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

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The transition to turbulence in plane Couette flow is characterized by the presence of oblique bands, alternatively laminar and turbulent, over an interval $R \in [R_g, R_t]$ with $R_g \approx 325$ and $R_t \approx 415$ [1]. The physical mechanisms producing these patterns are still not well understood but one can account for certain properties of the transitional regime over $[R_g, R_t]$ 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 $R \geq R_t$ 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 $R_t \approx 360$ and $R_g \approx 273.5$ [3].

In this context we have studied the dynamics of the laminar-turbulent pattern obtained in a wide domain ($432 \times 256$), optimally accommodating three oblique bands at $R = 275 \gtrsim R_g$ [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 $R_t$, 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