On the dynamics of laminar-turbulent patterns in plane Couette flow

Paul Manneville

Laboratoire d'Hydrodynamique, CNRS UMR 7646, École Polytechnique 91128 Palaiseau
paul.manneville@ladhyx.polytechnique.fr

The transition to turbulence in plane Couette flow is characterized by the presence of oblique bands, alternatively laminar and turbulent, over an interval $R \in [R_{\rm g}, R_{\rm t}]$ with $R_{\rm g} \approx 325$ and $R_{\rm t} \approx 415$ [1]. The physical mechanisms producing these patterns are still not well understood but one can account for certain properties of the transitional regime over $[R_{\rm g}, R_{\rm t}]$ in a phenomenological way similar to classical approaches in terms of envelopes designed for instabilities developing on laminar backgrounds, e.g. convection, with the randomness of the featureless regime at $R \geq R_{\rm t}$ treated as a tunable external noise [1].

In extended geometry, numerical simulations are expensive [2] but qualitatively realistic results can be obtained by decreasing the resolution in the cross-flow direction (y) perpendicular to the plane of the flow (x, z). The price to be paid is a downward shift of the transitional range. Using ChannelFlow with 15 Chebyshev polynomials along y, one gets $R_{\rm t} \approx 360$ and $R_{\rm g} \approx 273.5$ [3].

In this context we have studied the dynamics of the laminar-turbulent pattern obtained in a wide domain (432×256), optimally accommodating three oblique bands at $R = 275 \gtrapprox R_{\rm g}$ [4]. From this pattern, we have been able to prepare an initial state with two unequally distributed parallel bands. We will present results of a numerical simulation starting from this state and showing that the wavelength modulation relaxes in a diffusive way (at least at the beginning) yielding a uniform 2-band pattern.

This observation supports the idea that, sufficiently far from pattern onset at $R_{\rm t}$, the *amplitude* of the laminar-turbulent modulation remains saturated so that the dynamics can be reduced to that of the band position, i.e. the spatial *phase*, as would result from a naive application of the phase formalism for laminar dissipative textures [5] even though it develops from a turbulent background at decreasing R.

Références

1. A. Prigent, G. Gregoire, H. Chaté, O. Dauchot, Long wavelength modulation of turbulent shear flows, *Physica D*, **174**, 100–113 (2003).
2. Y. Duguet, P. Schlatter, D.S. Henningson, Formation of turbulent patterns near the onset of transition in Couette flow, *J. Fluid Mech.*, **650**, 119–129 (2010).
3. P. Manneville, J. Rolland, On modelling transitional trubulent flows using under-resolved direct numerical simulations : the case of plane Couette flow, *Theor. Comput. Fluid Dyn.*, **25**, 405–420 (2011)
4. P. Manneville, On the decay of turbulence in plane Couette flow, *Fluid Dyn. Res*, **43**, 065501 (2011).
5. Y. Pomeau, P. Manneville, Stability and fluctuations of a spatially periodic convective flow, *J. Physique - Lettres*, **40**, L-609–612.