Dynamics of turbulent structures in Couette-Poiseuille flow

B. Semin, T. Liu, R. Godoy-Diana and J.E. Wesfreid*

In the transition regime in wall-bounded shear flows, active turbulence is characterized by coherent structures, such as streamwise vortices called rolls, and modulations of the streamwise velocity called streaks. We investigate experimentally the dynamics of these structures and the detailed interplay of their components.

We performed experiments in a plane Couette-Poiseuille channel of gap $2h$. The streaks and rolls are quantified respectively by the streamwise velocity fluctuation u_x and the spanwise velocity u_z, measured using particule image velocimetry (PIV). We study the decay of turbulence using a 'quench' protocol, i.e. an abrupt decrease of the Reynolds number Re from a fully turbulent state to a laminar regime

We show that the rolls decay faster than the streaks[1]. The streaks have two decay stages in the decay process. During the first stage of the decay, the remaining rolls slow down the decay of the streaks. This is consistent with the lift-up effect, i.e. the formation of streaks by linear advection of the rolls.

We also study the effect of the noise, which is the external disturbance generated by the belt driving cylinder, on the transient decay and the permanent regime. The decay dynamics is independent of the noise level. The noise shifts the apparent critical onset of transition.

Additionnaly, we investigate the waviness of streaks using vortex generators to induce unstable wavy streaks. The evolution of the streaks becoming wavy from a straight state is characterized using stereoscopic PIV. We apply a spatial filter to separate the straight part and the wavy part of the streamwise velocity. We define the wavy vorticity ω_{ywavy} from this latter component, as a quantitative measurement of the waviness of the streaks. Spanwise velocity (fig. 1B and C) and the wavy wall-normal velocity are correlated to the increase of the waviness of the streaks, as expected from self-sustaining models. For streaks of low waviness, the value of u_z is small and related to the amplitude of the streak u_x, as expected for linear lift-up.

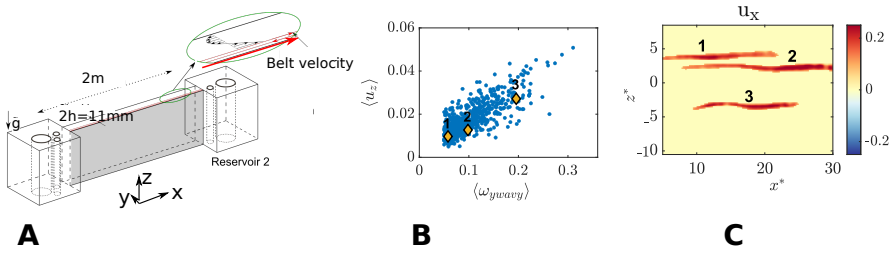

Figure 1: A: schematic view of the experimental set-up. B: Spanwise velocity of the streaks as a function of the wavy vorticity. C: corresponding streaks.

*Laboratoire PMMH, CNRS, ESPCI Paris, Université PSL, Sorbonne Université, Université Paris Cité, 7 quai saint-Bernard, 75005 Paris, France

[1]Liu et al, *J. Fluid Mech.* **915**, A65 (2021)