Characterization of turbulent and non-turbulent parts in visualization images of channel flow

R. Takai*, S. Yimprasert†, K. Kato*, and M. Matsubara*

In the transitional channel flow, turbulent and non-turbulent parts coexist; the fraction of turbulence increases with Reynolds number Re, and at some Re resulting in fully-developed turbulence. Yimprasert et al.[1] conducted flake visualizations, and reported characteristic flow structures and the fraction of turbulence using a threshold. On the other hand, Seki et al.[2] carried out hot-wire measurements and distinguished turbulent and non-turbulent parts from the measured velocity data without introducing an artificial threshold, assuming that these parts have significantly different statistics. However, no unique way to distinguish turbulent and non-turbulent parts has been established. In the present study, we explore methods to detect turbulence without using an artificial threshold for qualitative visualization images.

The visualization images were processed in the same way done by Yimprasert et al.; the difference between two spatially filtered images was calculated, and then a band-pass filter was applied to extract turbulent structures. The complementary cumulative distribution function $C(\theta)$ of the processed image intensity magnitude θ is shown in Figure 1. For low Reynolds number the variation is small (non-turbulent part). As Re increases, the variation spreads gradually. Interestingly, the spreading part with relatively large θ keeps nearly a constant slope, which was also reported by Seki et al. and is regarded as a characteristic distribution of turbulence, although the present data is based on image intensity (not velocity). In the transitional regime, the obtained $C(\theta)$ seems to consist of these turbulent and non-turbulent parts. As Re increases, the function corresponding to turbulence with the linear slope becomes more dominant. In the talk, we will also report the characteristics of the detected structures such as time/length scales using the present method.

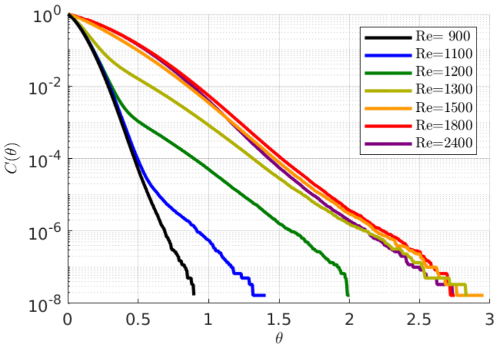

Figure 1: Complementary cumulative distribution function of image intensity magnitude $C(\theta)$ at different Reynolds numbers Re

*Dep. Mechanical System Engineering, Shinshu University, 4-17-1, Wakasato, Nagano, Japan
†Mechanical Engineering Dep., Naresuan University, 99 Moo 9, A. Meung, Phitsanulok, Thailand

[1]Yimprasert, Kvick, Alfredsson, and Matsubara *Exp. Fluids* **62**, 31 (2021).
[2]Seki and Matsubara, *Phys. Fluid* **24**, 124102 (2012).