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The Instability of a Localized Vortex Disturbance in Uniform Shear Flow

Jacob Cohen[(1)], Victoria Suponitsky[(1)], Pinhas Z. Bar-Yoseph[(2)]

(1) *Faculty of Aerospace Engineering, Technion, Haifa, Israel*
(2) *Faculty of Mechanical Engineering, Technion, Haifa, Israel*

The objective of the present numerical (and theoretical) study is to examine the capability of a simple model of interaction, between a localized vortical disturbance and laminar uniform unbounded shear flow, to reproduce the generation mechanism and characteristics of the coherent structures (streaks and hairpin vortices) that naturally occur in turbulent (and transitional) bounded shear flows. The results demonstrate that a small amplitude initial disturbance eventually evolves into a streaky structure, whereas a large amplitude disturbance evolves into a hairpin vortex, independent of its initial geometry. Main non-linear effects are: relative movement of the vortical structure, destruction of its streamwise symmetry, and its alignment with the vorticity lines (which in the linear case is poor). The optimal spanwise spacing (producing the maximal transient growth) between two concentrated vorticity regions (expressed in wall units) corresponds well to the spacing of streaks in turbulent boundary layers. Finally, the numerical results will be discussed with respect to relevant theories.

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