Lift-up and convective nonnormalities : the dynamics of a recirculation bubble and wakes

Jean-Marc Chomaz

Directeur de Recherche au CNRS, Laboratoire d'Hydrodynamique, Ecole Polytechnique.

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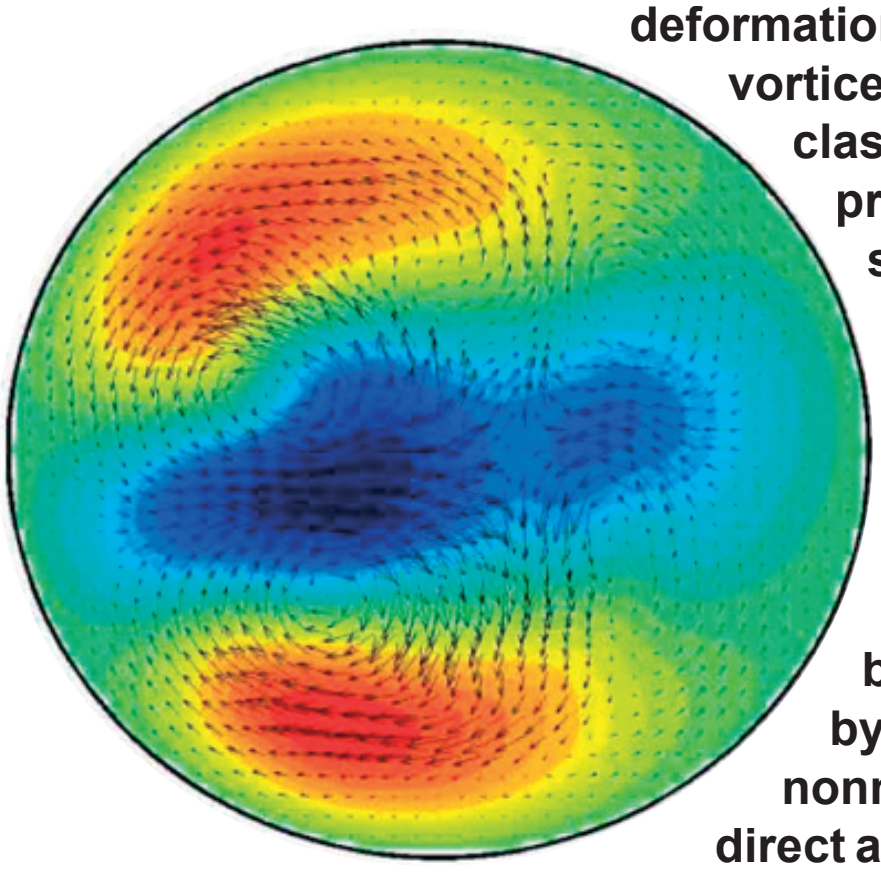
ABSTRACT :

The stability of the recirculation bubble behind a smoothed backward-facing step or in the lee of variuos objects (wakes) is numerically computed. Destabilization occurs through a stationary or oscillatory three-dimensional modes. 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 to the transport of the base flow by the perturbation and the convective nonnormality associated to the transport of the perturbation by the base flow explain the properties of the flow. The lift-up nonnormality 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 nonnormality results in a different localization of the direct and adjoint global modes, respectively downstream and upstream. Implication of these properties on the linear and nonlinear dynamics will be discussed.



contact : Catherine.Thuriot@imft.fr