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Onset and evolution of energetic passing particle driven instabilities in KSTAR

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Understanding mechanisms of energetic particle (EP) driven instabilities and their role in EP transport has been a central topic in magnetic fusion research [1]. In addition to its practical importance in fusion reactors in terms of self-heating, hence reducing the recirculation power, EP-wave interaction physics in tokamak plasmas also provides an outstanding playground where nonlinear physics can be explored with controlled experimental set up and advanced diagnostic tools. In this work, we carry out KSTAR experiments in order to make a systematic study of the onset and evolution of EP driven instabilities.

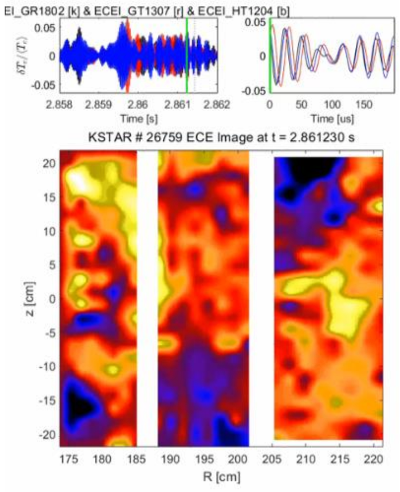

Figure 1: ECEI measurements of n=1 passing particle driven fishbone activity.

An emphasis is put on the major role of energetic passing particles because EPs produced by the KSTAR NBI system are passing ones. A systematic scan of NBI power shows a progressive reduction of sawteeth activities and concomitant onset of low frequency passing particle driven low frequency fishbones [2,3]. Analyses of electron cyclotron emission imaging (ECEI) and two colour interferometry (TCI) data clearly support this phenomenon. A detailed analysis of this passing particle driven fishbone mode is underway using the M3D-K code.

To increase EP contents in a single discharge, hence increasing the EP contribution to plasma beta, we apply ECH to elevate the core electron temperature while decreasing the plasma density via density pump-out. After some transient period, the current profile becomes stationary with q_0 is slightly larger than 1 and nearly flat in the core. In this phase, we observe a clear appearance of high frequency twin chirping modes with n=4 and 5 (n: toroidal mode number). The chirping speed of these modes are ~10 MHz/sec with almost identical initiation and finishing chirping time. Analysis of experimental conditions suggest that these modes be energetic particle modes (EPMs) whose detailed identification and analysis are underway. The frequency sweeping range of these chirping modes are approximately 70 → 40 kHz for n=4 and 140 →100 kHz for n=5, respectively, in the plasma frame. Interestingly, neither ECEI nor TCI detect these high frequency modes. Harmonics of low frequency coherent modes (n=1, 2, 3) co-exist with these chirping modes even without any signature of tearing mode activities. These are likely to be MHD modes related to the flat q-profile, i.e. interchange modes. Impacts of these chirping and coherent modes on EP transport are under investigation and will be discussed at the conference.

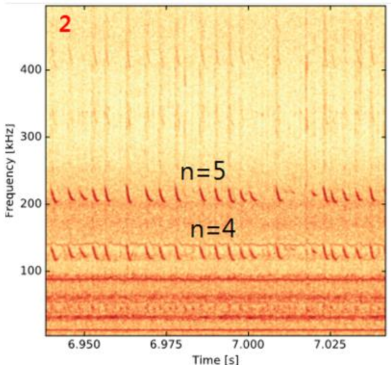

Figure 2: Observation of “twin” EPMs with n=4 and 5 after establishment of a stationary q-profile.

References

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