§7. Nonlinear Evolutions of TAEs and Fishbone-like Burst Modes in CHS

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In recent studies of energetic ion driven instabilities, nonlinear phenomena are clearly found in some shots, that is, (1) bursting amplitude modulation, (2) rapid frequency chirping, and (3) spectrum splitting[1)]. The bursting amplitude modulation is very typical in fishbone like burst modes(FBs). This feature also appears in toroidal Alfvén eigenmodes (TAEs) when these modes are strongly excited. Accompanying this amplitude modulation, the mode frequency is rapidly chirped down (rarely chirped up) in each burst. These nonlinear phenomena are clearly

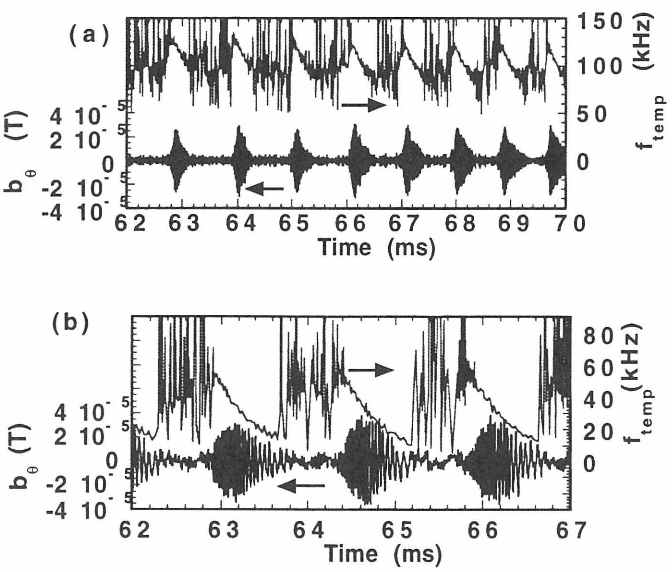
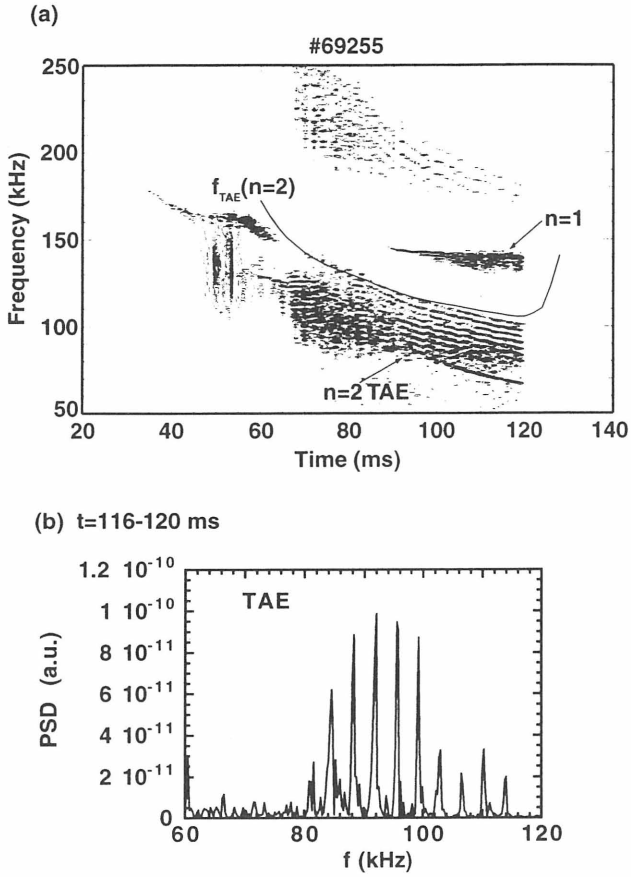


Fig.1 Time evolutions of magnetic fluctuations and the temporal frequency of n=2 TAE(a) and m=2/n=1 FBs(b).

seen in Fig.1 for n=2 TAEs, and m=2/n=1 FBs. In each burst, the frequency of TAE fluctuations is rapidly chirped down by about 25% in about 0.3 ms. The frequency chirping is most prominent in FBs, where the frequency is chirped down by a factor of 3 –6 in about 1 ms for m=2/n=1 FBs.

Power spectrum of the magnetic fluctuations related to TAEs is split into equally spaced multiple peaks (Fig.2). This seems to be similar to the spectrum splitting or "pitchfork splitting" in TAEs observed in JET[2)]. The spectrum splitting is clearly seen in the latter half of the discharge. The power spectrum is split into multiple peaks with about 3.6 kHz frequency spacing. All the peaks have the same toroidal mode number. The low frequency part of the split spectra seems to barely intersect with the lower bound of the n=2 TAE gap. The spectrum of n=1 mode (~150 kHz) observed from t~90 ms is also split into multiple peaks. Note that this n=1 mode is thought to be global Alfvén eigenmode (GAE)[3)]. In this plasma, the slowing down process of energetic beam ions is dominant in contrast to the JET case where the pitch angle scattering process is dominant due to ICRF heating.

Types of TAEs and FBs excited in CHS sensitively depend on the magnetic axis position R_{ax}. Moreover, the above-mentioned nonlinear phenomena in TAEs and FBs will



be dependent on the beam ion content and the ratio of beam

Fig.2 (a) Time evolution of n=2 TAE magnetic fluctuations where it is split into equally spaced multiple peaks. (b) Power spectrum of the split TAE.

be dependent on the beam ion content and the ratio of beam ion velocity for the Alfvén velocity $V_{b//}/V_A(0)$. In these experiments, the beam beta value $<\beta_{b//}>$ was derived from the amount of the induced beam driven current. When both $<\beta_{b//}>$ and $V_{b//}/V_A(0)$ become large, e.g., $<\beta_{b//}> \geq 0.2$ % and $V_{b//}/V_A(0) \geq 0.75$ in the configuration of $R_{ax} = 0.95$ m, the bursting amplitude modulation, rapid frequency chirping and spectrum splitting in TAEs seem to be triggered[1)]. FBs are excited on $<\beta_{b//}> \geq 0.1$ % and $V_{b//}/V_A(0) = 0.2 – 0.7$.

References
1) K. Toi et al., to be published in Nucl. Fusion.
2) A. Fasoli et al., Phys. Rev. Lett. **81** (1998) 5564.
3) M. Takechi et al., this issue.