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Sawtooth heat pulses interacting with plasma flows, turbulence and gradients in the tokamak edge plasmas

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The impacts of sawtooth heat pulses on electron and density and pressure gradients and flows of plasma, and turbulence are presented. These experiments are performed in the edge plasmas of the HL-2A tokamak, using multiple Langmuir probe arrays. When the sawtooth heat pulses propagate to the edge, the gradients, intensity of zonal flows, radial electric fields and turbulence all increase.

Figures 1 (a)-(d) show the conditional average of the soft X-ray signals, turbulence intensity, radial electric field and low frequency zonal flow (LFZF) intensity.

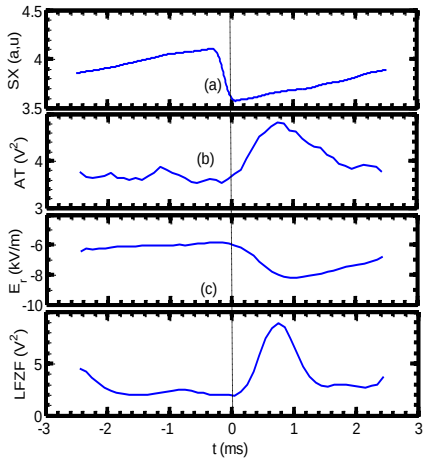

Fig 1. Conditional average of (a) soft X-ray signals, (b) turbulence intensity, and (d) LFZF intensity.

The sawtooth propagation velocity is ~1.2km/s in the radial direction. Before the sawtooth crashes, the intensity of the turbulence, radial electric field and LFZFs changes slightly while after the sawtooth crash start, ~0.2ms, it increases rapidly. ~0.8ms, after the sawtooth crashes, the intensity of the turbulence, radial electric field and LFZFs reaches the maximum. The intensity of the turbulence and the amplitudes of the electric fields are all up 30%. For the LFZFs, its intensity is increased by 300%. The results suggest that the sawtooth heat pulses can significantly change the edge turbulence, electric field and flows.

The delay time for the L–I transitions relative to sawtooth crashes is also estimated [1]. Figure 2 provides

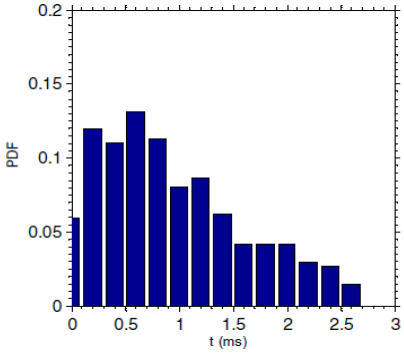

Fig 2. PDF of the delay time for the L-I transition, following sawtooth crashes.

the probability distribution function (PDF) of the delay time for the L–I transitions with respect to sawtooth crashes. Here, we count the delay time for more than 60 sawtooth crashes which lead to L–I transitions. The most probable delay time between the sawtooth crashes and onset of the I-phases is found to be slightly less than ~1 ms.

The confirmation of the casual relationship between flows and turbulence shows that the electric field and the zonal flows are all driven dominantly by turbulence. The delay time of the maximum of the intensity of the electric field and zonal flows relative to the sawtooth crash start is ~ 1 ms and consistent with that of the sawooth-triggered I-phases. The results have the implication that the sawtooth heat pulses may trigger L-H transitions through enhancing the edge turbulence, zonal flows and electric field.

References

[1] K. J. Zhao et al., Nucl. Fusion **53** (2013) 123015.