§10. Consideration on Pellet Ablation Characteristics and its Relation with Plasma Rotation

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Consideration on pellet ablation characteristics and on the relation with plasma rotation in the JIPP T-IIU tokamak has been carried out.

Characteristics of a cloud ablated from an ice pellet has been investigated in detail by an "injection-angle controllable system". A long "helical tail" of ablation light has been observed by using CCD cameras and a high speed framing photograph. The direction of this helical "tail" is independent to that of the total magnetic field lines of the torus. Experiments as to four conditions with the combination of two (CW and CCW) toroidal field directions and two plasma current directions show that the "tail" poloidally rotates to the electron diamagnetic direction, and toroidally to the opposite to the plasma current direction as to almost all conditions of injection angles.

In order to understand details of an ice-pellet ablation structure, a new spectroscopy system has been developed to have the local parameters within the ablation cloud. The electron density and temperature in the cloud have been obtained from the Stark broadening of Balmer Beta line, and from the line-to-continuum intensity ratio, respectively. Through the analysis by a multi-Lorenzian fitting method, it has been found that the typical cloud density is in the range of 10^{16} - 10^{17} cm^{-3}, and the typical temperature is in the range of 1 - 4 eV. Potential measurements of pellet-injected plasmas by using a heavy ion beam probe (HIBP) method have also been carried out.

Based on cloud parameters, characteristic times for various processes such as charge exchange, elastic collision, excitation, ionization and recombination are analyzed. Since the charge-exchange and elastic-collision times are greatly shorter than the ionization time in this region, consideration on various characteristic times leads us to the conclusion that the "tail-shaped" phenomena may come from the situation of charge exchange equilibrium of hydrogen ions and neutrals at extremely high density regime in the ablation cloud.

Also, the "tail" phenomenon has been analyzed by considering both effects; i.e., the effect by collisions of hydrogen atoms/ions in a cloud with bulk ions, and the effect of E_r x B drift due to macroscopic radial electric field. The analysis shows that the velocity of the cloud **V** will be written as follows:

$$\mathbf{V} = (gN_{bi} + kN_{ci}) / (N_{ci} + N_{cn}) \cdot (E_r / \mathbf{B}).$$

Here, N_{bi} is the total number of hydrogen ions on the magnetic surface, N_{ci} the total number of hydrogen ions in the ablation cloud, N_{cn} the total number of hydrogen atoms in the ablation cloud, and E_r the radial electric field in the plasma. Also, g is the momentum transfer rate from bulk ions to cloud neutrals, and k means the screening rate of radial electric field of the plasma in the cloud. In this equation, the first term represents the effect of momentum transfer from bulk ions, and the second term means the effect of plasma potential on the cloud. For the toroidal component of **V** (V_t), **B** is replaced by B_p, and for the poloidal component of **V** (V_p), **B** is replaced by B_T.

From the experimental results and theoretical consideration, the "tail" structure may be caused both by the situation of charge exchange equilibrium of hydrogen ions and neutrals at extremely high density regime in the cloud, and by the effect of the plasma potential and rotation.

References
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