§ 10. Precursor-less Sawtooth like Events Observed in ECH Sustained Plasmas of CHS

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In CHS, Sawtooth oscillations are often observed in inward-shifted plasmas ($R_{ax} = 0.92\,\mathrm{m}$) heated by NBI. In most of cases, both high frequency ($10 - 30\,\mathrm{kHz}$) and low frequency ($2 - 8\,\mathrm{kHz}$) MHD modes appear just before the crash and low frequency mode persists after the crash. These modes have the $m/n = 2/1$ mode structure. The former mode is energetic ion driven MHD mode, that is energetic particle mode (EPM) and the latter one is low-n interchange mode. The sawtooth crash shows a character of the annular crash.

On the other hand, a different type of sawtooth-like events were observed in outward-shifted plasmas of $R_{ax} = 0.97\,\mathrm{m}$. It was observed in the plasma sustained by ECH after NBI is turned off, as shown in Fig.1. The averaged bulk plasma beta during ECH is fairly low ($\simeq 0.1\,\%$). Energetic ion driven modes with $m/n = 3/2$ are excited during NBI phase, and they disappear in the ECH phase. The expanded time traces of SX signals at various chord radial positions are shown in Fig.2(a). Most interesting point is that sawtooth oscillations do not accompany any precursors and postcursors. Moreover, the crash time is about $\simeq 0.1\,\mathrm{ms}$ and is much shorter than that in inward-shifted plasmas heated by NBI ($\simeq 1\,\mathrm{ms}$). Figure 2(b) shows the change in each SX emissivity across the sawtooth crash. All of SX signals inside the sawtooth-inversion radius simultaneously drop at the crash. It indicates the character of the core crash, in contrast to the sawtooth crash in inward-shifted plasmas of CHS. The inversion radius estimated from the Fig.2(b) is $\rho_{\tan} \simeq 0.2 - 0.3$, where $\rho_{\tan}$ denotes the tangent minor radius of SX signals. This radius is much smaller than that of the $q = 2$ rational surface, where the current density profile is assumed as $j = j_0 \left(1 - \rho^2\right)^2$. Moreover, $q = 3$ rational surface does not exist inside the plasma. These characters of the sawtooth crash in ECH plasmas differ from that in NBI plasmas considerably. Since any precursor does not appear and the crash observed in low-density plasma heated by ECH, this phenomenon may be related to relaxation oscillations of electrostatic potential. This sawtooth crash observed in low collisionality regime may have close connection with those in high temperature plasmas of LHD. More detailed studies on the sawtooth crash in the ECH phase are required in near future.

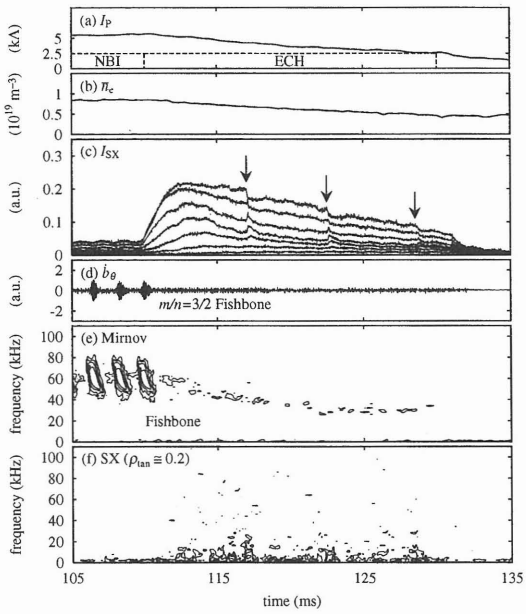

Figure 1 Time evolutions of several diagnostic signals during ECH phase of the outward-shifted plasma, where NBI is turned off at $t = 110\,\mathrm{ms}$. Sawtooth crashes take place three times shown by vertical arrows.

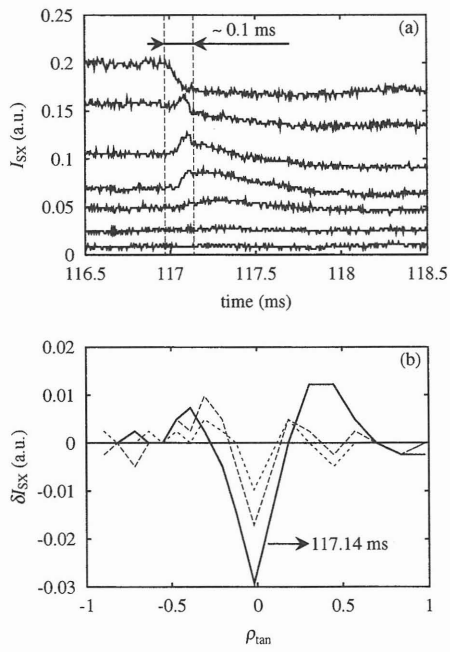

Figure 2 (a) Expanded time traces of SX signals at various chord radial positions. (b) Temporal evolutions of the change in SX emissivities during the sawtooth crash.