§13. Equilibrium Analysis of Quasi-single Helicity State in a Reversed Field Pinch Plasma

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In the Quasi-Single Helicity (QSH) state of Reversed Field Pinch Plasma, a certain toroidal Fourier mode (mode number, *n*) in the magnetic fluctuation of m = 1 mode selectively grows and the plasma becomes semi-helical state. (m is the poloidal Fourier mode number.) The word "Quasi" is added since other helical modes also exist with smaller amplitudes and the state differs from Pure-Single Helicity State. An example of the time variations of several m = 1 modes of toroidal magnetic field at the wall is shown in Fig.1. This is the result of typical QSH shot in the large RFP experiment on TPE-RX, where the $m = 1/n = 6$ mode of fluctuation dominantly grows at $t \sim$ 43ms (from the start of discharge) and the growth of other modes remains small.[1)] In the tomography analysis of soft x-ray detector arrays clearly shows the helical structure in the core region of plasma after the growth of this mode.

The objective of this collaboration study is to compare the QSH on TPE-RX and LHD plasma for finding the similarity and difference between them and to survey the possibility of contribution from RFP QSH state for finding the high beta equilibrium of LHD plasma.

In the discussion about QSH state of TPE-RX, which was held during the collaborative QSH experimental campaign on TPE-RX, the importance of the plasma density control (high density operation) in QSH state was pointed out since the QSH state on TPE-RX had been observed in a very low density region, ($n_e \sim 4 \times 10^{18}$ m^{-3}).

Considering this point, the gas puffing system (GP) developed by NIFS was installed in TPE-RX. This system has a large gas through put capability and can control (increase) the electron density of TPE-RX. The result of the GP experiment is shown in Fig.2 for the ordinary shot without the QSH state, where the density increases more than a factor of two after the GP. However, when the GP is applied to the QSH state, the QSH state terminates and shifts to the so-called locked mode (LM) after several ms from GP. In the LM, $m = 1/n$ = 6,7,8,9,10... modes have the almost same amplitudes and align the phase of toroidal angle, which produce the toroidally localized steady magnetic field perturbation (locking not only in the phase but also to the wall). In this LM, the helical structure of the plasma is destroyed and the plasma is not in the QSH state any more.[2)]

During the QSH state all observed modes are locked to the wall and no mode rotation is observed. Nevertheless, the rapid shift from the QSH to LM state takes place by the GP, which contains interesting physics, possibly indicating the plasma rotation independent of the mode rotation, although further investigation will be required for the analysis.

Reference
1) Hirano, Y., *et al*., Phys. of Plasmas **13**(12)(2006) 122511-1
2) Hirano, Y., *et al*., Proc. of 12th IEA RFP WS (2007 March, Kyoto) 1

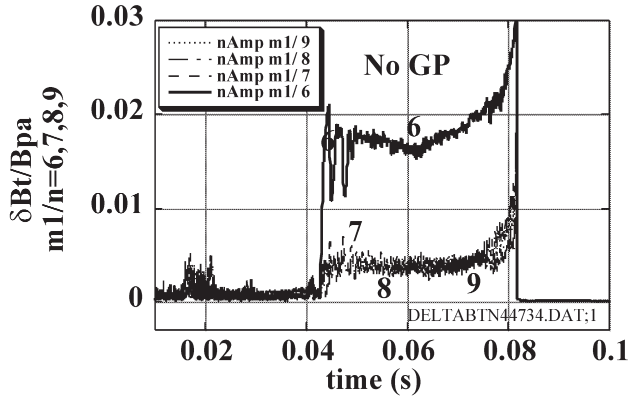

Fig.1 Fourier modes of $\delta B_t/B_{pa}$ m = 1/ and n = 6,7,8,9. Typical QSH without GP

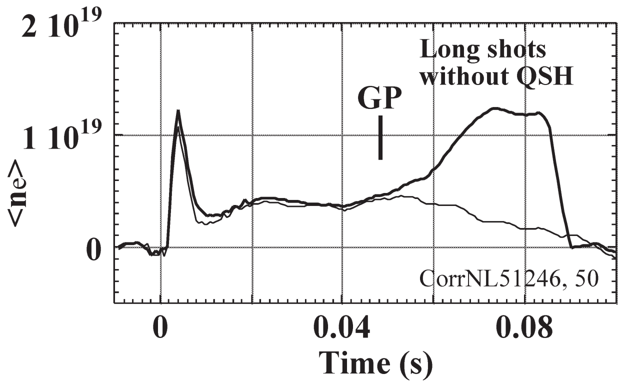

Fig.2 Chord averaged electron density. Typical QSH with GP at t = 50ms

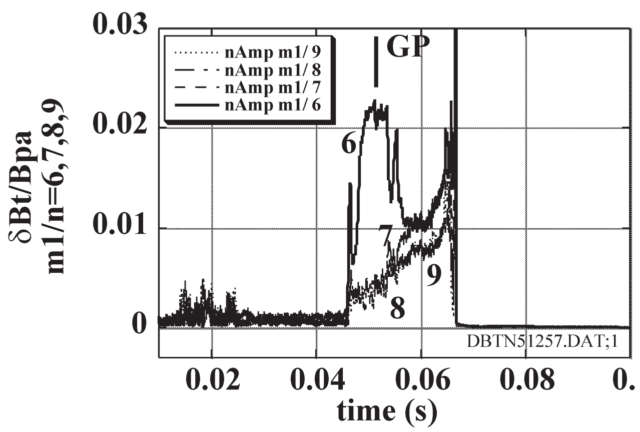

Fig.3 Fourier modes of $\delta B_t/B_{pa}$ m = 1/ and n = 6,7,8,9. QSH with GP at t = 50ms