Time-scale dependence of turbulence and heat pulse propagation velocity

N. Kenmochi[1,2], K. Ida[1,2], T. Tokuzawa[1,2], R. Yasuhara[1], H. Funaba[1], H. Uehara[1,2], D.J. Den Hartog[3], I. Yamada[1,2], M. Yoshinuma[1,2], Y. Takemura[1,2], H. Igami[1,2], R. Yanai[1]

[1] *National Institute of Fusion Science, Toki, Japan*

[2] *The Graduate University for Advanced Studies, SOKENDAI, Toki, Japan*

[3] *Wisconsin Plasma Physics Laboratory, University of Wisconsin-Madison, Madison, USA*

Plasma transport cannot be explained by local models alone, and the effects of non-local transport must be considered. 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 are insufficient. In this study, the new findings of turbulence and heat propagation phenomena that cannot be explained by the existing avalanche and turbulence spreading models are reported in the Large Helical Device (LHD) experiments.

An electron internal transport barrier (e-ITB) collapse phenomenon is targeted to induce large observable turbulence spreading phenomena. In the LHD, when thermal avalanche phenomena accompany the collapse of the e-ITB, both turbulence and thermal pulses are generated near the foot of the e-ITB and propagate to the peripheral region faster than the diffusion time. However, the propagation velocity of the turbulence pulses is about 10 km/s, which is faster than the propagation velocity of the heat pulse of about 1.5 km/s [1]. Existing models estimate that both heat and turbulence propagate at a velocity of about 1 km/s, but the turbulence pulse propagates more than one order of magnitude faster than this prediction. Although the simultaneous propagation of the turbulence and heat pulses has been reported in some experiments, the observed phenomenon in the LHD is thought to follow a different mechanism.

In order to systematically investigate the effects of the time scale of turbulence and heat pulses on their propagation velocity, the modulated electron cyclotron heating (ECH) experiments were performed in which the induced time width of the heat pulse was varied by changing the time width of the ECH. The results showed that the propagation velocity of the heat and turbulence pulses is faster with shorter pulse widths. The fact that turbulence and heat pulses with shorter time scales propagate faster indicates the existence of a phenomenon that cannot be explained by existing models in which heat and turbulence propagate simultaneously, and provides essential insight into the physical mechanism of non-local transport.

References

[1] N. Kenmochi *et al*. Scientific Reports **12**, 6979 (2022)