Experimental investigation of transient growth and large scale flow in plane Couette-Poiseuille flow

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1 Introduction

We present the first and detailed experiments on transient growth of localized turbulent spots induced by external impulsive forcing in plane Couette-Poiseuille flow. In our experiment, the turbulent structures have nearly zero advection velocity, which enables us to measure their full instantaneous spatial structure, as well as their temporal evolution, and to directly compare our results with theoretical predictions of transient growth (including maximal gain and the time at which it occurs). However, we also observe that due to the spatially localized nature of the perturbation, some initial time for unpacking is required before transient growth will amplify the streaks, which agrees with nonlinear transient growth theory. We present that when the Reynolds number and/or amplitude are high enough, the spot may become self-sustained with non-deterministic life time, which shows the limits of validity of the linear theory. In addition, we quantitatively investigate one important spatial aspect of transition to turbulence, which is the large scale flow (LSF) induced around the turbulent spot. We determine the LSF intensity as a function of Reynolds number and perturbation amplitude, and demonstrate the correlation between LSF intensity and the advection speed of the spot. We also calculate the friction coefficient proportional to the force that the laminar flow exerts on the turbulent spot.

References

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