POST-PROCESSING ASSIGNMENT

ME765 - Special Topics in Fluid Mechanics
High-speed and compressible flows
Fall 2018

Submission deadline: November 1st at 11:59pm

Description:

You are provided with an under-resolved Direct Numerical Simulation (DNS) of a compressible channel flow with differentially heated walls. The single snapshot of the three-dimensional simulation takes up about 700 Mb with a structured grid of just over 31 million grid points $(512 \times 240 \times 256)$. For reference, the resolved simulation required just over 3 billion grid points. The grid is homogeneous in the streamwise, x, and spanwise, z, directions; in these homogeneous directions, the boundaries assumes periodicity. A wall-clustering is used in the wall-normal direction, y; the grid locations in y are provided and should be used. The data is provided in Matlab format and binary format with a python script to access the data. You are provided with the following three-dimensional data: ρ, ρU, ρV, ρW, ρE. Note that $\rho E = \rho(e + \frac{1}{2}(U^2 + V^2 + W^2))$. The data is fully non-dimensionalized. The following information is provided:

- $(Lx, Ly, Lz) = (6\pi, 2, 2\pi)$
- $\gamma = 1.4$ and $Pr = 0.72$
- Universal gas constant $R = 0.31745$ (with consistent non-dimensionalization)

Accessing the database:

- Matlab format (about 700 Mb):
  `https://drive.google.com/file/d/1uk9Or885yJoVvTpGO-uGucWgD3g7RfHu/view?usp=sharing`
- Generic binary format (about 700 Mb):
  `https://drive.google.com/file/d/1eiTqiBQvjIpo6VdJbJztOOQ6ZS2c1S-I/view?usp=sharing`
- Python script to read generic binary:
  `https://drive.google.com/file/d/15GkZA4EBQbHbZtu57KQE3LUGBWzUl-bq/view?usp=sharing`
- Grid locations in the wall-normal direction:
  `https://drive.google.com/file/d/11TMxvNLx08IWe-PUm7TMfIvZQ1CdfP3U/view?usp=sharing`

Questions:

1. Plot the average streamwise velocities (all in one figure): $\overline{U}(y)$, $\overline{V}(y)$, and $\overline{W}(y)$.
2. Plot the following turbulence statistics (all in one figure): $\overline{u'u'}(y)$, $\overline{v'v'}(y)$, $\overline{w'w'}(y)$, $\overline{u'v'}(y)$, $\overline{u'w'}(y)$, and $\overline{v'w'}(y)$.
3. Plot the average Mach number: $\overline{M}(y)$.
4. Plot the average temperature profile: $\overline{T}(y)$.
5. Compute the average temperature gradient at the bottom and top wall.
6. Compute the average centerline and bulk Mach number.
7. Compute the planar average dilatation and show, at each y location, the minimum and maximum dilatation.
8. Plot the spectrum of the turbulent kinetic energy and dilatation at given y location.
9. Compute the ratio of grid spacing to the local Kolmogorov length scale.