Wall bounded turbulence

Large-scale coherent structures in fully developed turbulent pipe flow

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In Short

- Large-scale coherent structures have a significant contribution to transport of momentum and energy in wall-bounded turbulent flows.
- Reaching a deeper understanding of their nature and dynamics has great industrial and scientific relevance.
- Direct Numerical Simulation (DNS) of turbulent pipe flow with length of $L/R = 50$ will be conducted at bulk Reynolds number range of $5.3 \times 10^3 < Re_b < 25 \times 10^3$.
- A Dynamic Mode Decomposition (DMD) will be applied to the DNS data in a moving frame of reference.

For almost a century, wall bounded turbulent shear flows have been regarded as an attractive topic for physicists, mathematicians and engineers and have inspired wide ranges of studies. In most practical and industrial applications, Reynolds numbers acquire very high values leading to large energy losses which are caused by turbulence dissipation. Therefore, in-depth study of this phenomenon can result in a more realistic prediction of losses, efficient flow control and ultimately reduction of energy consumption.

The same motivation has triggered study and observation of large scale turbulent coherent structures which are also known as Large and Very Large Scale Motions (LSM and VLSM) in wall bounded turbulent flows. In spite of the increasing number of studies on these structures, a solid definition of their nature and vivid understanding of their evolution is still missing. On the other hand, interactions between such motions, their contributions to near wall turbulence, their length scales and their decay rates are among the many questions whose answers are believed to bring considerable insight to physics of wall turbulence.

Aiming to reach a deeper understanding of such structures, this study is focused on DNS of incompressible turbulent pipe flow at bulk Reynolds number range of $5.3 \times 10^3 < Re_b < 25 \times 10^3$, on a pipe length of $L/R = 50$ using a pseudospectral code [1] provided by our SPP partner University of Bremen (M. Avila). As an example, contours of streamwise velocity fluctuations are plotted in figure 1 for a simulation at bulk Reynolds number of $Re_b = 5300$. The entire pipe is cut along the streamwise and azimuthal directions at radial distance of $r/R = 0.9$ which corresponds to a wall distance of $y^+ = 18$. Colors vary from -0.2 to 0.2 corresponding to blue and red respectively.

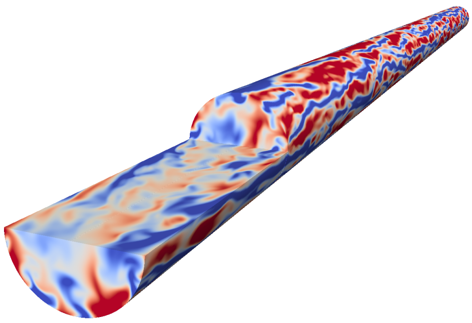

Figure 1: *Contours of streamwise velocity fluctuations at bulk Reynolds number of $Re_b = 5.3 \times 10^3$ (flow direction from right to left).*

The resulted data from this study will be analyzed using a Dynamic Mode Decomposition in a moving frame of reference to capture the structures traveling at the convective velocity (in collaboration with TU Berlin, J. Sesterhenn).

WWW

https://www.b-tu.de/en/research/research-projects/fluid-mechanics

More Information

[1] L. Shi, M. Rampp, B. Hof, M. Avila, *J.Computers and Fluids* **106**, 1-11 (2015).

Project Partners

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