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Parity transition of MHD fluctuations in helical plasmas

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Parity transitions in the radial structure of fluctuations caused by MHD instabilities are observed as common phenomena in toroidal magnetic confinement plasmas. Conventionally, only the even-to-odd parity transition is observed in tokamak[1] and helical devices[2]. However, for the first time in the Large Helical Device (LHD), the odd-to-even parity transition has been discovered. Both transitions of the LHD are considered to be observed when the instability with a magnetic island appears or disappears under the appearance of the resistive interchange mode.

The parity of the mode structure is related to the topology of the magnetic equilibrium. The even-to-odd and odd-to-even parity transitions in the radial displacement profile are associated with the occurrence and disappearance of magnetic islands. Understanding the mechanism of parity transitions that contribute to the appearance and disappearance of magnetic islands, which cause severe confinement degradation and, in the worst case, can lead to disruptions, is an important task for fusion science.

Figures 1 (a) and (b) show the magnetic island width evaluated from the peak spacing of the density fluctuation profile and magnetic fluctuation frequency around the even-to-odd parity transition. Before $t = 4.06$ s, the even-parity mode is observed, and $t \sim 4.065$ s, the magnetic island width starts to increase, and the even-to-odd parity transition is observed. Figures 1 (c) and (d) show the change in the magnetic island width and fluctuation frequency around the odd-to-even parity transition. From $t \sim 4.61$ s, the magnetic island width begins to decrease, and from $t \sim 4.615$ s, the even-parity mode dominates. During the even-to-odd parity transition, the magnetic island width increased slightly after the increase in magnetic fluctuation amplitude, and the fluctuation frequency decreased gradually. On the other hand, during the odd-to-even parity transition, the magnetic island width started to decrease together with the decrease in magnetic fluctuation amplitude, and the fluctuation frequency increased discontinuously. Figure 2 shows the relationship between amplitude and frequency of a magnetic fluctuation during both parity transitions, which shows the different behavior of both transitions.

The odd-to-even parity transitions is observed only after even-to-odd transitions. Additionally, it is found that higher amplitude of resonant magnetic perturbation imposed into plasmas leads to a higher likelihood of the odd-to-even parity transitions.

References
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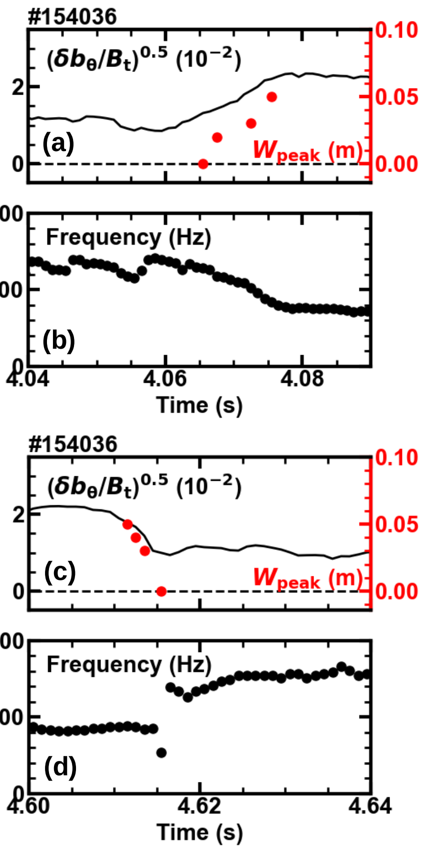

Figure 1. A typical discharge of (a)(b) the even-to-odd and (c)(d) the odd-to-even parity transition. (a)(c) magnetic island width evaluated from peak spacing of the density fluctuations profile and magnetic fluctuation amplitude. (b)(d) magnetic fluctuation frequency.

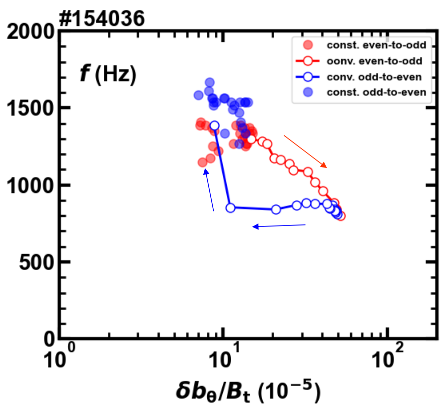

Figure 2. Relationship between amplitude and frequency of a magnetic fluctuation during even-to-odd (open red circles) and odd-to-even (open blue circles) parity transitions. Closed red (closed blue) circles mean parameters before even-to-odd (after odd-to-even) parity transition.