§14. Magnetic Field Fluctuation Measurement with Heavy Ion Beam Probe in CHS

Shimizu, A., Fujisawa, A., Nakano, H. (Univ. Adv. Study), Ohshima, S. (Nagoya Univ.), Iguchi, H., Okamura, S., Matsuoka, K., CHS Group

Magnetic field fluctuation is important to study MHD instability, anomalous transport, etc. In many experimental devices, Mirnov coils are used to measure magnetic fluctuation and to study MHD instability mode. Mirnov coils are economical and simple tools to measure magnetic fluctuation, however, they cannot allow us to know the profile of fluctuation amplitude in core plasma. Heavy Ion Beam Probe (HIBP), which is ordinarily used to measure plasma potential, can give us the information of magnetic field fluctuation in the core. In CHS experimental device, we have tried to obtain the magnetic field fluctuation with HIBP. The report describes the preliminary results.

With the detector in the energy analyzer of HIBP system, we can obtain the deflection of beam in the toroidal direction. This deflection reflects the change in magnetic field in the plasma. In the axisymmetric approximation, the deflection of beam observed with HIBP is as follows,

$$\phi_D = \frac{qR_s\tilde{A}_{\phi s}}{mv}\int_{\ell_s}^{\ell_d}\frac{1}{R}d\ell - \frac{q}{mv}\int_0^{\ell_s}\frac{\tilde{A}_\phi}{R}d\ell - \frac{2q}{mv}\int_{\ell_s}^{\ell_d}\frac{\tilde{A}_\phi}{R}d\ell. \qquad (1)$$

Here, ϕ_D is the deflection of beam in toroidal angle, ℓ is the beam path, A_ϕ is the toroidal component of vector potential, R is the major radius, q is charge, v is the beam velocity, m is mass of beam. Subscript s and d mean the positions of sample volume and detector, respectively, and tilde means the fluctuated component. The first term on the right-hand side is local fluctuation in plasma. The second and third terms are the path integrals of fluctuation on primary and secondary beam paths, respectively. An analysis shows that the local fluctuation of vector potential could be the dominant cause for the fluctuation of beam deflection [1].

In CHS experiment, a sort of MHD instability mode, "burst mode" is observed in low-density NBI plasmas. This is characterized by fishbone like signals in magnetic probes. An example of magnetic probe signal in burst mode is shown in Fig.1 (the upper signal). In this case, the axis of major radius was 92.1 cm, the strength of magnetic field was 0.88 T, and line averaged density was typically1.5×10^{13} cm^{-3}. The lower signal in Fig. 1 shows the time trace of normalized beam deflection (or magnetic field fluctuation) in the toroidal direction. The position of sample volume of HIBP was at $\rho = 0.5$. This signal is strongly correlated with the magnetic probe ones. The power spectra of HIBP signal and of magnetic probe signal (integrated by time) are shown in Fig.2 (upper). The power spectra of both signals have sharp peaks at 5 kHz. The magnetic probe signal has a broadband peak between 10 and 40 kHz. The coherence between these signals is shown in Fig. 2(lower). The coherence is very large (~1) at 5 kHz. In the frequency regime from 20 to 40 kHz, high coherence (~0.8) is also seen, though the HIBP signal shows no clear peak in the power spectrum.

The radial profile of fluctuation obtained from HIBP signal is shown in Fig.3. The solid and dotted lines are the integrated powers in the range of from 2 to 8 kHz and that from 20 to 40 kHz, respectively. A clear peak is seen close to ρ = 0.5, demonstrating that fluctuation should be localized on the rational surface where the rotational transform is 0.5.

This is the first measurement of magnetic field fluctuation in core plasma of helical device. The investigation of mode structure for several MHD instabilities is a future subject.

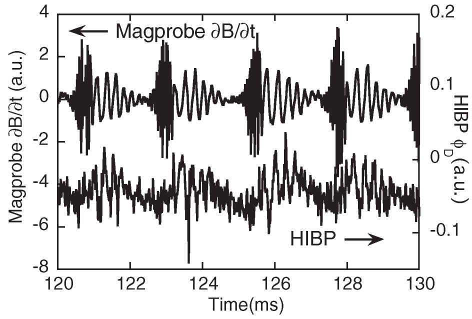

Fig.1 Time trace of magnetic probe signal (upper) and toroidal beam deflection of HIBP (lower)

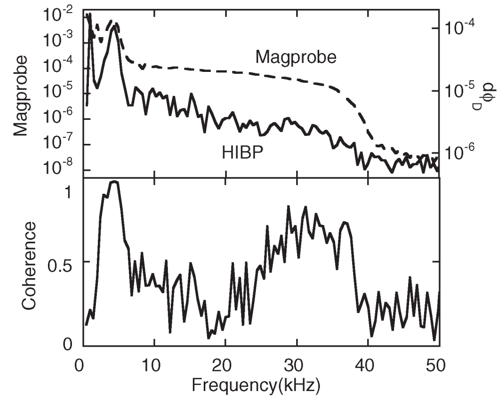

Fig.2 Upper: power spectra of magnetic probe signal integrated by time and HIBP signal. Lower: Coherence between magnetic probe and HIBP signals.

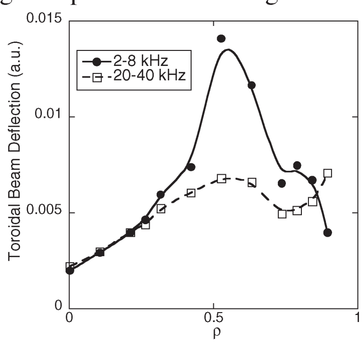

Fig.3 Radial profile of toroidal beam deflection obtained from HIBP.

[1] A. Shimizu, A. Fujisawa, S. Ohshima, H. Nakano *et. al.*, Review of Scientific Instruments, **76** (2005) 043504-1