

§32. Mutual Neutralization between H^- and H^+ in a High-Density Helicon-Wave H^- Source

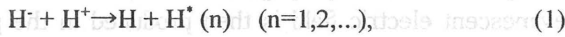
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To fulfill the requirement of high-current H^- (D^-) beam sources for NBI heating of thermonuclear fusion plasmas in the next generation, we have developed a helicon-wave-excited H^- ion source without erosive electrodes.

Efficient production of H^- was attained by time-modulated operation and the spatial control of the plasma parameters by means of sheet plasma formation.

With regard to the atomic processes concerning H^- , mutual neutralization between H^- and H^+ ,



is known as the dominant loss process, which leads to simultaneous optical emissions such as Balmer-series. The reaction (1) is of importance in the loss process of H^- in the extraction region of the H^- sources and can be utilized for the measurements of H^- density by the optical emission spectroscopy.

We studied the mutual neutralization process (1) in the recombining phase (afterglow) of a high-density ($n_+ \sim 10^{12} \text{ cm}^{-3}$) and low-pressure (5 mTorr) hydrogen plasma produced by helicon-wave excitation.

The H^- density (n_-) was measured by laser-photodetachment and the correlation between the intensities of Balmer series ($I_{H\alpha}, I_{H\beta}$) was investigated.

Figure 1 shows the temporal variations of n_-, n_+ and $I_{H\alpha}, I_{H\beta}$ in the afterglow. The emission intensities $I_{H\alpha}, I_{H\beta}$ had two-decay structure. For 10 μs after the termination of the discharge, the intensities first decreased drastically with the decay time of approximately 2 μs . In accordance with the increase in n_- , the decay of the intensities became slow. The fast and slow decay structures were observed. This can be understood by the following model. For the first 10 μs , the emission of the Balmer series is mainly due to the radiation from H^* excited by fast-electron-impact. The intensity component of the fast structure (I_{ie}) due to electron-impact-excitation decreases with the electron temperature. On the other hand, H^* produced by the reaction (1) increases with n_- . If we suppose that the slow structure after 20 μs is due to the radiation from H^*

produced by the mutual neutralization, the intensity component (I_{mn}) due to the reaction (1) is proportional to the product of n_- and n_+ . We determined I_{mn} by subtracting I_{ie} from $I_{H\alpha}$.

Figure 2 shows the temporal variations of $n_- \times n_+$ and I_{mn} in the afterglow and fairly good agreement was observed between both. This confirms that the slow decay structure in the Balmer series is mainly due to the emission from the reaction (1).

Henceforth, we will determine the rate coefficient for the emission process by the reaction (1) and develop a conventional diagnostics for H^- density by using the optical emission spectroscopy.

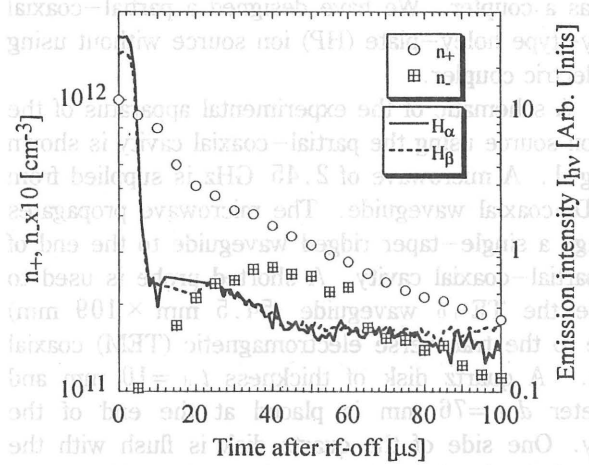


Fig. 1 Temporal variations of n_-, n_+ , and $I_{H\alpha}, I_{H\beta}$ in the afterglow.

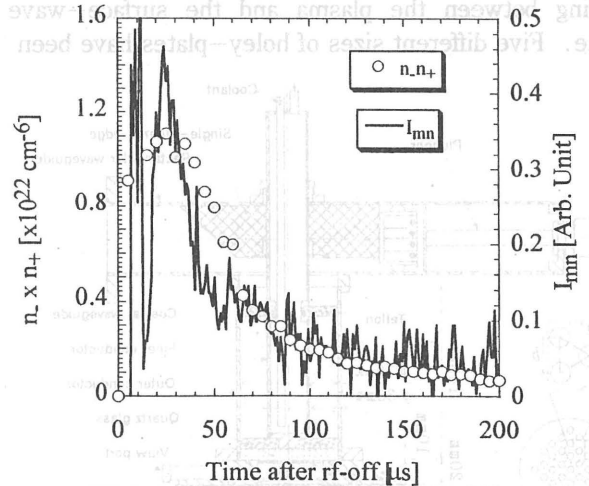


Fig. 2 Temporal variations of the product $n_- \times n_+$ and I_{mn} .