§31. Behavior of High-energy Ions Created by ICRF in LHD

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In the 4th experimental campaign conducted in 2000 the behavior of high-energy ions was investigated using a natural diamond detector (NDD) [1] and a time-of-flight neutral particle analyzer (TOF-NPA) [2]. It is important to study how distribution function is changed for understanding of ICRF heating mechanism. Therefore the temporal behavior of high-energy ions was investigated in two cases of fundamental ICRF heating (minority heating). One is the behavior of high-energy ions measured by the NDD after turn-off of ICRF heating power, and another is that during power modulation measured by the TOF-NPA. Pitch angle dependence of the distribution function was also investigated by changing the line of sight of the TOF-NPA.

Figure 1 shows the time evolution of count numbers of neutral particles detected by the NDD after turn-off of ICRF heating superposed to NBI heated plasma ($\overline{n_e} = 1.4\times10^{19}$ m^{-3}, T_{e0}=2.0 keV, and P_{ICH}=1.8 MW). The count numbers are normalized using those at turn-off of the ICRF heating power for various measured ion energies. It was found that the count number decays faster after turn-off of ICRF in the higher energy. This tendency agrees well with the calculation of the Fokker-Planck equation with the second order of Legendre expansion, whose argument was selected at cosine of the pitch angle based on Stix [3].

Figures 2 shows the experimental phase delay of count number (solid circles) measured by the TOF-NPA relative to the modulated ICRF heating power ($\overline{n_e} = 0.5\times10^{19}$ m^{-3}, T_{e0}=1.3 keV, P_{ICH}=1.2 MW, and ΔP_{ICH}=77 kW). It was found that the phase delay increased with the energy. The result was compared with the calculation of the Fokker-Planck equation (solid line) assuming effective temperature of hydrogen of 11 keV.

The angle of line of sight of the TOF-NPA to the magnetic axis, ϕ was scanned from 40.4° to 93.9° in shot by shot of the five successive fundamental ICRF sustained discharges, keeping plasma parameters and ICRF injection power constant, i.e. $\overline{n_e} = 0.9\times10^{19}$ m^{-3}, T_{e0}=1.5 keV, and P_{ICH}=1.45 MW. Figure 3 shows the contour of count number of neutral particles detected by the TOF-NPA. This may show "butterfly" ("rabbit-ear") structure of the distribution function in the high energy velocity space. This can be explained as follows: The particles are accelerated perpendicularly to the magnetic field line at the cyclotron resonance layer; therefore the population of trapped particles increases, and the banana tip where the parallel velocity becomes zero moves towards the ion cyclotron resonance layer. However, the particles whose banana tip is located at lower magnetic field side than the ion cyclotron resonance layer cannot be accelerated. Therefore the population of the particles whose banana tip is located at the cyclotron resonance layer becomes large as shown in Fig. 3.

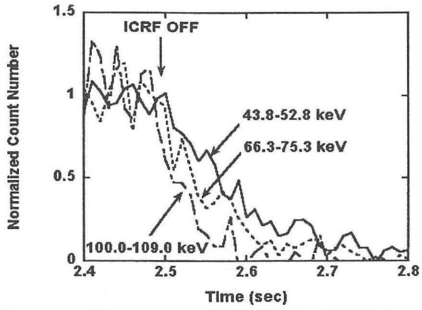

Fig. 1 Decay of count number after ICRF turn-off

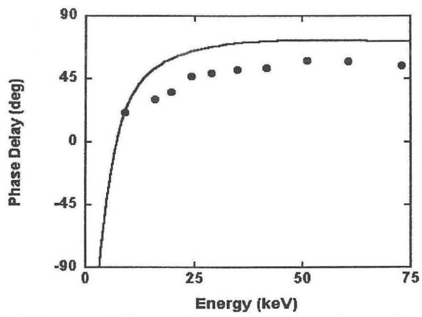

Fig. 2 Phase delay of count number during power modulation. (circle: experiment, line: calculation)

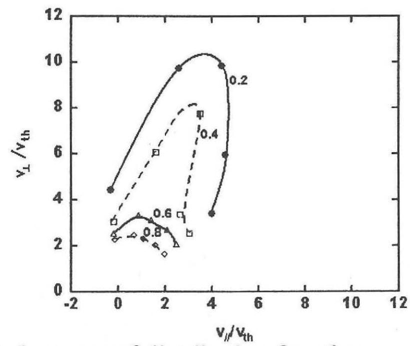

Fig. 3 Anisotropy of distribution function

Reference

[1] Isobe, M. et al.: Review of Scientific Instruments **72** (2001) 611.
[2] Ozaki, T. et al.: Review of Scientific Instruments **71** (2000) 2698.
[3] Stix, T.H.: Nucl.Fusion **15** (1975) 737.