

### §39. Evaluation of Deeply Trapped Fast-ion Confinement Using the NB-blip Experiments -II-

Osakabe, M., Tokuzawa, T., Isobe, M., Nagaoka, K., Murakami, S. (Dept. of Nucl. Engin., Kyoto Univ.), Kobayashi, S. (IAE, Kyoto Univ.)

The decay times of neutral flux after NB-short pulse injection are measured by Si-diode Fast Neutral Analyzers(FNAs) for three different configurations of LHD[1]. These decay times contain the information of lifetimes ( $\tau_{lifetime}$ ) of fast-ions on the orbit and energy slowing-down times ( $\tau_s^{E_{inj.} \rightarrow E_{thres.}}$ ) of them from the NB-injection energy to the threshold energy of the measurements, as shown below;

$$1/\tau_{decay} = 1/\tau_s^{E_{inj.} \rightarrow E_{thres.}} + 1/\tau_{lifetime} \quad ---(1),$$

$$\text{where } \tau_s^{E_{inj.} \rightarrow E_{thres.}} = \frac{\tau_{se}}{2} \ln \left( \frac{E_{inj.}^{3/2} + E_c^{3/2}}{E_{thres.}^{3/2} + E_c^{3/2}} \right) \quad ---(2).$$

The  $E_c$  is the critical energy where the heating power to bulk electrons by fast-ions becomes equal to that to bulk ions. Using eq.(1), lifetimes of fast-ions are evaluated from the decay times and are compared to the 90-degree pitch angle scattering times and charge exchange loss times in Fig.1(a) and (b). As shown in these figures, the lifetimes are anti-correlating to the charge exchange loss times and are correlating with the 90-degree pitch angle scattering times. This suggests that the lifetime of fast-ions on the NPA sight lines are dominated by the pitch-angle scattering not by the charge exchange loss. Considering the fact that the pitch-angle resolution of the NPA is about 0.1degree, the pitch-angle loss time from the sightline becomes much smaller value than the 90-degree pitch-angle scattering time and the value would be the order of mili-second. On the other hand, the measured lifetimes are order of 100-ms, this difference can be understood as follows. The lifetime is determined by the balance between the loss-rate from the NPA sight lines and incoming rate to it with the pitch angle scattering processes. If the fast-ions are lost significantly from the plasmas, the incoming rate to the sight line becomes small and the observed lifetime will be small. Therefore, the lifetime normalized by the 90-degree pitch angle scattering rate indicates the confinement property of fast-ions in LHD-plasmas. The dependence of normalized lifetimes, on the LHD configurations is shown in Fig.1(c). Fig.1(c) shows clearly the superiority of fast-ion confinement of inwardly shifted magnetic configurations to the outward ones.

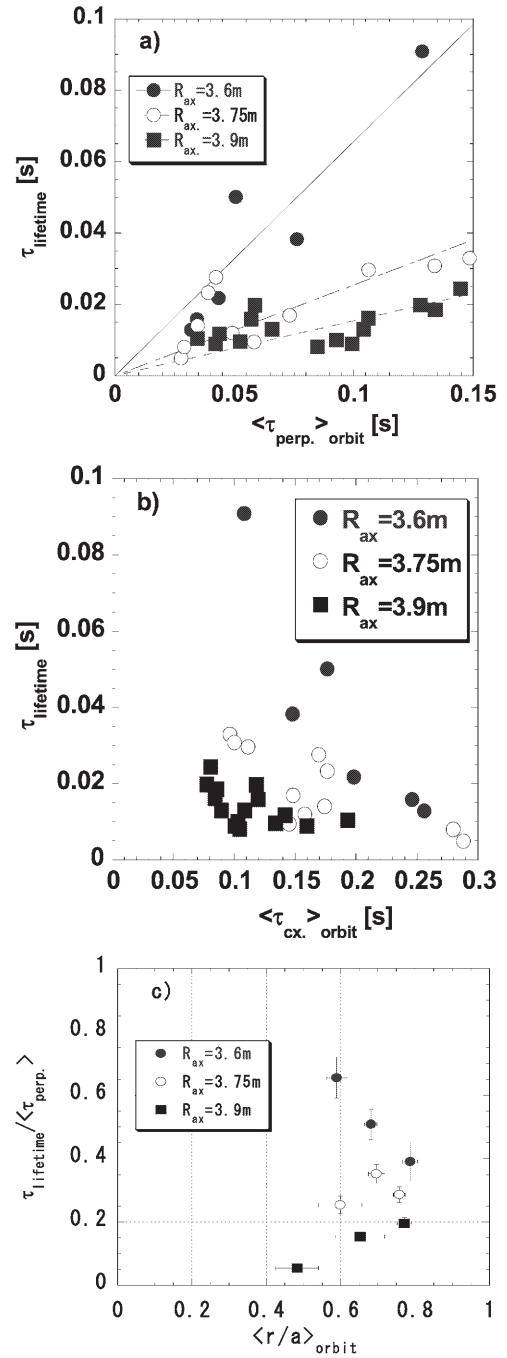


Fig. 1. The evaluated lifetimes of fast-ions are compared to (a) the orbit averaged 90-degree pitch angle scattering times ( $\langle \tau_{perp.} \rangle_{orbit}$ ) and (b) the charge exchange loss rate ( $\langle \tau_{cx.} \rangle_{orbit}$ ). (c) The distribution of normalized lifetimes are shown for three different LHD configurations. The closed circles(●), open circles(○) and closed squares(■) indicates the LHD-configurations of  $R_{ax}=3.6m$ ,  $3.75m$  and  $3.9m$ , respectively.

This work is supported by NIFS08ULBB503 and NIFS08ULBB512.

[1] Osakabe.M., et.al., this annual report.