§10. Fast Density Variation due to the Pellet Injection

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Ice pellet injection is a very promising method to control density profiles. However, the fundamental process of particle deposition (pellet ablation) is not fully understood. From the viewpoint of diagnostics, the pellet injection causes very fast density variation in plasmas. It is not easy to follow the fast variation accurately.

In the JIPP T-IIU tokamak, a microwave interferometer and an HCN laser (λ=0.337mm) interferometer are used to measure electron density. The latter measures 6 chords, and it has a beat frequency of 50kHz. Since the phase detection circuit has a slow time response, we cannot measure fast density variation. In order to achieve the fastest response for the given beat frequency, the beat signal was directly fed into an ADC(1MHz sampling rate), and a program calculates phase from the timing of 0-crossing. As a result, we obtain the phase with the time interval of about 10μsec. With this method we can measure rather mild density variation due to a pellet. To measure faster density behavior, homodyne measurements have also been done. Although the latter method have much faster time response, it cannot measure the density quantitatively.

Here, we show the mild density variation due to the pellet which was broken into several pieces, and was injected to the plasma equational plane. Fig.1 shows the time evolutions of line density for 3 chords. The line density began to increase about 0.3msec after the timing of the pellet injection. The timing is monitored by Hα signal which views along the pellet orbit. It took about 0.2msec for the density to reach the maximum (Fig.2). Subsequently, it decreases with the time scale of about 5msec. After that, the central chord (ch.4) keeps about 40% higher density than that just before the pellet injection. This constant density lasted for more than 15msec. The following table summarize the density increment of each chord,

Ch.	h/a	ΔNL[$10^{20}m^{-2}$]	$\Delta\bar{n}_e$[$10^{20}m^{-3}$]
3	-0.27	0.062	0.13
4	0	0.051	0.11
5	0.39	0.073	0.16

where, h/a is the normalized chord distance.The line averaged density increment slightly increases as the chord distance. This fact indicates the density increment is larger in the outer region on this injection. In addition, the volume factor $2\pi r dr$ suggests that the particle deposition is large at the outer region. Thus, the profile becomes more flat just after the pellet injection. After that, while the central chord keeps its line density, the outer chord (ch.5) decays toward the level just before the pellet injection. Therefore, the flat density profile returned to a peaked one. Now we estimate the incremental particle number. If we adopt $0.13\times10^{20}m^{-3}$ as the average density increment, then the incremental particle number could be about 0.14×10^{20}. This is comparable to the supplied particle number ($\sim0.1\times10^{20}$) by a pellet.

We are planning to modify the beat frequency from 50kHz to 200kHz. With this frequency we can follow 4 times faster density variation.

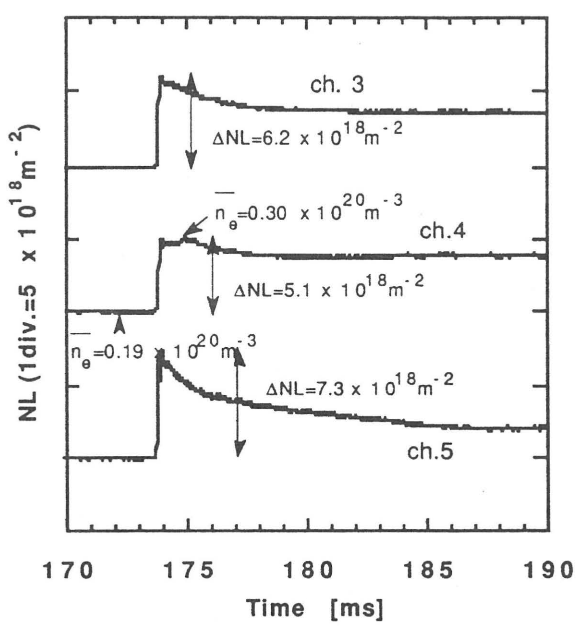

Fig. 1. Time evolutions of line density.

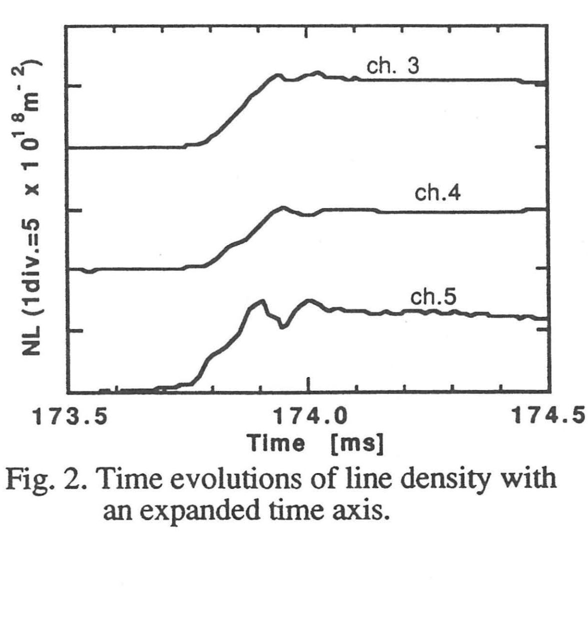

Fig. 2. Time evolutions of line density with an expanded time axis.