IAEA FEC 201

Contribution ID: **115** Type: **Poster**

Fast Ion Generation by Combination Heating of ICRF and NBI in Heliotron J

Friday, 21 October 2016 14:00 (4h 45m)

The fast ion generation and confinement are studied by using ICRF minority heating (H minority and D majority) for the simulation study of alpha particles, whose heating is essential for fusion reactors. In a three dimensional magnetic field device, Heliotron J (R_0 = 1.2 m, a = 0.1-0.2 m, B_0 1.5 T), fast ion generation and confinement by ICRF minority heating are studied in combination with NBI heating. Fast ions are measured using a charge-exchange neutral particle analyzer with ten channels for hydrogen. The energy range is extended from the injection energy of the NBI beam, 25 keV, to 60 keV during the ICRF pulse in the newly attempted low-epsilon_t configuration and medium density operation (1x10^{19} m^{-3}). This configuration is better in the fast ion generation and confinement than the high bumpiness configuration which is the best among the bumpiness scan. Here, the toroidicity and the bumpiness normalized by the helicity for the low-epsilon_t and the high bumpiness configurations are (0.77, -1.04) and (0.86, -1.16) in Boozer coordinates, respectively. They are key parameters in 1/nu regime of helical devices. The low-epsilon_t configuration is expected to have good confinement from the neo-classical theory. The observed fast ions are limited up to 35 keV in the high bumpiness configuration for the same conditions. The Monte-Carlo calculation is also performed for understanding the fast ions observed in the experiment. The test ions (protons), which represent the NBI particles, start at the middle point of the NB path in a plasma with the NB injection energy. The energy tail spread more toward the high energy region in the low-epsilon_t and its direction is relatively narrow in comparison with the high bumpiness. The experimental and calculation results are explained partially by the loss region of fast ions for these configurations.

Paper Number

EX/P8-18

Country or International Organization

Japan

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Session Classification: Poster 8

Track Classification: EXC - Magnetic Confinement Experiments: Confinement