Comparison of PIV and visualisation in Couette-Poiseuille flow

Victoria Nicolazo-Crach, Tao Liu, Ramiro Godoy-Diana, José Eduardo Wesfreid, Benoît Semin

PMMH, CNRS, ESPCI Paris, Université PSL, Sorbonne Université, Université Paris Cité, F-75005, Paris, France
victoria-nicolazo.crach@etu.sorbonne-universite.fr

In a linearly stable Couette-Poiseuille flow, the sub-critical transition to turbulence is linked to the appearance of coherent turbulent structures which take the form of streamwise vortices (or rolls) and modulations of the streamwise velocity (or streaks). Streaks, streaks break-up and vorticity are subjected to the self-sustaining process (SSP) of turbulence. When the turbulence decays, a Reynolds number dependent time-scale has been measured using visualisation [1], and two time-scales using PIV [2]. The goal of this study is to determine which time-scale and which structure is measured by visualisation by the means of a comparison between visualisation and PIV on the same experimental set-up.

The experiment is carried out in a plane Couette-Poiseuille channel in which the flow is driven by a moving belt, two tanks at the ends of the channel ensure a zero mean flux (Fig.(A)). The moving belt direction defines the streamwise direction x, while z is the spanwise direction and y the wall-normal direction. The streaks and rolls are quantified respectively by the streamwise velocity fluctuations u_x and u_z, measured using PIV (Fig.(B)). To study the decay of turbulence, we perform a "quench", an abrupt decrease of the Reynolds number Re, from a fully turbulent state to a laminar regime.

During this transition to a laminar regime, the coherent structures can be observed, either by visualisation or PIV. We implement the visualisation method by introducing in the flow anisotropic aluminium particles ($30-80$ μm) which reflect light directed in the spanwise direction. The fluid is then rheoscopic, making water movements visible to the naked eye (Fig.(C)). Until now no measurement of visualisation and PIV has been made on a linearly stable plane Couette-Poiseuille flow using the exact same set-up.

The experiment showed that light intensity from visualisation seems to have the same characteristic time of decay as streaks during quench (Fig.(D)). This allows us to conclude that such visualisation method appears to represent streamwise velocity fluctuations.

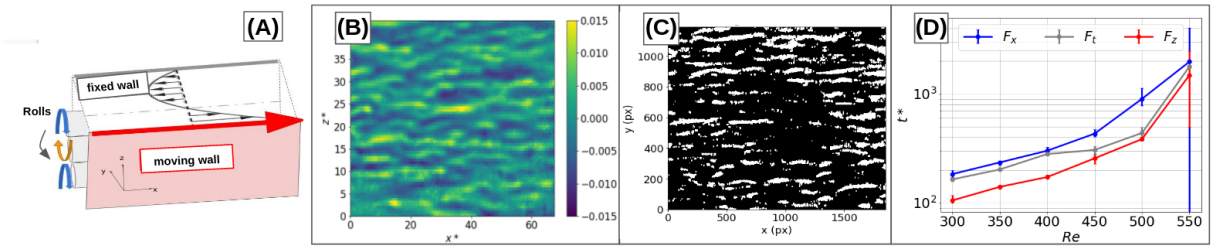

Figure 1. (A): Sketch of the experiment. (B): Dimensionless streamwise fluctuation velocity u_x^*. (C): Processed binary visualisation image of streaks. (D): Characteristic times of decay for turbulent fractions from visualisation (F_t) and PIV (F_x,F_z in the streamwise and spanwise direction respectively).

References

1. S. Bottin, Structures cohérentes et transition vers la turbulence par intermittence spatio-temporelle dans l'écoulement de Couette plan, PhD thesis, *Université Paris XI*, (1998).
2. T. Liu, B. Semin, L. Klotz, R. Godoy-Diana, J. E. Wesfreid & T. Mullin, Decay of streaks and rolls in plane Couette-Poiseuille flow, *J. Fluid Mech.*, **915**, A65 (2021).