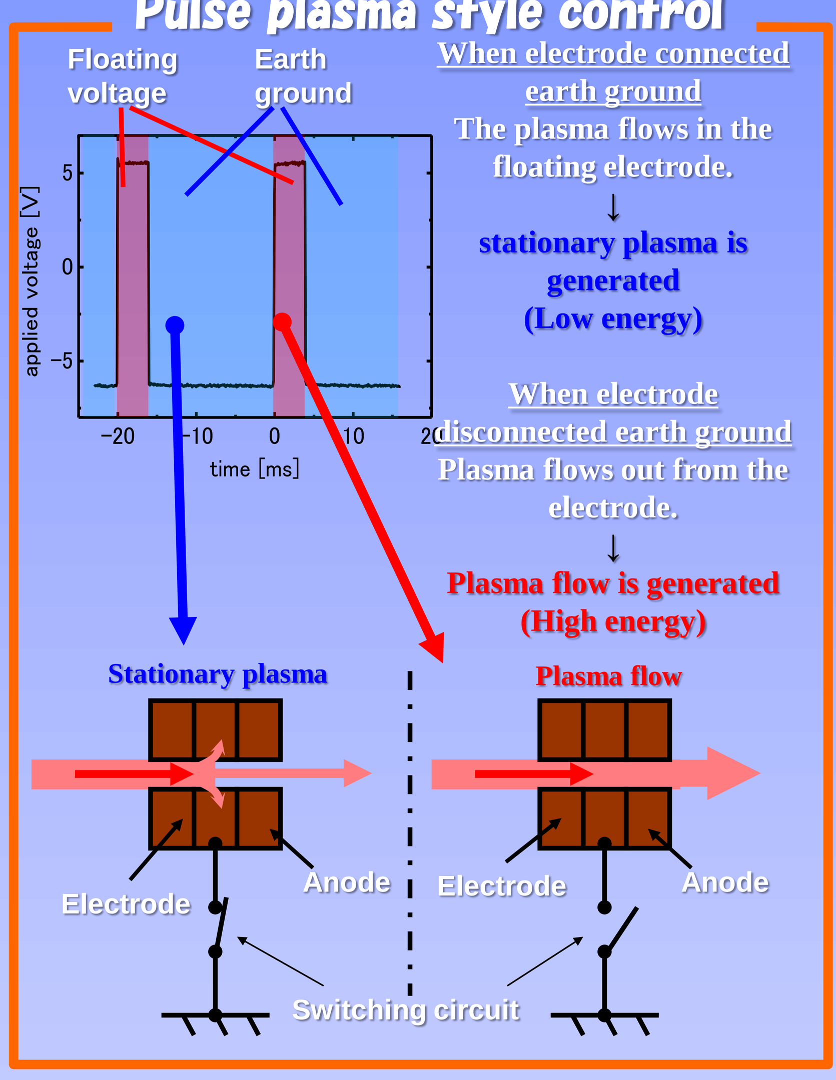
It is reported by nuclear-fusion device "JET", the recombination plasma with pulse plasma flow has been studied by observing the short double minimum (negative) spike in Dα/Hα emission from the plasma.



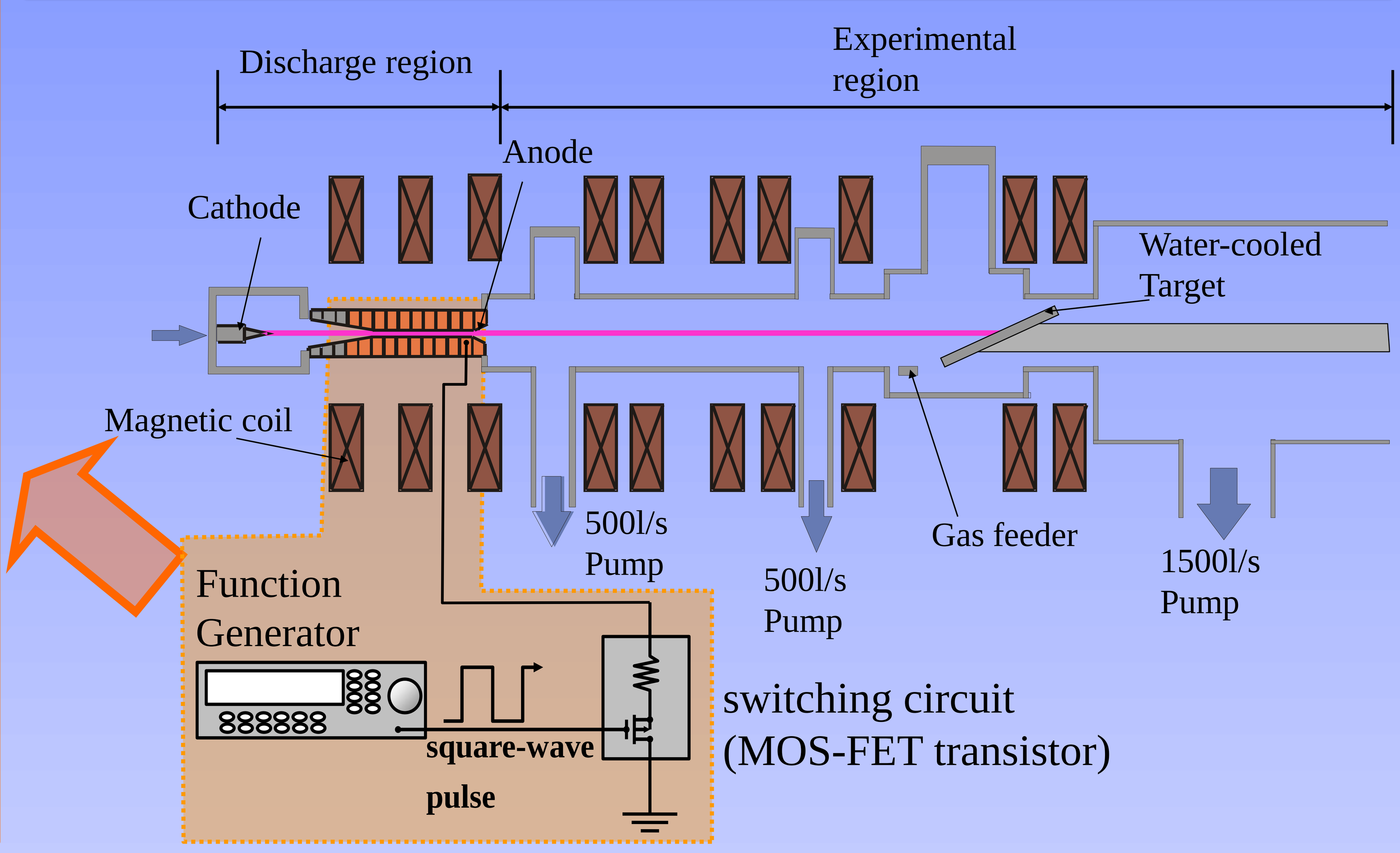
① Emission intensity by electron-ion recombining (EIR) becomes weak because the number of excitation atoms decreases. After, emission intensity increases by electron-impact excitation with the electron temperature increases.

② Emission intensity becomes weak again because electron-impact excitation decrease by the electron temperature decreases. After, emission intensity increases by recombining with the number of excitation atoms increase.

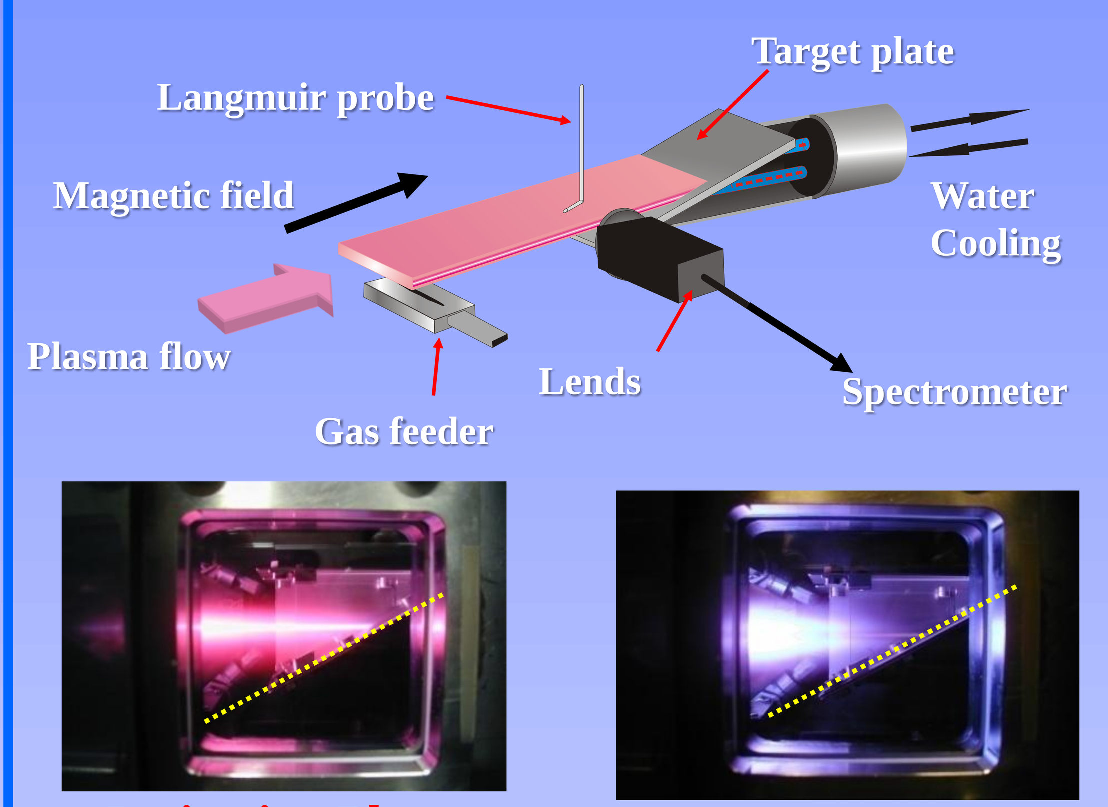
Pulse plasma style control



Linear plasma device(TPD-Sheet IV)



Experimental region

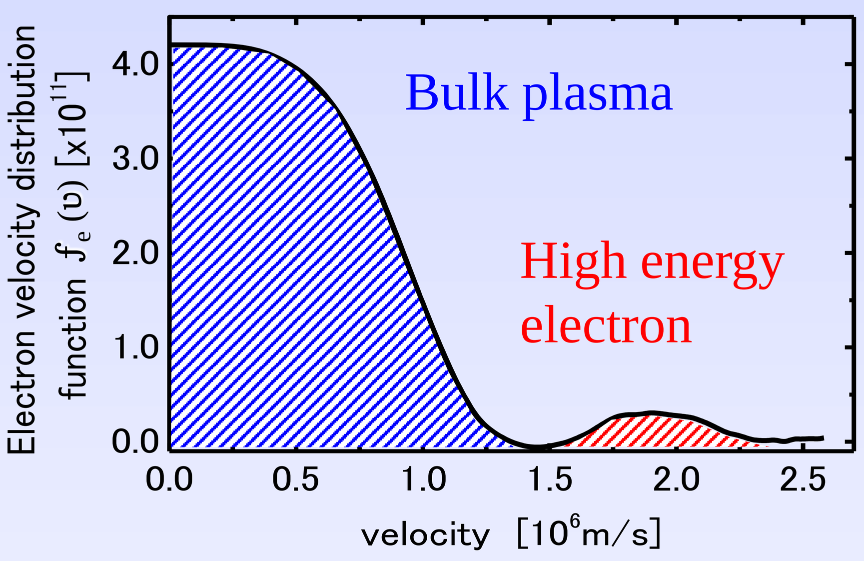


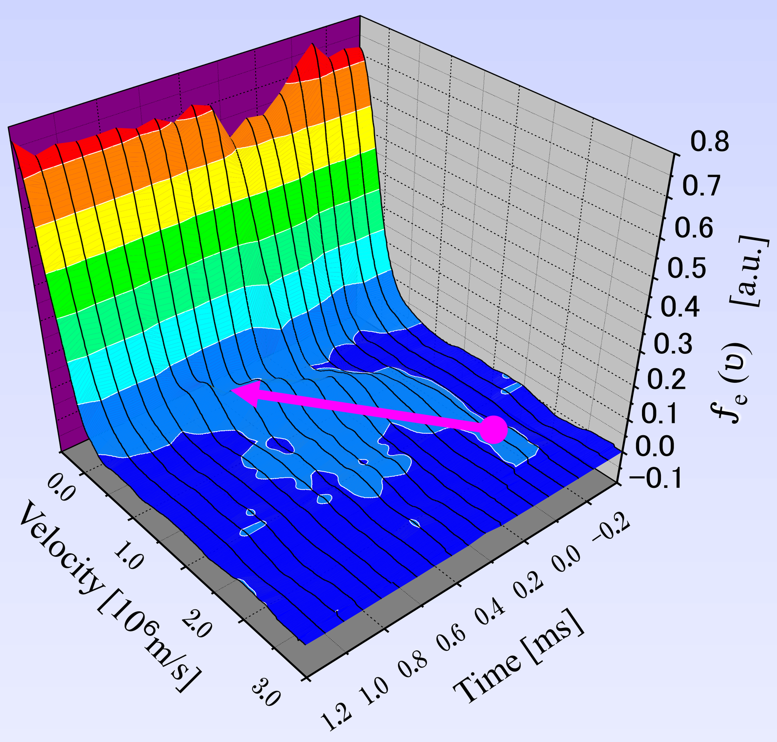
Ionization Plasma (High temperature) Recombination Plasma (Low temperature)

Photograph around experiment region

Experimental Results of $f_e(\upsilon)$

pulse width : 0.3ms
Emission Current : 70A
Gas pressure : 1.0Pa (Recombining Plasma)





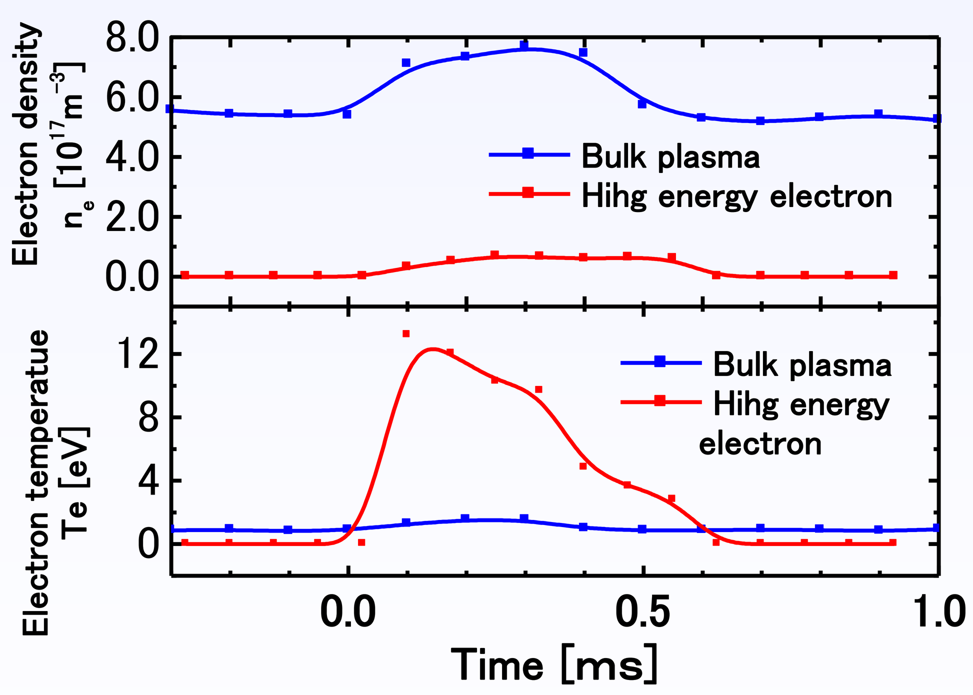
Electron density: n_e

$$n_e = \frac{2^{3/2} m_e^{1/2}}{e^{3/2}} \int_0^\infty \left(\frac{dJ_e}{dV_p}\right) d\sqrt{V_p} \quad [\mathrm{m^{-3}}]$$

Electron temperature: T_e

$$T_e = \frac{1}{n_e} \frac{2^{3/2} m_e^{1/2}}{e^{3/2}} \int_0^\infty V_p \left(\frac{dI_e}{dV_p}\right) d\sqrt{V_p} \quad [\mathrm{eV}]$$

Time-dependent of the electron temperature and the electron density is calculated by using $f_e(\upsilon)$ because of non-Maxwellian.

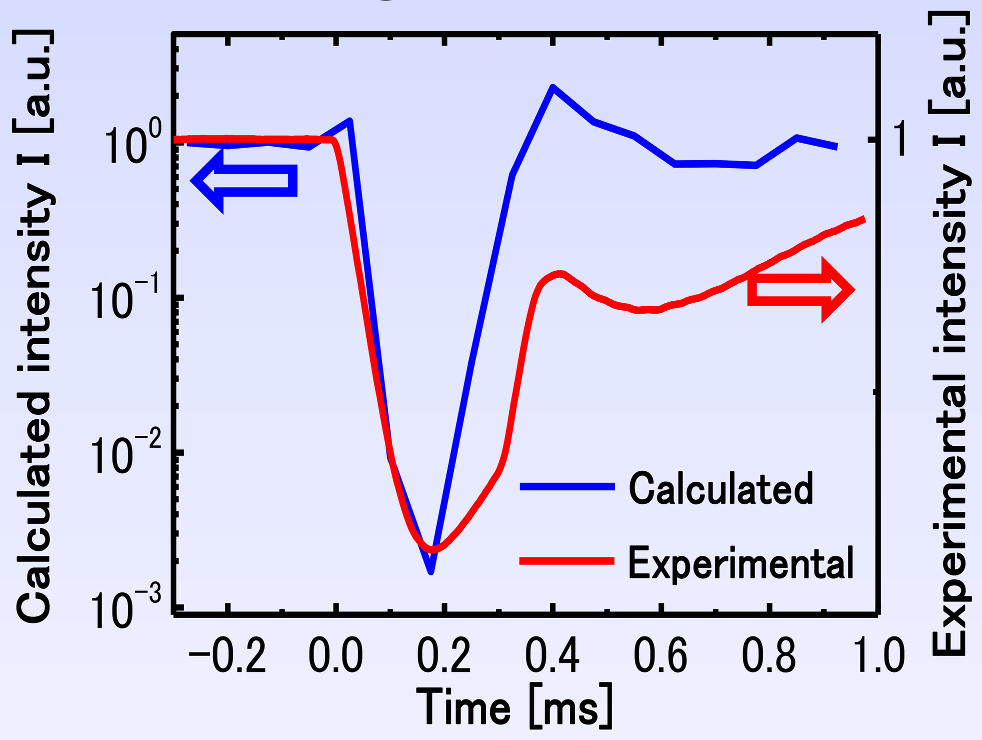


•Electron density
Bulk plasma: 5.5×10^{17} → 8.0×10^{17} [m^{-3}]
High energy electron : → 6.5×10^{16} [m^{-3}]

•Electron temperature
Bulk plasma: 0.8 → 1.6 [eV]
High energy electron : → 13.1[eV]

Experimental and Modeling results of Hα intensity

Comparison with experimental and modeling results



Modeling: corona model

$$\frac{dn(p)}{dt} = k(p)n(2)n_e - \sum_{i<p} A(p,i)n(p) = 0$$

$k(p)$: rate coefficient
$A(p,i)$: Einstein coefficient
$n(p)$: population of level "p"

$$I = \frac{hc}{\lambda}\frac{A}{\sum A} n(q)k(p)\cdot n_e$$

Conclusions

Experimental observations of the time evolution of the electron density n_e, the electron temperature T_e, the electron velocity distribution function $f_e(\upsilon)$, and hydrogen Balmer series spectra have been carried out on hydrogen recombination plasma with plasma flow. The emission intensity of Hα is calculated by using coronal model.

(1) The short double minimum (negative) spike in Hα emission from the plasma is observed in recombination plasma with pulse plasma flow.
(2) In the pulse plasma flow, the high energy electrons except for bulk plasma are appeared.
(3) The high energy electrons are dominant for the emission intensity of Hα in comparison with experimental and modeling results.

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