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Reynolds number scaling of straining motions in turbulence.
GERRIT ELSINGA, Delft University of Technology, T. ISHIHARA, Nagoya University, M.V. GOUDAR, Delft University of Technology, C.B. DA SILVA, University of Lisbon, J.C.R. HUNT, University College London — Strain is an important fluid motion in turbulence as it is associated with the kinetic energy dissipation rate, vorticity stretching, and the dispersion of passive scalars. The present study investigates the scaling of the turbulent straining motions by evaluating the flow in the eigenframe of the local strain-rate tensor. The analysis is based on DNS of homogeneous isotropic turbulence covering a Reynolds number range $Re_\lambda = 34.6$ - 1131. The resulting flow pattern reveals a shear layer containing tube-like vortices and a dissipation sheet, which both scale on the Kolmogorov length scale, η. The vorticity stretching motions scale on the Taylor length scale, while the flow outside the shear layer scales on the integral length scale. These scaling results are consistent with those in wall-bounded flow, which suggests a quantitative universality between the different flows. The overall coherence length of the vorticity is 120η in all directions, which is considerably larger than the typical size of individual vortices, and reflects the importance of spatial organization at the small scales. Transitions in flow structure are identified at $Re_\lambda \approx 45$ and 250. Below these respective Reynolds numbers, the small-scale motions and the vorticity stretching motions appear underdeveloped.

Gerrit Elsinga
Delft University of Technology

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