§5. Improvement in a Transit Time Distribution Analysis for the Evaluation of the Stability of Electron Heat Transport State in LHD

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Recently, a transit time distribution (TTD) analysis has been introduced to evaluate the stability of the electron heat transport state, especially in a plasma exhibiting a nonlocal transport phenomenon observed in LHD[1]. The nonlocal transport phenomenon is a core electron temperature T_e rise in response to an edge cooling induced by a pellet injection and so on[2]. In magnetically-confined high-temperature plasmas, the turbulence driven transport plays an important role in the plasma confinement. The temperature and its gradient can mainly specify the turbulence state. Thus there is a consistent relationship among an electron heat flux normalized by the electron density q_e/n_e, the T_e and its gradient. In this case, the change in the normalized electron heat flux normalized by the electron density $\delta q_e/n_e$ is almost negligible, compared to the change in the T_e gradient. Thus the TTD analysis can be applied to the temporal evolution of the T_e gradient. The preliminary analysis with the TTD of the T_e gradient suggests an intriguing possibility that the core electron heat transport state is on the metastable state and the edge electron heat transport state transits to another state. However, it is recently found that the T_e values, which is measured with an electron cyclotron emission (ECE) radiometer, are corrupted by a 60-Hz inductive noise and its harmonics. This contamination will impact on the shape of TTD. In order to evaluate the TTD more precisely, we have to remove the induction noise from the ECE signals. For this purpose, an adaptive digital filter technique is used. Here, the frequency of the waveform being adapted ranges from 60 Hz (fundamental) to 600 Hz (tenth harmonics). Figure 1 shows the temporal evolutions of the T_e at r/a = 0.84 measured with the ECE radiometer before and after the ADF is applied. Here, a is the plasma minor radius. As can been seen in Fig. 1, the corruption of the waveform by the 60-Hz inductive noise is drastically reduced when the ADF is applied. The output of the ADF is found to be stabilized after about third cycle of the 60-Hz waveform. Figure 2 shows the Fourier spectra of those waveforms from t = 2.6 s to t = 2.7023 s. As you can see, there are clear peaks at around 60 Hz (fundamental), 180 Hz (third-order) and 300 Hz (fifth-order) in the original T_e signal measured with the ECE radiometer. On the other hand, there are no clear peaks in the ADF-applied spectrum. Figure 3 shows the TTD of the T_e gradient at r/a = 0.36 around the appearance of the nonlocal transport phenomenon. Here a 100-Hz low-pass filter is applied to the T_e values. When the ADF is used, in the core region of LHD plasma, the undulating TTD shape at the region with the larger T_e gradient becomes smooth and the two peaks around the zero displacement of the T_e gradient become more noticeable. The TTD shape refined by the ADF can shed light on the stability of the electron heat transport state more clearly.

1) N. Tamura et al.: Ann. Rep. NIFS (2009 – 2010) 25.
2) N. Tamura et al.: Nucl. Fusion **47** (2007) 449.

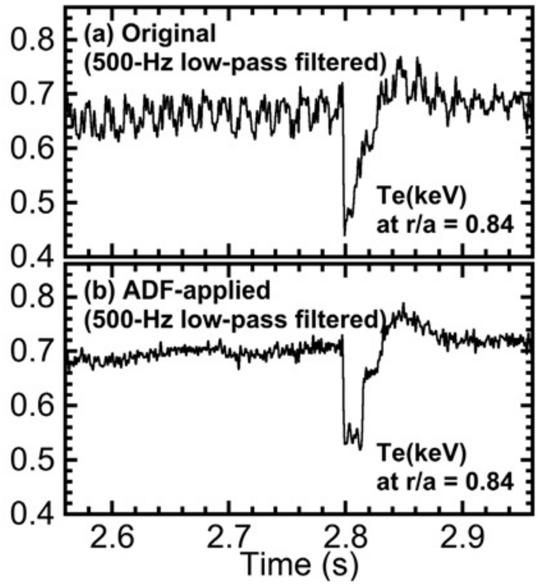

Fig. 1. Temporal evolutions of the electron temperature at r/a = 0.84, which is measured with the ECE radiometer, (a) before and (b) after the ADF is applied.

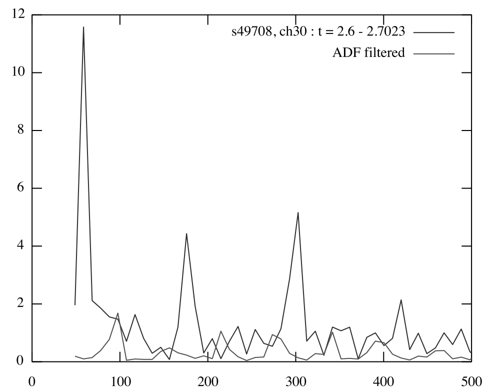

Fig. 2. Fourier spectra of the waveforms shown in Fig.1 from t = 2.6 s to t = 2.7023 s.

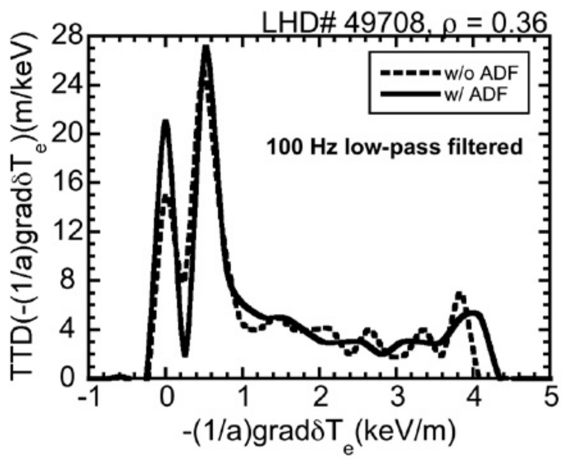

Fig. 3. Transit time distribution of the electron temperature gradient at r/a = 0.36 around the appearance of the nonlocal transport phenomenon. Here, a 100-Hz low-pass filter is applied to the T_e values.