Statistical transition to turbulence in plane channel flow

Sébastien Gomé[1], Laurette S. Tuckerman[1] & Dwight Barkley[2]

[1] Laboratoire de Physique et Mécanique des Milieux Hétérogènes (PMMH), CNRS, ESPCI Paris, PSL Research University, Sorbonne Université, Université Paris Diderot, Paris 75005, France
[2] Mathematics Institute, University of Warwick, Coventry CV4 7AL, United Kingdom
sebastien.gome@espci.fr

Intermittent turbulent-laminar patterns characterize the transition to turbulence in pipe, plane Couette and plane channel flows. The time evolution of turbulent-laminar bands in plane channel flow is studied via direct numerical simulations using the parallel pseudospectral code ChannelFlow in a narrow computational domain tilted by 24° with respect to the streamwise direction. Depending on the Reynolds number, a turbulent band can either decay to laminar flow or split into two bands. As with past studies of other wall-bounded shear flows [1,2], in most cases survival probability distributions are found to be exponential for both decay and splitting, indicating that the processes are memoryless. Statistically estimated mean lifetimes for decay and splitting are plotted as a function of the Reynolds number (Figure 1), leading to the estimation of a critical Reynolds number $Re_{\mathrm{cross}} \simeq 950$, where decay and splitting lifetimes cross at greater than 10^6 advective time units.

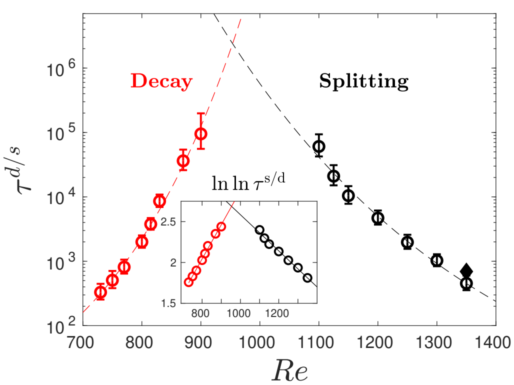

Figure 1. Evolution of mean lifetimes (red) and splitting times (black) with Reynolds number Re. Insight : $\ln \ln \tau^{s/d}$ versus Re and associated linear interpolations.

Laminarization of a turbulent band statistically proceeds by a sharp disappearance of small-scale structures (streaks and rolls) and by a slow decay of large-scale components, which become prominent after a specific time. The remaining large-scale flow is aligned with the disappearing band, and moves parallel to the band. In the case of a band splitting, the dynamics of large-scale spectral components seem to statistically follow the same pathway during the splitting of a turbulent band and may be considered as precursors of splitting.

Références

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2. Shi, L., Avila, M., Hof, B. Scale invariance at the onset of turbulence in Couette flow, *Phys. Rev. Letters*, **110** (20) : 204502, 2013.

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