Soft X-ray measurement in IRE on the TST-2 tokamak

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Back ground and purpose

Spherical tokamak (ST) having aspect ratio A≲1.5 have been investigated as cost effective alternative to the tokamak fusion concept [1]. the avoidance of a characteristic relaxation phenomenon in ST, that is Internal Reconnection Event (IRE) [2], is one of the crucial issues to execute the stable operation. When IRE takes places, the large amount of magnetic energy stored in plasmas is converted to the kinetic energy of plasmas by magnetic reconnection process and then the stored thermal energy and particles in the core region is lost abruptly. In this experiment, there is feature that n and m can be determined by measurement only Soft X-ray (SXR).

Experimental apparatus

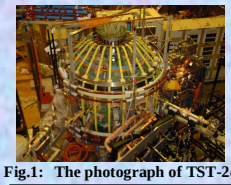
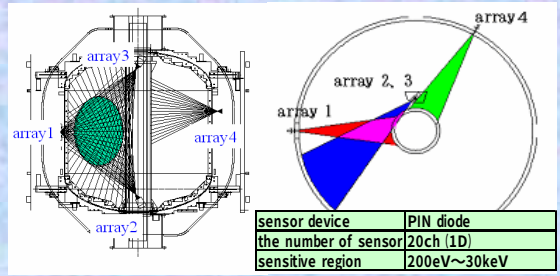


Fig.1: The photograph of TST-2@K

Major radius	0.38m
Minor radius	0.25m
Aspect ratio	1.6
κ	1.8
Bt	0.2〜0.3T
I_p	〜140 kA
n_e	〜10^{19} m^{-3}

Table.1: The parameter of TST-2



sensor device	PIN diode
the number of sensor	20ch (1D)
sensitive region	200eV〜30keV

Fig.2: Poloidal and toroidal cross diagram of installation of each detector array. And the specifications of array.

Experimental results

In Fig.4, the IRE occurred at about 35.8ms. Precursor was observed during several milli-seconds before IREs. The frequency of SXR precursor was analyzed by fast Fourier transform (FFT) technique, and it turned out that the fluctuation had two dominant Fourier components (Fc) with 10kHz and 4kHz. Fc with 10kHz and 4kHz were existed sometimes independently without IREs. The presence of both components with 10kHz and 4kHz leads to IREs.

Non-IRE discharge

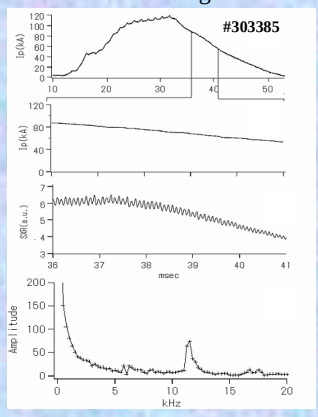


Fig.3: Plasma current and intensity of SXR when IRE did not occur. There is only Fc with 10kHz. The non-IRE discharge of only Fc with 10kHz existed, too.

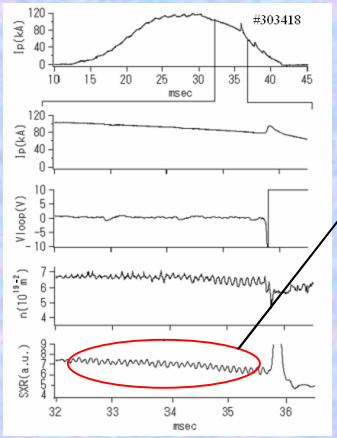


Fig.4: Plasma current, loop voltage, density and intensity of SXR when IRE occurred.

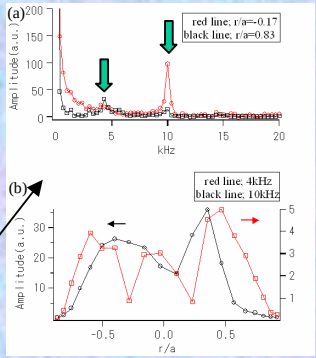


Fig.5: (a) The amplitude of frequency of precursor before IREs, where r is the length of perpendicular line from the center of plasma to the line of sight. (b) The amplitude of Fc with 10kHz and 4kHz of array1.

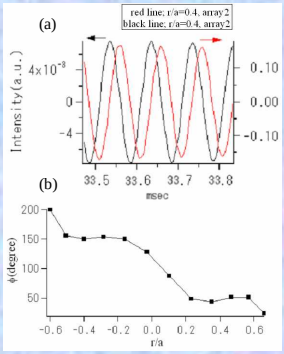


Fig.6: (a) The intensiy of Fc with 10kHz at r/a=0.4 of array1 and array4. (b) The phase of the Fc with 10kHz.

Fc with 10kHz: n/m=1/1

The phase difference of about 120 degree between two wave shows n=1. Fig.6(b) is shown the phase of the Fc with 10kHz. The phase difference of about 180 degree between peaks shows m=1.

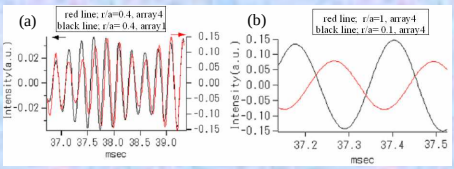


Fig.7: The intensity of Fc with 4kHz, (a) in array4 and array1 at r/a=0.4, (b) in array4 at r/a=1, 0.1

Fc with 4kHz: n/m=3/4

There is no phase difference between array1 and array4. Therefore the m is considered to be 3. The poloidal number is m=4 because phase difference was about 180 degree between the two chords in array4 which are 45 degree apart in the poloidal direction. In addition m=4 is consistent with the amplitude profile with three peaks in array1 (Fig. 3(b)).

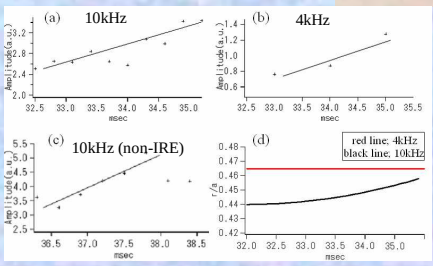


Fig.8: (a),(b) The time evolution of amplitude of Fc with 10kHz and 4kHz when IRE occurred. (c)The time evolution of Fc with 10kHz when IRE didn't occur. (d) The shift of peak; black line is 10kHz, red line is 4kHz.

The overlap of two magnetic islands

Both Fc with 10kHz and 4kHz are grown, and the position of peak of 10kHz was shifted outside until just before IRE.

Summary and Discussion

Two modes (about 10kHz and 4kHz) exist before IRE. Only when two modes exist, IRE occurs. And these structures of precursor were identified. It turns out that about 10kHz mode structure is n/m=1/1, and about 4kHz mode structure is n/m=3/4. There is no change of frequency until precursor begins to take place and it results in IRE, but amplitude increases. The overlap of modes is considered to be the cause of IRE in TST-2 from the positional relation of Islands, and changes of amplitude.

Reference
[1] Peng Y.-K.M., Strickler, D.J., *Nucl Fusion* **26** (1986) 769.
[2] Sykes A. et al *Nucl. Fusion* **32** (1992) 694