Propagation characteristics of preceding turbulence pulses at avalanche events

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Understanding turbulent transport is an important issue in magnetic fusion plasma research. Plasma transport cannot be explained only by local models, and it is necessary to consider the effects of non-local transport, in which transport is observed over long ranges rather than the effects of diffusive transport. In particular, avalanche phenomena and turbulence spreading have been recognized as causes of non-local transport, but observations of these phenomena are limited due to measurement limitations, and both experimental and theoretical understanding of these phenomena is insufficient. This study aims to clarify the propagation characteristics of avalanche phenomena and turbulence by using the advanced diagnostics of the Large Helical Device (LHD).

In this study, we targeted the collapse of the electron internal transport barrier (e-ITB) to induce large observable turbulence spreading phenomena. By forming a magnetic island near the e-ITB, a high-pressure gradient can be created to induce the collapse of the e-ITB, which can generate thermal avalanche phenomena with large heat flux movement. In addition, by measuring the turbulence intensity inside the magnetic island, where there is no pressure gradient and turbulence is not driven, the propagating turbulence can be observed independently of the background turbulence. This technique is a new method to observe avalanche phenomena and turbulence spreading caused by the collapse of e-ITBs with good reproducibility, and will greatly contribute to the understanding of the physical mechanism of non-local transport.

In the LHD, we observed the propagation of turbulence pulses preceding thermal pulses during the thermal avalanche phenomena associated with the collapse of e-ITBs [1]. As shown in Figure 1, both turbulence and thermal pulses generated near the foot of the e-ITB and propagated to the peripheral region faster than the diffusion time, but the propagation speed of the turbulence pulse was about 10 km/s, which is faster than the propagation speed of the thermal pulse of about 1.5 km/s. Existing models estimate that both heat and turbulence propagate at a speed of about 1 km/s, but it is clarified that there exists a phenomenon in which turbulence pulses propagate more than one order of magnitude faster than predicted by theoretical models.

The fact that turbulence pulses propagate preceding thermal pulses indicates the existence of a phenomenon that cannot be explained by existing models, namely, the simultaneous propagation of avalanches and turbulence, and provides important insight into the physical mechanism of non-local transport. Furthermore, this research result indicates that it may be possible to predict plasma temperature changes by observing the predictive turbulence.

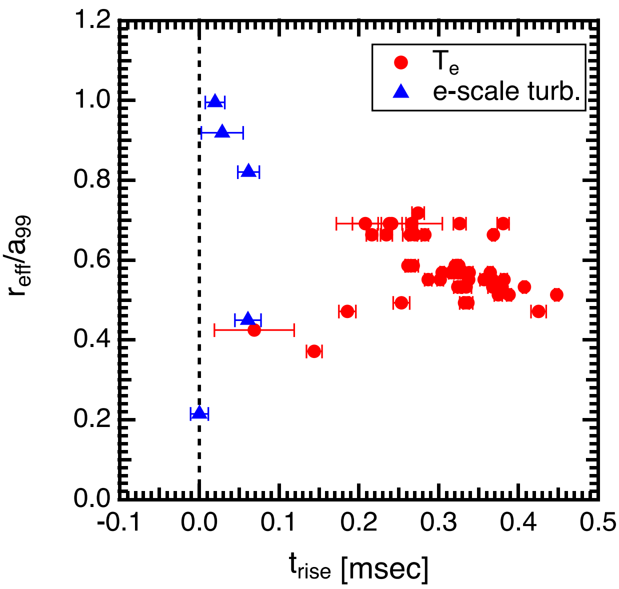

Figure 1. Observation time of turbulence and thermal pulses at each measurement position. The propagation speed of the turbulence pulse is about 10 km/s, which is faster than the propagation speed of the thermal pulse of about 1.5 km/s.

Reference
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