Proposition de Stage de master 2 - Master 2 project - 2021

Etude du cycle de régénération de la turbulence dans un écoulement de canal par analyse basée sur le résolvant

Investigation of the self-sustaining process in a turbulent channel flow using resolvent analysis

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Keywords : stability in fluid flows, resolvent analysis, proper orthogonal decomposition (POD), turbulence, channel flow, data analysis, matlab

This master project deals with the study of important dynamical phenomena in wall turbulence, and will consists in post-processing, and possibly modeling, of data obtained from numerical simulations.

Experimental and numerical works have established that turbulence in the near wall region is governed by an autonomous cycle [1] which is mainly independent of the outer flow. In this cycle, streaks and rolls interact to regenerate turbulence. A situation where such a cycle can be observed easily is the numerical simulation of a minimal flow unit [2]. Figure 1 shows the evolution of a near wall streak in such a simulation. At the beginning of the cycle the streak is quiet (left), then it oscillates (middle), and finally bursts (right). This bursting somehow re-generates vortices that will regenerate the streak, so that the all process can start again. This is the well-known self-sustaining process (SSP) in turbulence [1].

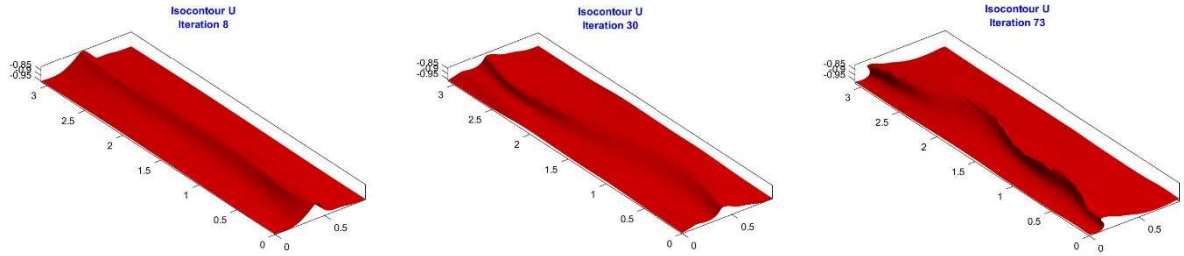

Figure 1 : Several instants in the life cycle of a near wall streak in a minimal flow unit.

In this master project, data obtained from the numerical simulation of a minimal channel flow unit will be investigated by miscellaneous data processing techniques and stability analyses, including resolvent analysis [3], to shed light on the SSP. Recent works [4] have applied this type of analysis on a Couette flow, and here a Poiseuille flow will be considered instead. Depending on the results, a different situation could be studied, such as a flow with a non-rigid wall [5]. Also, producing a low-order dynamical model of the flow would be an interesting outcome of this project.

References :

[1] Waleffe, On a self sustaining process in shear flows, Phys. Fluids 9 (1997).
[2] Jimenez J., Pinelli A. (1999), The autonomous cycle of near-wall turbulence. J. Fluid Mech. 389, 335-359.
[3] Cavalieri A, Jordan P., Lesshafft L., Wave-Packet Models for Jet Dynamics and Sound Radiation, Applied Mechanics Reviews 2019, Vol. 71, 020802.

[4] Nogueira P., Morra P., Martini E., Cavalieri A., Henningson D. D., Forcing statistics in resolvent analysis: application in minimal turbulent Couette flow.
[5] Sebastian R, Marx D, Fortuné V, Numerical simulation of a turbulent channel flow with an acoustic liner, J. Sound Vib. 456, 306-330 (2019).

Practical details : this work is for a duration of about 5 months, and will take place at the Université de Poitiers and Institut Pprime, in the 2AT team (Acoustics Aerodynamics and Turbulence), A monthly grant of about 550€ (this will be the legal amount) will be provided.
The candidate should follow a master's degree or an engineer degree and have knowledge of fluid mechanics, turbulence, and ideally of some analysis tools (Fourier transform, POD, linear stability analysis). She/he should feel easy with mathematical and numerical techniques. The work will be done mostly in matlab.
Do not hesitate to contact us for further information. To apply, send us by email: a CV, a mark sheet, and possibly the name of a referee (one of your professors of former advisors).

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