§4. Analysis of NBI Heat Depositions in the High Ion Temperature Plasma of LHD

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High ion temperature plasma is obtained after the rapid change of the plasma density due to a pellet injection in the LHD plasma. The rapid increase of the plasma density by the pellet injection enhances the ionization of neutral beams, and following rapid density decay increases the heating power per particle. In order to analyze the transport property of this time developing plasma we have to use the beam deposition analysis code including the effect of the plasma time development.

In the previous studies we have developed two simulation codes for the analysis of the NBI beam ion distributions and heat depositions; FIT3D[1] and GNET[2]. FIT3D can evaluate the heat depositions, beam pressures, toroidal torques and etc. including the prompt orbit effect in a relatively short time about 5 minutes per beam line with PC. GNET can evaluate the heat depositions, detail beam ion distributions and etc. including the full orbit effect during slowing down but in a relatively long time about 10 hours per beam line with 100-CPU parallel machine. However these simulation codes assume steady state plasma and can not analyze the time developing plasma.

In this study we develop GNET-TD code based on the GNET code taking into account the time development of the plasma density and temperature. We perform the simulation runs in the time development plasma of LHD and estimate the time development of the beam ion distribution and heat depositions.

We include the experimental time development data (shot #110597, Rax=3.6m, Bax=-2.85T) of the temperature and density to GNET-TD code and, also, beam ion source profiles are evaluated by HFREYA using the same time development data. We analyze the time development of the beam ion distribution and the heat deposition profile.

Figure 1-(top) shows the time development of the ion and electron heat deposition power in the region r/a<0.5 and the line averaged density. We can see that after the carbon pellet injection at t=4.57s the line averaged density increases rapidly and decay slowly about 0.1s. The heat deposition power for ion and electron increase about 0.05sec and, then, gradually go down in the tangential heating NBI cases (NBI-1,2,3). On the other hand the heat deposition power is increased slowly after the pellet injection in the perpendicular injection case (NBI-5). The modulation effect of the heat deposition can be seen in the NBI-4 case, where the heating power is modulated to measure the ion temperature; 80ms on and 20ms off.

Figure 1-(bottom) shows the radial profile of the heat deposition before/after the pellet injection in the case of NBI-2 (tangential injection, counter direction). We can see the broader heat deposition profile just after the pellet injection (t=4.574s), and then peaked ones again (t=4.654s). Because of the increase of the density the deposition power goes up after the pellet injection. Figure 2 shows the total beam ion distribution just after the pellet injection.

[1] S. Murakami, et al., Fusion Technology 27 Suppl. S (1995) 256.
[2] S. Murakami, et al., Nucl. Fusion 46 (2006) S425.

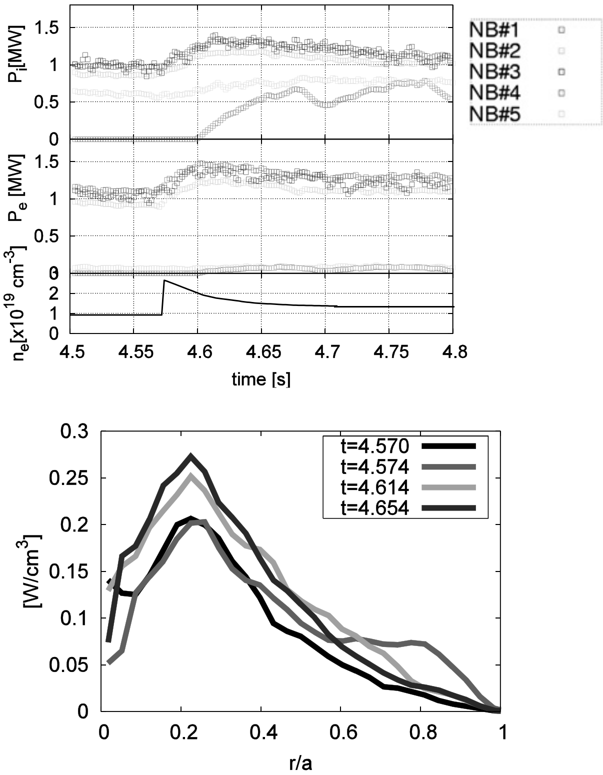

Fig. 1. Time development of the ion and electron heat deposition power in the region r/a<0.5 and the line averaged density (top). Radial profile of the heat deposition before/after the pellet injection in the case of NBI-2 (bottom).

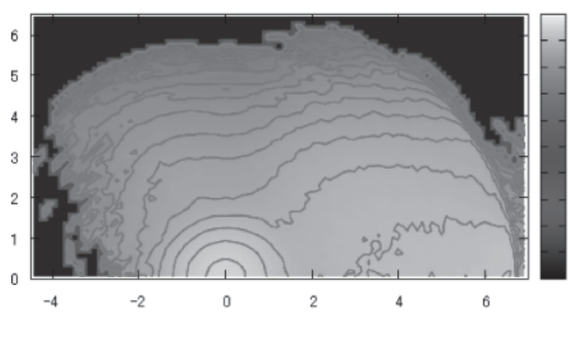

Fig. 2. Total beam ion distribution just after the pellet injection..