§28. Two-Dimensional Structure of the MHD Instabilities and Its Non-Linear Evolution in the Large Helical Device

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It is important to further understand the role MHD instabilities play in plasma confinement in helical systems. Since mode amplitudes depend nonlinearly on the pressure gradient, it is not straightforward to make theoretical predictions of mode structures and amplitudes, and thus determine their effect on confinement. We experimentally study the evolution of pressure driven modes using images measured by a fast, tangentially-viewing soft X-ray camera [1]. Sawtooth-like MHD activity occurs in high density plasmas when the pressure gradient in the core region exceeds a limit. It is found that the magnetic surfaces are strongly deformed just before the sawtooth crash. The magnetic reconnection due to this deformation causes rapid energy flow from the core to the edge.

It is oberserved that the core pressure gradient after the sequential pellet injection is 2 ~ 3 times larger than found in normal operation with gas fueling. As the pressure gradient increases, sawtooth-like events begin. These events are often followed by large amplitude oscillations which persist for 0.1 - 0.3s. The electron density decreases and the electron temperature gradually increases during this time. Thus, we can investigate the influence of resistivity on the mode behavior by comparing cases with similar pressure gradients and different electron temperatures.

Fig.1 shows the fluctuating components of the image from the tangential soft x-ray camera at the time of the maximum fluctuation amplitude (1.515 s). First, an m=3 mode evolves within 500ms and deforms the magnetic surface (Fig. 1(B2) white area). When the mode saturates, an enhanced heat flux from the core to the edge is observed, causing flattening of the pressure profile. The SX emission from the outer plasma increases after the event (see Fig.1 (B3)). The enhanced flux could be caused by reconnection where the magnetic surfaces are heavily compressed due to an interchange mode.

The pressure gradients at the rational surface are also studied. There is an onset of MHD events when the pressure gradient exceeds a limit ($-d\beta/d\rho$ 1 %). The onset value does not change significantly when the iota profile is modified by the plasma current. The magnetic Reynolds number S ($= \tau_R/\tau_{alfven}$) is used as a measure of the resistivity. For similar pressure gradients, sawtooth activity occurs for lower values of S and saturated oscillations occur at higher values of S. This can be understood qualitatively from the following model. The amplitude of the MHD instabilities increases with the pressure gradient. It saturates when there is a balance between the fluctuation-driven flux and the pressure gradient. However, in higher resistive plasmas, reconnection occurs more easily at the same instability amplitude. Thus, sawtooth-like events are triggered in plasmas with lower S. This model is consistent with the observation that the repetition rate is higher when the electron temperature is low.

We have observed similar sawtooth-like activity near different rational surfaces, e.g., ι = 1/3, 1/2, 1/1, with m = 3, 2, 1. Though the pressure profile is modified by the sawtooth-like activity, the effect on the global confinement is small. The decrease in the stored energy is less than several % when the sawtooth-like activity is present.

[1] S. Ohdachi et al., Rev. Sci. Instrum **74**, 2136 (2003).

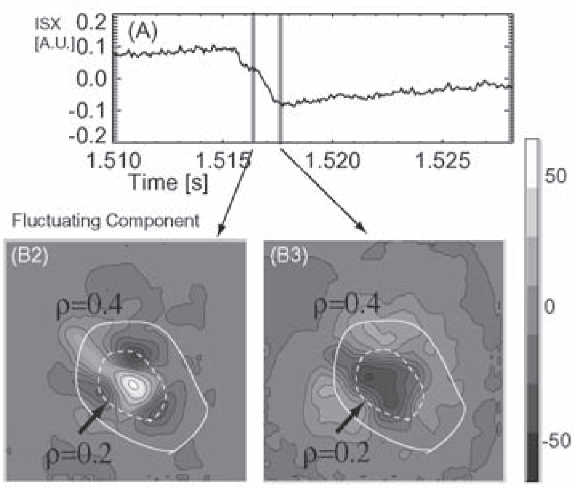

Fig.1: Two-dimensional structure of a sawtooth event is shown in (B2) and (B3).