 Proceedings of ICCES'08, pp.1222-1223

Scaling Law of Fine Scale Eddy Cluster in Homogeneous Isotropic Turbulence

T. Kubota[1], M. Tanahashi[1,2] and T. Miyauchi[1]

Summary

Recent big DNSs of turbulence have shown that turbulence is composed of universal fine scale eddies which have been verified in homogeneous isotropic turbulence[1], turbulent mixing layer[2] and turbulent channel flow[3]. The characteristics of these eddies can be scaled by Kolmogorov length (η) and Kolmogorov velocity (u_k), and the most expected diameter and maximum azimuthal velocity are about 8η and $1.2u_k$ except for the near-wall eddy[3]. The intense fine scale eddies which are closely related with the intermittency of turbulent energy dissipation rate can be scaled by u_{rms}. From the existence of inertial sub-range in energy spectrum, large and medium eddies have been supposed to explain the energy cascade. However, there is no detailed information about large scale (or medium scale) structure in the physical space. In high Reynolds number turbulence, large scale clusters of fine scale eddies have been observed in various turbulent flows [**??**]. In this study, the size of fine scale eddy clusters and its relation to energy cascade are investigated using DNS data of homogeneous isotropic turbulence up to $Re_\lambda = 344.1$ with 1280^3 grid points.

In this study, PDF variance is introduced to investigate scaling of the fine scale eddy cluster quantitatively. The PDF variance is defined based on deviations of the concentration PDF from that of homogeneous distribution, and has been used for the investigation of particle distribution in turbulence [4]. Maxima of Q_c along each segment of a coherent fine scale eddy is used in this analysis. The PDF variance gives measure of concentration of segments of the coherent fine scale eddy and increases with localization of those. PDF variance for all eddies shows a peak at about 16η. For $Re_\lambda = 256.1$, 16η is about half of λ. For other Reynolds number cases, PDF variance also shows a peak at $1/2\lambda$, which means that mean distance of the eddy center is Taylor micro scale. Our previous study based on visualization [5] has suggested that mean distance between neighboring coherent fine scale eddies are about λ for low Reynolds number cases. The present results coincide with the previous visualization, and show quantitatively that mean length of segment and mean distance of coherent fine scale eddies are Taylor micro scale.

With the increase of lower limit of Q_c, peak value of the PDF variance and the cell size where the PDF variance shows the maximum values increase. These results suggest that stronger eddies create larger clusters The maximum PDF variance

[1]Department of Mechanical and Aerospace Engineering, Tokyo Institute of Technology, 2-12-1 Ookayama, Meguro-ku, Tokyo 152-8550, Japan

[2]Corresponding author. Tel./Fax +81-3-5734-3181, E-mail: mtanahas@mes.titech.ac.jp

can be observed at $a\eta = 143\eta$ for $Q_c/(u_{rms}/\eta)^2 > 0.25$. This cell size corresponds to about half of l_E for this Reynolds number. Since similar results were obtained for other Reynolds number cases, spatial nonuniformity of the strong fine scale eddy is enhanced at $a\eta \approx 1/2l_E$. Therefore, it is concluded that mean distance of the strong coherent fine scale eddies is the integral length scale.

References

1. Tanahashi, M., Miyauchi, T. and Ikeda, J., *Simulation and Identification of Organized Structures in Flows*, pp.131–140, Kluwer Academic Publishers (1999).
2. Tanahashi, M., Iwase, S. and Miyauchi, T., *J. Turbulence*, 2, pp.1–17 (2001).
3. Tanahashi, M., Kang, S.-J. Miyamoto, T., Shiokawa, S. and Miyauchi, T., *Int. J. Heat Fluid Flows*, 25, pp.331–340 (2004).
4. Hogan, R. C., *Phys. Fluids*, 13-10, pp.2983–2945 (2001).
5. Tanahashi, M., Iwase, S., Uddin, A. Md., Takata, N. and Miyauchi, T., *Thermal Science and Engineering*, 8-3, pp.29–38 (2000).