§15. Progress on Temporally and Radially Resolved Charge Exchange Diagnostics of Fast Ions on LHD

Goncharov, P.R., Ozaki, T.

Experiments on suprathermal ion physics are carried out on LHD with a 40 channel Compact Neutral Particle Analyzer (CNPA) [1]. The analyzer is used both in passive non-perturbing chord-integral neutral particle flux measurements and for local probing with an impurity pellet. The analyzer observes trapped particles with $|v_{||}/v| \lesssim 0.25$ and the pitch angle cosine value $v_{||}/v$ changes sign along the diagnostic sightline. The measurable energy range for H^0 is 1 - 170 keV.

The analysis of escaping neutral particles formed from plasma ions in charge exchange (CX) collisions serves as one of the principal tools to study the core ion temperature, $T_i(\rho)$ radial profiles, fast ion confinement, ion kinetics and heating mechanisms by $f_i(v, \vartheta, t)$ measurements. A significant progress on the CNPA diagnostic has been made recently on LHD [2, 3].

The illustrative experimental results presented here show the time and energy resolved non-perturbing measurements of the natural neutral flux from tangential and perpendicular hydrogen NBI and hydrogen minority ICRF heated Ar/He background plasma (Fig. 1) and the active probing with a polystyrene pellet during the steady state with combined heatings (Fig. 2).

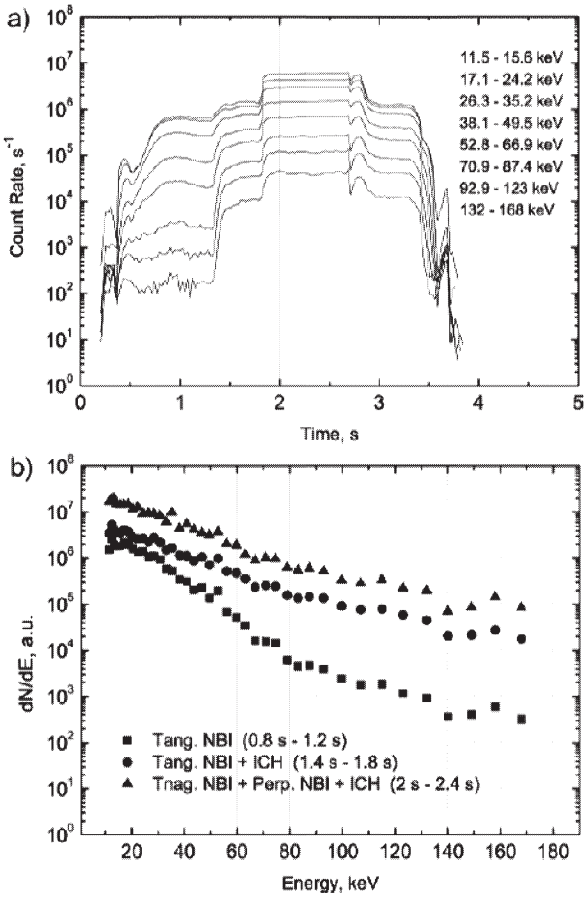

FIG. 1. Passive non-perturbing measurements: a) time behavior of the neutral particle flux in eight energy subintervals; b) neutral spectra obtained in different heating conditions.

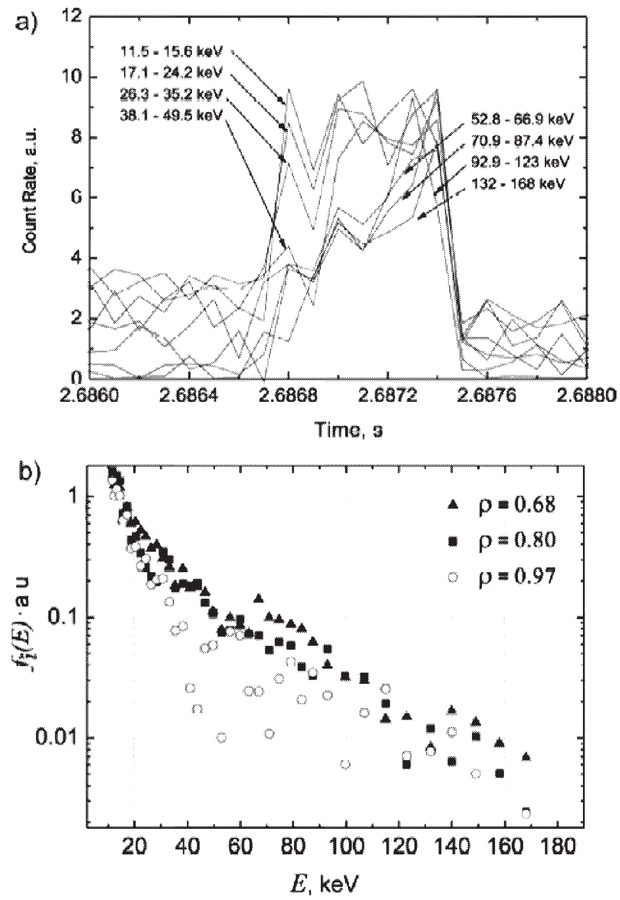

FIG. 2. Active PCX measurements: a) time behavior of the neutral particle flux in eight energy subintervals; b) neutral spectra obtained from different radial positions.

The tangential NBI #1 E_{inj} = 153 keV and the perpendicular NBI #4 E_{inj} = 40 keV. Fig. 1 (a) shows the time behavior of the neutral flux in eight subintervals of the total range. The uppermost curve corresponds to the lowest energies. A pronounced response to ICRF can be seen as a substantial increase of the high energy CX particle flux. The perpendicular NBI pulse causes a clear further increase. This is consistent with the measurement geometry and the observable particle pitch angles. The CX neutral spectra corrected for detection efficiencies, shown in Fig. 1 (b) reflect the fast ion population growth and the distribution tail slope change due to ICH accelerating particles orthogonally and the perpendicular NBI.

The response of the CEM currents to the injection of D_{pel} = 880 μm, v_{pel} = 477 m/s $(-C_8H_8-)_n$ pellet can be seen in Fig. 2 (a). Summary curves are shown for the same eight energy subintervals as above. The ablation signal time abscissa corresponds to the pellet penetration into the plasma column. The energy spectra from the outer (ablation start), intermediate, and inner (ablation end) radial locations are presented in Fig. 2 (b). The time resolution of 100 μs allows one to obtain several radially resolved spectra depending on the pellet ablation time interval. These $f_i(E)$ histograms were reconstructed from PCX neutral spectra by using the detection efficiency data and the energy dependent equilibrium neutral fraction $F_0(E)$.

References

1) Chernyshev F.V., et al., Instr. and Exp. Tech., **47** (2004) 214
2) Goncharov, P.R., et al., Fusion Sci. Technol., **49** (2006)
3) Goncharov, P.R., et al., Rev. Sci. Instrum. **77** (2006)