

§12. Destabilization of Fishbone-like Burst Modes by Tangential Neutral Beam Injection

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In CHS, excitation mechanisms of kinetically driven MHD modes and their effects on energetic ion confinement are extensively studied in a plasma heated by tangential neutral beam injection. So far, fishbone-like burst modes (FBs) and toroidicity induced Alfvén eigenmodes (TAEs) are observed in NBI heated plasmas. FBs in a tokamak plasma are excited by resonant interaction between $m=1/n=1$ internal kink mode and the precessional motion of energetic trapped ions. In contrast to a tokamak plasma, the CHS plasma is basically current-free and is confined in the three dimensional magnetic configuration. It is important to clarify the relevant MHD modes and the resonant orbits of energetic ions.

In outward-shifted plasmas, $m=3/n=2$ FBs are observed. In inward-shifted plasmas, $m=2/n=1$ FBs are observed. Figure 1 shows the time evolution of magnetic fluctuations of $m=3/n=2$ FBs and energetic ion loss flux measured by the escaping ion probe, where the magnetic axis position is $R_{ax}=0.97$ m. As seen from Fig. 1, magnetic fluctuations exhibit the fishbone-like amplitude modulation during the NBI pulse. Energetic ion loss is suddenly enhanced when the magnetic fluctuations reach the peak level.

Energetic ions with the pitch angle $\sim 45^\circ$ are preferentially expelled by $m=3/n=2$ FBs, and their energy is slightly lower than the injection energy. On the other hand, the time behaviour of $m=2/n=1$ FBs observed in the inward shifted plasma ($R_{ax}=0.92$ m) is shown in Fig. 2. The amplitude of magnetic fluctuations grows in the rising phase of the net plasma current and then the sawtooth oscillations characterized by the annular crash near the $q=2$ surface are induced in the latter half of the discharge. Radial profiles of soft X-ray fluctuations related to $m=2/n=1$ FBs have two peaks in the region of $\rho (=r/a) < 0.7$, exhibiting ballooning nature (Fig. 3). The largest peak is located near the plasma axis. In this experimental condition, the radial profile of a beam driven current is not predicted to be a peaked one, since deviation of energetic passing ions from the magnetic surface is fairly large, i.e., about 1/3 of

the averaged minor radius of a plasma. Note that the pitch angle scattering time of beam ions is by one order of magnitude larger than the slowing down time (~ 10 ms) where it is much larger than the energy confinement time of the bulk plasma. It is concluded that excitation of FBs by energetic trapped ions is unlikely, because energetic trapped ions would hardly be generated during tangential neutral beam injection.

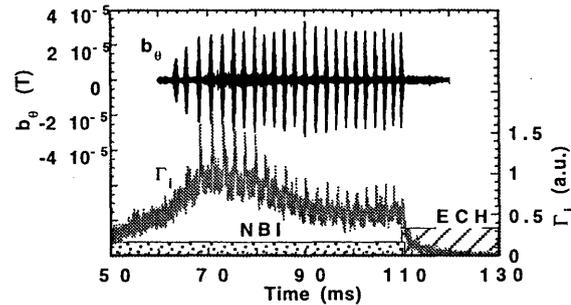


Fig.1 Time evolution of magnetic fluctuations of $m=3/n=2$ FBs and energetic ion loss flux in the outward-shifted plasma of $R_{ax}=0.97$ m, where $B_t=0.9$ T, line averaged electron density $\sim 0.8 \times 10^{19}$ m^{-3} and peak plasma current ~ 6 kA.

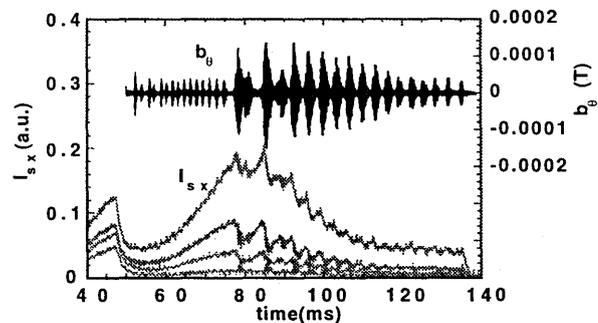


Fig.2 Time evolution of magnetic fluctuations of $m=2/n=1$ FBs and soft X-ray emissions in the inward-shifted plasma of $R_{ax}=0.92$ m at $B_t=0.9$ T.

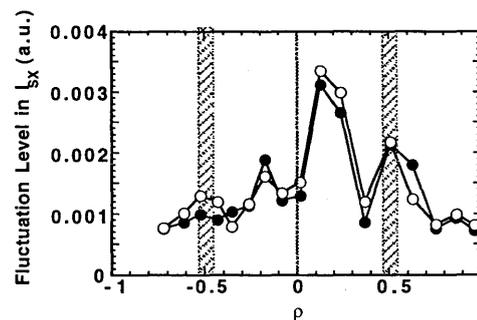


Fig.3 Radial profiles of soft X-ray fluctuations during two bursts of $m=2/n=1$ FBs. Shaded zones indicate the predicted rational surfaces of $q=2/1$.