Neutral beam injection heating in high density mode plasma of the GAMMA 10 tandem mirror

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The neutral beam injection (NBI) experiments are performed for main plasma heating and particle fueling in the central-cell of the GAMMA 10 tandem mirror [1,2]. Hot ion mode plasmas are usually created by ion cyclotron heating (ICH). In the hot ion mode, the ion temperature at the central cell is achieved about 5 keV. However the plasma density is comparatively low (the electron line density nl_{cc} is about 3×10^{13} cm^{-2}) in hot ion mode plasmas. On the other hand, high-n mode plasmas have comparatively high density with low ion temperature less than 1 keV. The objective of this study is to find a more effective heating scheme of NBI by comparing the effect of NBI in high-n mode with that in hot ion mode.

Figure 1 shows the time behavior of nl_{cc} and diamagnetism (DM_{cc}) measured at the central-cell in the NBI experiment of hot ion mode. It is shown that nl_{cc} keeps increasing during the NBI pulse. DM_{cc} also increases in the initial period of NBI, and then turns to decrease in the course of NBI. Figure 2 shows the same time behavior in high-n mode. Although each time evolution of nl_{cc} and DM_{cc} is similar to those of hot ion mode, the observed DM_{cc} in high-n mode increases larger than that in hot ion mode in the initial period of NBI. A major difference of plasma parameters between hot ion mode and high-n mode is ion temperature. In this case, the amount of energy transition rate from beam particles to the target plasma in high-n mode plasmas is estimated to be larger than that in hot ion mode plasmas. In order to investigate the above results quantitatively, a numerical calculation code was applied. This simulation code utilizes five differential equations based on the zero-dimensional balance of particle and energy. Calculation results roughly reproduce these experimental results. In this paper, the detailed experimental results are presented together with the simulation results.

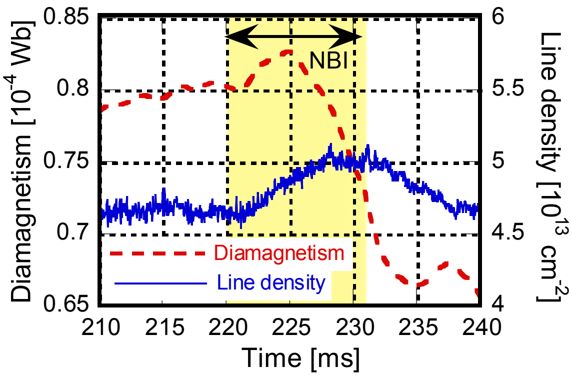

Figure 1 : Hot ion mode

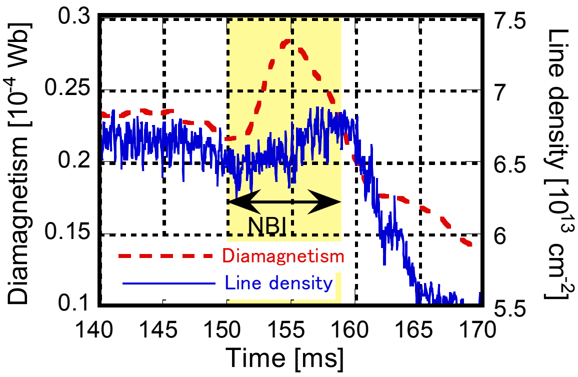

Figure 2 : High-n mode

[1] Y. Nakashima, et al., Trans. Fusion Sci. Tech. **43** No.1T, 135 (2003).
[2] Y. Nakashima, et al., Trans. Fusion Sci. Tech. **47** No.1T, 155 (2005).