§10. Impurity Transport Study in High-density Discharges of LHD Based on a Conventional Method

Morita, S., Goto, M., Zhou, H.Y., Dong, C.F., Sakamoto, R.

High-density discharges up to $1x10^{15}cm^{-3}$ have been achieved using multi-pellet injection at outwardly shifted configurations ($3.8 \le R_{ax} \le 4.0m$). Peaked density profiles are seen after the pellet injection and sustained during several hundred milliseconds with appearance of the maximum diamagnetic energy. Impurity transport study becomes important in such a high-density operation in relation to the impurity accumulation. However, the use of active method with impurity pellet injection is quite difficult, because the electron temperature remarkably changes as a function of time. A classical method using passive spectroscopy is then applied to the present core impurity transport study [1].

A typical waveform in high-density discharges is traced in Fig.1. Nine H_2 pellets are repetitively injected during 0.7-0.9s (see Fig.1(c)). Line-averaged electron density continuously increases during the pellet injection and reaches $4x10^{14}cm^{-3}$. Electron temperature at plasma center quickly decreases down to 0.3keV with the density rise. Na-like resonance transition of FeXVI (335.4Å) suddenly increases after the pellet injection taking its maximum at the final pellet injection (t=0.95s). The FeXVI is then used for the present study.

The iron density profiles calculated at T_e=0.4keV and $n_e=5x10^{14}cm^{-3}$ are shown in Fig.2 as an example of the calculation, where the n_{Fe}/n_e is assumed to be 10^{-4}. It is seen that the FXVI is located at the plasma center.

The impurity transport is studied with traditional method using impurity transport code. Values of diffusion coefficient, D, and convective velocity, V, have been already examined in usual NBI discharges [2], e.g., $D=0.2m^2/s$ and V=-3m/s for titanium impurity. For FeXVI, then, $D=0.2m^2/s$ and V=-3m/s are used for the analysis. The result is shown in Fig.3(a) as a parameter of the iron impurity density normalized by electron density. The impurity density is thus determined to be $6x10^{-7}$ to the electron density. The total radiation loss from iron is also estimated to be 200kW from the analysis of FeXVI under $T_e(0)$=0.3keV and $n_e=5x10^{14}cm^{-3}$ indicating entirely low power loss compared with the input NBI power of 15-20MW. Profiles of Z_{eff} with values close to unity have been also observed in such high-density discharges [3], indicating pure hydrogen plasma.

The time behavior of FeXVI is analyzed as parameters of D and V. It is difficult to obtain two parameters separately from usually used passive spectroscopy. A typical result is shown in Fig.3 for V dependence. The value of D is fixed as $0.2m^2/s$, since the electron diffusion coefficient does not change during the discharge [4]. The inward velocity has to be reduced after the pellet injection at t=0.95s in order to describe such a quick reduction of the FeXVI signal.

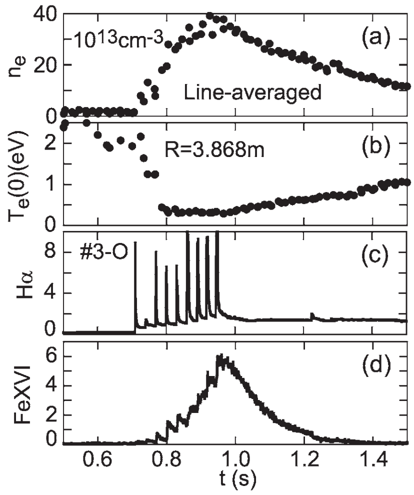

Fig.1 High-density discharge with nine H_2 pellet injection; (a) line-averaged n_e, (b) $T_e(0)$, (c) Hα and (d) FeXVI.

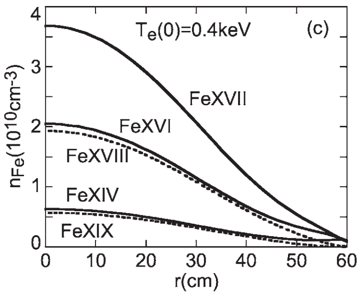

Fig.2 Typical example of iron density profiles after pellet injection calculated with $T_e(0)$=0.4keV and $n_{Fe}/n_e=10^{-4}$.

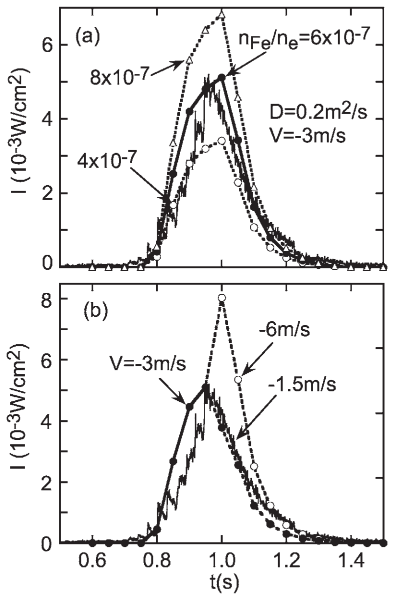

Fig.3 Analyses of FeXVI intensity as parameters of (a) n_{Fe}/n_e and (b) convective velocity.

1) S.Morita, et al., to be published in PST **11** (2009).
2) H.Nozato, S.Morita et al., PoP **13** (2006) 092502.
3) H.Y.Zhou, S.Morita et al., RSI **79** (2008) 10F536.
4) R.Sakamoto et al., to be published in Nucl. Fusion.