The 100 eyes Tomographic PIV

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ABSTRACT

PIV is one of the methods to measure velocity in a flow field, but its dynamic velocity range is narrower than other flow velocimeter. This disadvantage is particularly apparent in measurements of spectrum in turbulent boundary layers, where the higher wave number side of the spectrum cannot be measured with high accuracy.

In this study, we captured images of the same particle in the flow field from many different direction simultaneously, and reduced the measurement error of the particle displacement by averaging the acquired particle positions, so called 'Multiple Eye PIV' [Maekawa, A., Sakakibara, J., 2018, *Meas. Sci. Tech.*, **29**, 064011]. We applied this method to obtain the energy spectrum in a turbulent pipe flow aiming for resolving higher wave number. Particle images were captured by a single high-speed C-MOS camera (Fastcam Nova S6, 6000 fps, Photron) through a mirror array consists of 110 flat mirrors arranged in the shape of an axisymmetric ellipsoid (Fig.1), as shown in Fig.2. The images were evaluated by Tomographic PIV method to resolve three-dimensional velocity field.

Fig.3 shows energy spectrum in a pipe measured by Tomographic-PIV with number of mirrors, N, up to 100 in addition to the 2D2C-PIV with a single mirror. Although the spectrum curve for the result of Tomographic-PIV begins to depart from the reference curve at wavenumber beyond 10^{-1}, such wavenumber grows as N increases, and consequently the plateau of the curve appeared at lower energy. Such a downward shift of the plateau is expected due to the improvement of the dynamic velocity range, which is approximately one order in energy, i.e. three times in velocity, found between N=4 and 100. Note that the cases of N=4 and 40 loses the dynamic range against the 2C2D-PIV case. From the above, we can summarize that the advantage of Multiple Eye PIV over the 2C2D-PIV is effective when the number of mirrors is more than 40.

In this experiment, the issue is that particles images flickered. In order to resolve this issue, we tried to use fluorescent particles, and obtained a clear particle images in the following experiment. We are now analyzing whether the energy spectrum can be measured with higher accuracy due to improved resolution of the particles.

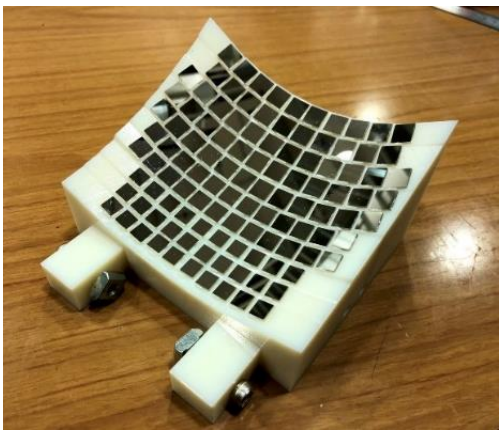

Figure 1 Mirror array

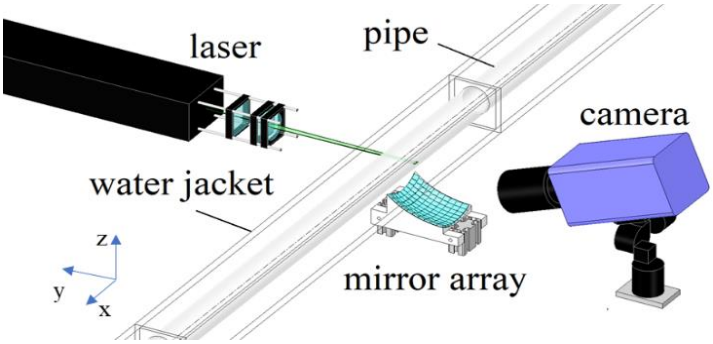

Figure 2 State of using a mirror array

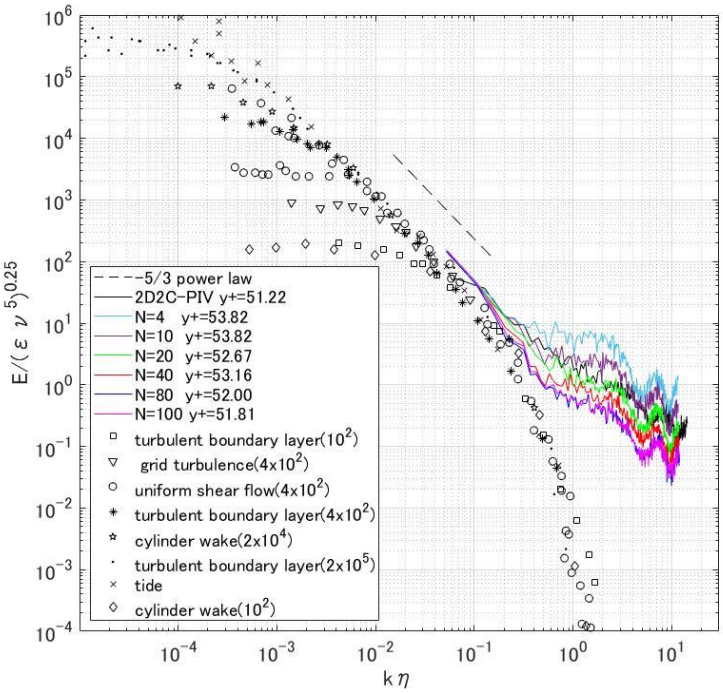

Figure 3 Energy spectrum