Direct numerical simulation of pipe flow

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Despite the believed linear stability of pipe Poiseuille flow, turbulence can appear for Reynolds numbers, R, larger than approximately 2000. However, in highly controlled experiments, laminar flow has been observed at $R \approx 10^5$. There is a threshold for the amplitude of the perturbation, below which all perturbations eventually decay. This threshold is typically assumed to behave as $R^{-\beta}$, with $\beta > 0$, as $R \to \infty$. Determining the correct value of β has proven to be a great challenge. Earlier experiments and computations have indicated values in the range $1 \leq \beta \leq 3/2$.

In this talk, we present some initial results from direct numerical simulation of pipe Poiseuille flow at large Reynolds numbers. Such simulations require state of the art codes as well as massive computer resources. We have used a code[1] based on compact finite differences of at least eighth order of accuracy in the axial direction, and Chebyshev and Fourier expansions in the radial and azimuthal directions, respectively. In order to do DNS for large Reynolds numbers, the code has been parallelized for distributed memory computers.

We have considered wall imposed disturbances in the form of suction and blowing. Especially, we are currently considering suction and blowing through two small holes located close to each other. Modeling such perturbations requires very high resolution and the use of parallel computers is essential.

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[1]Developed by J. Reuter, Universität Stuttgart, and D. Rempfer, Illinois Institute of Technology.