Marquet, Olivier; **Lombardi, Matteo**; **Chomaz, Jean-Marc**; **Sipp, Denis**; **Jacquin, Laurent**

Direct and adjoint global modes of a recirculation bubble: lift-up and convective non-normalities. (English) Zbl 1165.76337

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Summary: The stability of the recirculation bubble behind a smoothed backward-facing step is numerically computed. Destabilization occurs first through a stationary three-dimensional mode. Analysis of the direct global mode shows that the instability corresponds to a deformation of the recirculation bubble in which streamwise vortices induce low- and high-speed streaks as in the classical lift-up mechanism. Formulation of the adjoint problem and computation of the adjoint global mode show that both the lift-up mechanism associated with the transport of the base flow by the perturbation and the convective non-normality associated with the transport of the perturbation by the base flow explain the properties of the flow. The lift-up non-normality differentiates the direct and adjoint modes by their component: the direct is dominated by the streamwise component and the adjoint by the cross-stream component. The convective non-normality results in a different localization of the direct and adjoint global modes, respectively downstream and upstream. The implications of these properties for the control problem are considered. Passive control, to be most efficient, should modify the flow inside the recirculation bubble where direct and adjoint global modes overlap, whereas active control, by for example blowing and suction at the wall, should be placed just upstream of the separation point where the pressure of the adjoint global mode is maximum.

MSC:

76E99 Hydrodynamic stability
76D05 Navier-Stokes equations for incompressible viscous fluids
76M10 Finite element methods applied to problems in fluid mechanics

Software:

ARPACK

Full Text: DOI

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