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Edge states for the turbulence transition in the asymptotic suction boundary layer. (English)

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Summary: We demonstrate the existence of an exact invariant solution to the Navier-Stokes equations for the asymptotic suction boundary layer. The identified periodic orbit with a very long period of several thousand advective time units is found as a local dynamical attractor embedded in the stability boundary between laminar and turbulent dynamics. Its dynamics captures both the interplay of downstream-oriented vortex pairs and streaks observed in numerous shear flows as well as the energetic bursting that is characteristic for boundary layers. By embedding the flow into a family of flows that interpolates between plane Couette flow and the boundary layer, we demonstrate that the periodic orbit emerges in a saddle-node infinite-period (SNIPER) bifurcation of two symmetry-related travelling-wave solutions of plane Couette flow. Physically, the long period is due to a slow streak instability, which leads to a violent breakup of a streak associated with the bursting and the reformation of the streak at a different spanwise location. We show that the orbit is structurally stable when varying both the Reynolds number and the domain size.

MSC:

76F06 Transition to turbulence

76D10 Boundary-layer theory, separation and reattachment, higher-order effects

Keywords:

boundary layers; nonlinear dynamical systems; transition to turbulence

Full Text: DOI

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