§12. Confinement of Perpendicularly Injected Energetic Ions on Different Magnetic Configurations in CHS

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Confinement of helically trapped ions is one of the key issues in the slowing down process of energetic ions injected by neutral beam on helical devices. In CHS, confinement of collisionless trapped ion confinement depends on the magnetic field configuration. In the configuration with the strong inward shift, the distortion of $|B_{min}|$ contours from the magnetic flux surfaces is minimized. In this configuration, the drift motion of the helically trapped particles does not deviate significantly from the magnetic flux surfaces and good confinement of fast ions are expected. In contrast, in outward shifted magnetic field configuration, the distortion of $|B_{min}|$ contours from the magnetic flux surfaces is large and helically trapped ions crossing the magnetic flux surfaces will be lost.

In order to investigate magnetic axis dependence of trapped particle confinement in CHS, diagnostic neutral beam (DNB) was perpendicularly injected into electron cyclotron resonance heating (ECRH) sustained plasma with magnetic axis position, R_{ax} of 88.8 cm (inward shifted configuration) and 99.5 cm (outward shifted configuration). Line averaged n_e and central electron temperature is 1×10^{19} m^{-3}, 0.43 keV for R_{ax} 88.8 cm and 0.46×10^{19} m^{-3}, 1.1keV for R_{ax} 99.5 cm in this experiment. The beam energy (E_b) of DNB is set to be 27 keV and there are three components of beam energy: full energy (27 keV), half energy (13.5 keV) and one-third energy (9 keV). Injected energetic ions are observed with the holizontally scannable neutral particle analyzer (NPA).

Figure 1 shows the energy spectrum when the DNB is injected at tangential radius (R_T^{DNB}) of 31 cm in co-direction in the magnetic configuration of R_{ax} 88.8 cm (a) and R_{ax} 99.5 cm (b). The NPA was scanned horizontally shot by shot from tangential radius (R_T^{NPA}) of 18 cm to 74 cm and the neutral flux is integrated over 40 msec during the discharge. Each energy component of the DNB, E_b (27 keV), $E_b/2$ (13.5 keV), $E_b/3$ (9 keV) was clearly observed. E_b component shows slowing down process while $E_b/2$ and $E_b/3$ components show pith-angle scattering. When the energy of injected ions is high enough not to be affected by pitch-angle scattering, the slope of the energy spectrum is determined from the ratio of energetic ion slowing down time (τ_{se}) to the confinement time (τ_{conf}) as:

$$f(E) \cong \left(\frac{S_0 \tau_{se}}{2E_b}\right)\left(\frac{E_b}{E}\right)^{-(\tau_{se}/2\tau_{conf}+1)} \qquad (1)$$

where S_0 is the energetic ion source term. Applying the eq.(1) as a fitting curve, τ_{conf} is derived from energy spectrum (Fig.2). In this experiment, estimated τ_{conf} is 6.2 msec for R_{ax} 88.8 cm and 5 msec for R_{ax} 99.5 cm respectively. This result indicates that inward shifted configuration has better confinement of perpendicularly injected energetic ions compared with that of outward shifted configuration.

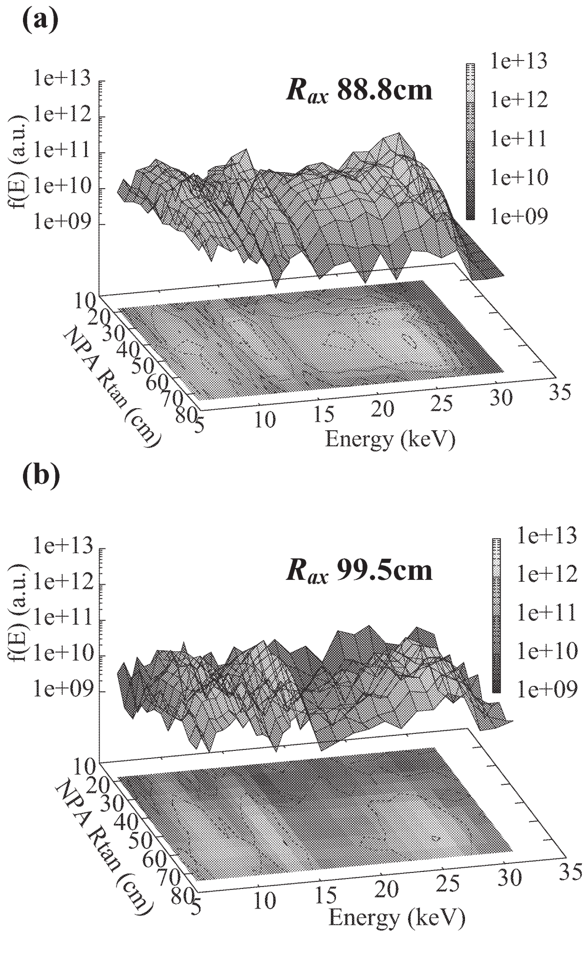

Fig.1 Energy spectrum of energetic ions measured at each tangency radius of NPA for DNB injection with R_T^{DNB} of 31 cm in (a) Inward sifted configuration (R_{ax} 88.8cm) and (b) Outward shifted configuration (R_{ax} 99.5cm)

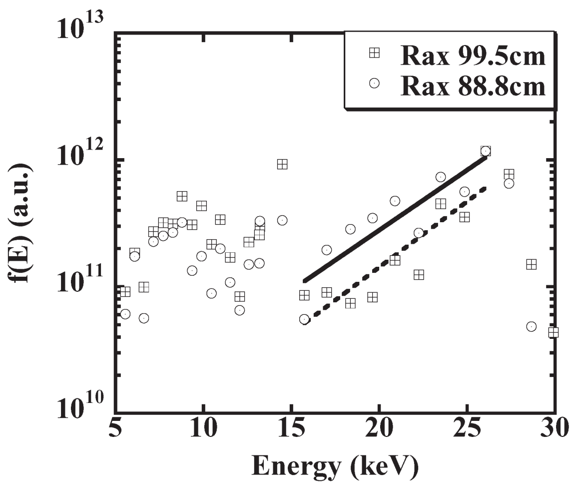

Fig.2 Energy spectrum of energetic ions measured at R_T^{NPA} 49cm (64cm) for the plasma with R_{ax} 88.8cm (99.5cm), and solid (dashed) line shows eq.(1) fitted to experimental result.