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ヘリオトロンJにおけるICRFによる高速イオンエネルギースペクトルの空間・磁場配位依存性

Dependence of Fast Ions Generated by ICRF Minority Heating on Magnetic Field and Spatial Position in Heliotron J

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Confinement of high-energy particles is an important issue for plasma heating. Using fast protons generated by ion cyclotron range of frequencies (ICRF) minority heating in Heliotron J, generation and confinement of fast protons have been investigated experimentally. In the previous researches for the dependences of effective temperature of hydrogen and deuterium temperature on heating position, the observed results were not consistent with the expectation from the standard heating mechanism of minority heating. It's possible that measured fast protons do not represent the characteristic of averaged fast protons. The aim of this study is to carry out the investigation of the spatial distribution of fast protons in the wide area of the vertical cross-section and to clarify the effect of generation and confinement of fast protons on magnetic configurations (bumpiness).

An ICRF wave was injected into electron cyc1otron heated (ECH) plasmas. The ICRF frequency of 23.2 MHz was selected for the high bumpiness and 19.0 MHz was selected for the low bumpiness for the on-axis heating. The line-averaged electron density is 0.4 x 10^{19} m^{-3}, the 70-GHz ECH injection power is 0.30-0.35 MW, and the ICRF injection power is 0.25-0.30 MW. The minority ratio (H/H+D) is about 10 %. By using a charge exchange neutral particle analyzer (CX-NPA) of an E//B type, energetic ions are observed.

The energy spectra of hydrogen and deuterium measured in the high bumpiness and low bumpiness at the horizontal angle 0° are illustrated in Fig.1. In medium bumpiness, the vertical angle dependence of the energy spectra is relatively weak. On the other hand, in the high bumpiness, the vertical angle dependence of the energy spectra is found. The effective temperature of hydrogen was measured from the gradient of plotted data from the energy range of 1 keV to 6 keV (See Fig.2). The effective temperature of hydrogen is almost same at each angle in the medium bumpiness. However, in the high bumpiness, the vertical angle dependence was found to be strong. The most significant horizontal dependence was found at the vertical angle 2°. The previous study indicated that the spatial change of fast protons is large only in the inner-side heating of the medium bumpiness. However, this result indicates the spatial change of fast protons is large even in the center heating of the high bumpiness. In each angle, the effective temperature of fast protons in the high bumpiness is larger than that in the medium bumpiness. It is clarified that the generation and confinement of fast protons by using ICRF heating are the most efficient in the high bumpiness.

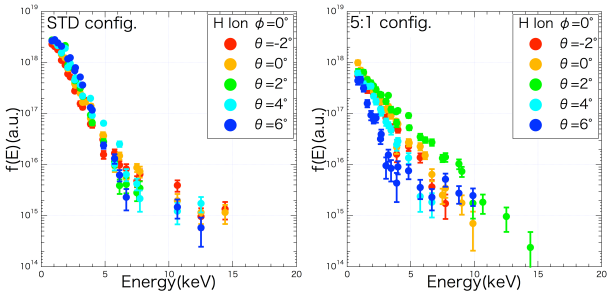

Fig.1：The energy spectra of hydrogen in the medium bumpiness (left) and the high bumpiness (right)

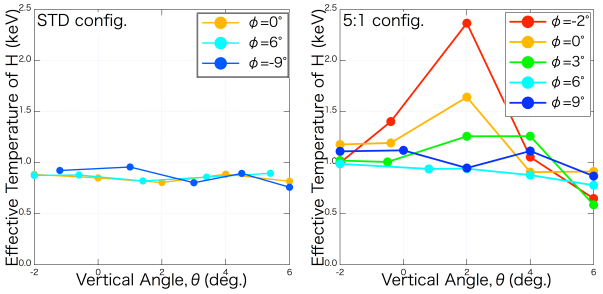

Fig.2：The effective temperature of hydrogen in the medium bumpiness (left) and the high bumpiness (right)