§19. Study of Magnetic Structure Using Heat Pulse Propagation Method

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It is predicted that the magnetic structure in edge region is chaotic due to the lack of symmetry in helical device. The chaotic state is also expected to change the state by increasing β in the calculation study. In experiment study, however, the definition of the last closed surfaces is difficult. In this article, to development the method of the measurement of chaotic state in high beta condition, the experiment of heat pulse propagation for identification of last closed surface is reported.

Fig.1 shows the radial profile of the electron temperature (T_e) and electron density (n_e) by Thomson scattering measurement. The plasma is sustained by the tangential NB and the beta value is approximately 1.1%. When the magnetic configuration is R_{ax}=3.6m, γ=1.25, *Bq*=100%, the location of the expected last closed surface is R=4.55m. In Fig.1, the steep gradient of electron profile in R<4.55m can be seen, and the folding point at R~4.55m agrees in the calculated last closed surface. This characteristic is often observed in low β plasma. The heat pulse propagation method is applied to low β plasma to investigate the characteristic of heat pulse propagation.

Fig.2 shows the experimental results of the heat pulse propagation. The heat pulse is generated by the power modulation ECH (MECH). Principally, the sensitivity of ECE is not enough due to low electron temperature. To secure the large amplitude of heat pulse in the edge region, the deposition point of ECH is set at half radius, as shown in upper left of Fig.2. Experimentally, it is also constrained condition not to generate high-energy particle due to low density at deposition point because the non-thermalized ECE doesn't properly response the electron temperature. In upper right of Fig.2 shows the raw waveforms of the heat pulse at R~4.49 (inside closed surface), 4.55 (on LCFS), 4,62m (in chaotic region). The aspect of the heat pulse propagation is summarized in Lower of Fig.2. The amplitude of heat pulse drops rapidly in the chaotic region, while it degreases gradually in the closed surface region. The delay time profile indicates the faster propagation than the neoclassical confinement time. This indicates the magnetic field line connecting to another radial points and chaotic area expands inward. These characteristics would be derived from difference of the degree of the chaotic state. The further validation is planed in next experiment campaign.

It is also considered that the appearance condition of MHD instability is related to the chaotic state. The coherent fluctuations in chaotic region are observed as shown in Fig.3. It is found that the enhanced mode has radially wide structure in the chaotic region. The similar tendency is confirmed in the configuration of R_{ax}=3.9m, in which there is the wide chaotic region.

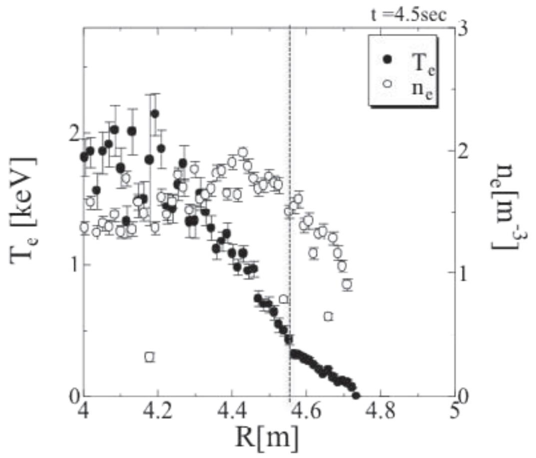

Fig. 1. Radial profile of the electron temperature (filled points, left axis) and electron density (circle, right axis) by Thomson scattering measurement. The position of calculated last closed surface is marked as dashed line.

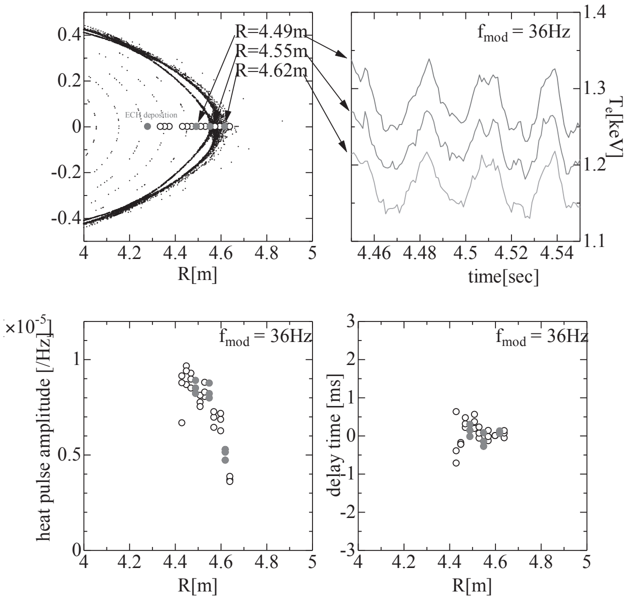

Fig. 2. Upper left) the Poincare plot of the magnetic field in vacuum condition and ECE measurement points. Upper right) The wave forms of the heat pulse. Lower left) the heat pulse amplitude. Lower Right) delay time of the heat pulse propagation.

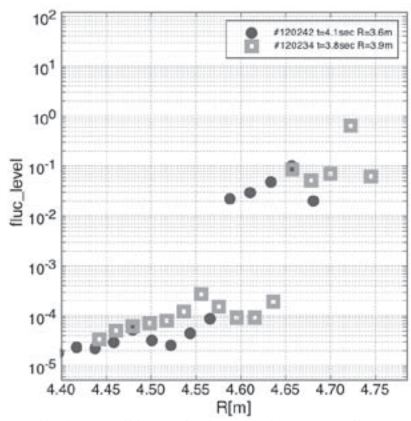

Fig.3 Radial profile of the coherent fluctuation level including the chaotic magnetic field range.