Effects of base-flow variations on the secondary instability in the wake of a circular cylinder

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Small base flow variations may have drastic effects on the stability properties of a fluid system. Several studies have been performed in the past in order to better understand such issue: for example sensitivity analyses were carried out for parallel flows[1], boundary layers [2] and bluff-body wakes [3,4,5]. These analyses, however, concern systems with steady flow configurations. Base flow variations may be relevant also for systems characterised by a periodic base flow. For instance it is well known that the periodic wake arising behind bluff bodies, may undergo a secondary bifurcation which generally leads the system towards a more complex state. As an example, Floquet stability analysis shows that the Karman street behind a circular cylinder becomes unstable to 3D perturbations when the Reynolds number exceeds the threshold $Re_{2,c} \approx 189$ (mode A). In this presentation we generalise the procedure introduced by Marquet et al. [4] and by Luchini et al. [5] to treat configurations characterised by an unsteady periodic base flow. By applying the generalised Lagrange identity to the system formed by the base flow and the linearised stability equations and using the properties of the adjoint operators, a relation between the drift of the Floquet exponent (indicating the stability of the flow) and a generic but localised structural perturbation of the governing equations will be derived. Such result will be used to build spatial sensitivity maps (see figure 1 for an example) which can be used to identify the regions of the flow where the placement of an infinitesimal small object produces the largest drift of the Floquet exponent. Such analysis may provide useful insights both for passive control strategies and for experimental investigations. As an example results obtained for the wake of a circular cylinder will be discussed.

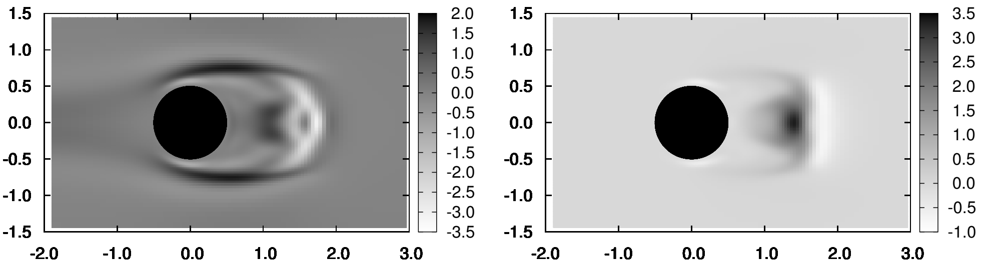

Figure 1: Sensitivity of mode A at Re=200 and $k = 1.6$ to a local force aligned to the local velocity acting on the base flow (left) and on the perturbation (right)

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[2]Zuccher at al.*J. Fluid Mech.* **513**, 135 (2004).
[3]Hill, D. C, AIAA Paper 92-0067 (1992)
[4]Marquet et al. *J.Fluid Mech.* **615**, 221 (2008)
[5]Luchini et al., AIAA paper n. 2008-4227 (2008)