§17. ICRF Heating Experiment in Heliotron-J

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The high energy particle confinement and MHD stability are key issues of a helical-axis heliotron device, Heliotron J as an advanced helical device. High energy ions generated by ion cyclotron range of frequencies (ICRF) heating are utilized for the investigation of energetic ion confinement in Heliotron J. A charge exchange neutral particle energy analyzer (CX-NPA) is scanned in the toroidal direction in order to observe ions in the wide range of the velocity distribution.

The ICRF heating is performed with minority heating mode for the investigation of energetic ions using a loop antenna. The high energy flux up to 10 keV is observed during ICRF pulse imposed on ECH target plasmas with Ti = 0.2 keV. The ICRF pulse is launched from the low field side at the corner section of the plasma. In this cross section, the mod-B has tokamak-like structure. The measured hydrogen-minority flux decreases as increasing the toroidal angle (becoming far from the pitch angle = 90 degrees) because of the perpendicular acceleration of protons by ICRF heating as shown in Fig.1.

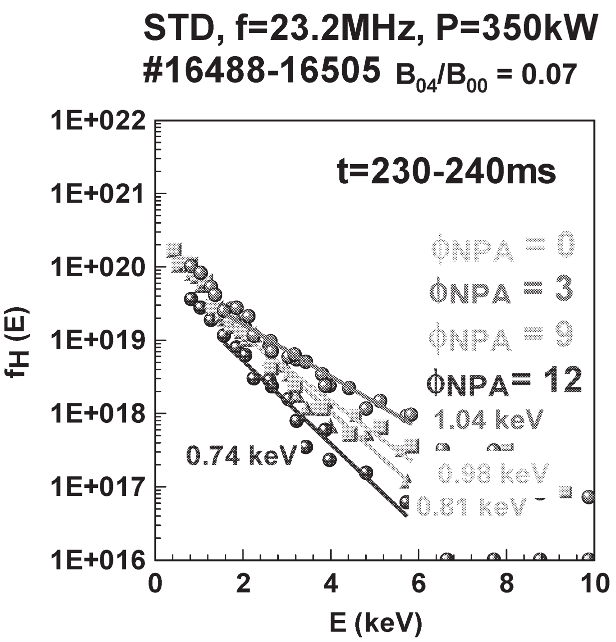

Fig.1. Energy spectra of hydrogen flux for various toroidal angles of CX-NPA. The effective temperature of the tail component is estimated.

It is noted that the loss region along the NPA's line of sight increases when the toroidal angle decreases from the result of the orbit calculation. Therefore, the flux peak located near the toroidal angle = 3 degrees (corresponding pitch angle = 117°). When the direction of the magnetic field is reversed, the difference of the observed fluxes is also found. The flux with the anti-parallel velocity is larger than that with parallel velocity. This is supposed to be due to the smaller loss region along the line of sight of NPA.

High energy ion confinement is studied in relation to the magnetic configurations. It is predicted that one of the magnetic Fourier components, toroidal mirror ripple component (B_{04}) plays a key role on the collisionless particle confinement in the Heliotron J configuration. Three configurations are selected; the mirror ripples (B_{40}/B_{00}, where B_{00} is the averaged magnetic field strength) are 0.02, 0.07 and 0.16 at the normalized minor radius ρ = 0.5. The case of 0.07 corresponds to the standard configuration (STD) of Heliotron J. This experiment has been performed in the low density deuterium plasmas ($<1\times10^{19}$ m^{-3}) since the plasma should be collisonless. The ICRF frequency is adjusted so that the cyclotron resonance layer may be positioned within ρ = 0.2. The observed high energy flux is largest in the case of the highest mirror ripple and the smallest for the lowest mirror although the loss region along the NPA's chord is largest in the case of 0.16 among the three configurations. The estimated tail temperature is 1.04 keV for 0.16 of B_{04}/B_{00}, 0.87 keV for 0.07, and 0.47 keV for 0.02, respectively. This result suggests that the configuration with larger mirror ripple in this experimental range has an effect to improve the confinement of high energy ions.

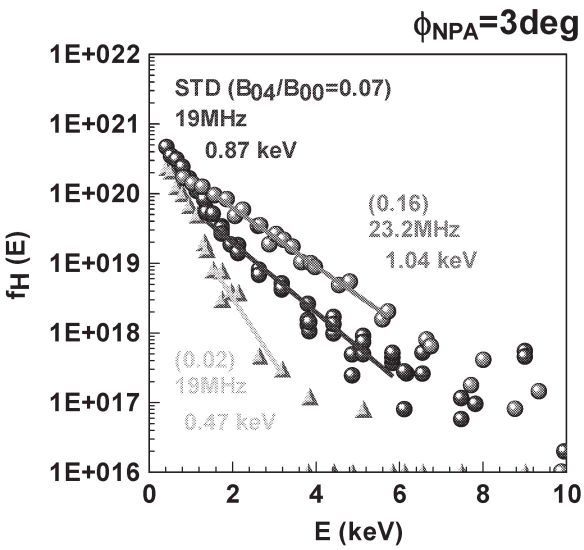

Fig. 2. Energy spectra of hydrogen flux in three configurations by changing bumpy component.

In this campaign, the high energy ion confinement is investigated using ICRF minority heating. As a result of the experiment, the velocity distribution of accelerated ions and the dependency of toroidal mirror ripple on the high energy formation and confinement are qualitatively understood. In the next campaign, the quantitative estimation of the high energy ion confinement is planned with power modulation method. The bulk heating experiment will be performed with a newly installed loop antenna in addition to the first one.