Time Evolution of the Elongation Ratio and Mirnov Oscillation under the Different Current Profiles in a Non-Circular Tokamak

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Time evolution of plasma properties of the non-circular cross section plasma are investigated in the case of the different filling pressure, while the decay index is fixed. In the case of the lower filling pressure, the elongation ratio is larger than that in the case of the higher filling pressure, and decreases with time due to the current peaking but nearly consant ($\simeq 1.5$) after the time of the current peak ($\simeq 6$ ms). The power spectrum and the poloidal mode number of Mirnov oscillation are compared with q_a and suggests that the $m=2$ tearing mode exists near the time of the current peak.

The effect of the decay index on the elongation ratio is important* and the elongation ratio depends also on the profiles of the plasma parameter (*e.g.* current profile). We investigate the elongation ratio and Mirnov oscillation under the different current profiles by changing the filling pressure (P_f) in TNT-A.[1,2]

The decay index and the toroidal field are fixed ($n_x = -(R/B_z)(\partial B_z/\partial R) \simeq -0.75$ (measured value with no plasma current), $B_t = 3.7$ kG). The stable discharges are obtained with $0.5 \times 10^{-4} \leq P_f \leq 3 \times 10^{-4}$ Torr. In this region the plasma current decreases with P_f (25 to 15 kA). Above 3×10^{-4} Torr we have the resistive discharges. Plasma parameters are measured in two cases (CASE A: 1.3×10^{-4} Torr, CASE B: 2.9×10^{-4} Torr) and listed in Table I.

We measure the electron temperature and the density by the Thomson scattering and 50 GHz microwave interferometer. The magnetic surfaces outside the plasma are calculated by the 14 magnetic probes and 6 one-turn loops. The plasma boundary is determined by the 3 movable aluminum limiters and the distribution of the H_α line intensity. The data of the magnetic fluctuations are obtained by the microcomputer (sampling time is 2 μs) and analyzed by the way of fast Fourier transform.

Figure 1 shows time evolution of $2a$, $2b$, κ ($2a$, $2b$: width and height of the plasma cross section, κ: elongation ratio$=b/a$) in CASE A and B. In the case of the lower filling pressure (CASE A), κ is larger all the time and shrink little after the current peak of 5.7 ms, and vertical shrink ($2b$) is smaller than in CASE B. A decreasing elongation as a function of time is due to the current peaking[3] and the decrease of the shell effect of the vacuum chamber. In the case of the higher filling pressure (CASE B), κ is smaller due to the current peaking estimated from the H_α line intensity distribution and the temperature profiles. At

Table I. Plasma properties at the time of the current peak under the different filling pressure. $\bar{j}$: mean current density, $\beta(0)$: central beta value (electron), τ_e: electron confinement time.

	CASE A	CASE B
P_f (10^{-4} Torr)	1.3	2.9
I_p (kA)	20	17
V_l (V)	3	3.3
κ	1.45~1.5	1.3~1.35
q_a	2.1	2.5
$\bar{j}$ (MA/m²)	0.77	0.58
$T_e(0)$ (eV)	200	160
$n_e(0)$ (10^{13} cm^{-3})	1.0	1.2
$\beta(0)$ (%)	0.61	0.58
τ_e (μs)	160~200	170~220
$\bar{Z}_{eff}$	~2.5	~2.5

* S. Shinohara *et al.*: in preparation for publication.

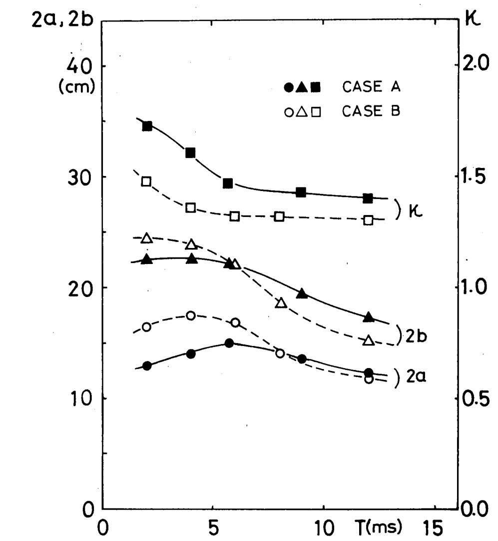

Fig. 1. Time evolution of the width and height of the plasma cross section and the elongation ratio.

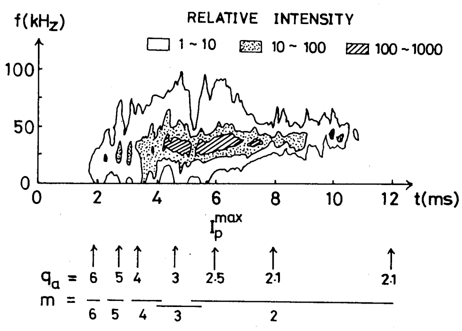

Fig. 2. Time evolution of the power spectrum of Mirnov oscillation and poloidal mode number against q_a value in CASE B.

the current peak, H_α line intensity, $\tilde{B}_p/B_p$ (poloidal magnetic fluctuation/poloidal field) are about 1.5 to 2 times higher than in CASE A ($\tilde{B}_p/B_p \simeq 1.1\%$ (CASE A), $\tilde{B}_p/B_p \simeq 1.6\%$ (CASE B)).

In a non-circular plasma, study of the unstable region of the MHD mode is important to lower the q_a value. Figure 2 shows time evolution of the power spectrum of Mirnov oscillation and the poloidal mode number (m) against q_a value in CASE B. The frequency of the strongest intensity increases slowly with time due to the change of the diffusion of electron and ion, and the changes of temperature and the density profiles. For two cases (CASE A, B), the m mode appears around $q_a = m$ for $m = 3$, 4, 5 and different mode number don't overlap for high m mode. However, $m = 2$ mode appears below $q_a \sim 2.5$ and still exists after the time of the current peak (~ 6 ms), which suggests this mode is the tearing mode because $q_a \gtrsim 2$ satisfies in all of the discharge duration time.

In this letter, it is shown that the elongation ratio decreases with the current peaking and the plasma current is limited at $q_a \geq 2$ because of the high level of the $m = 2$ mode (maybe tearing mode). Now, control of the current profiles by the gas puffing and the additional heating, and the detailed measurements by the laser, soft X ray detectors and the magnetic probes are under way.

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References

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2) H. Toyama *et al.*: *ibid.* **1** (1979) 365.
3) Current profile is estimated by A. Iwahashi *et al.*: J. Phys. Soc. Jpn. **45** (1978) 289.