Global stability of two side-by-side cylinder wakes

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ABSTRACT

Flows over bluff bodies are found in many engineering applications with the occurrence of massive flow separations and vortex shedding phenomena. Classical examples are given by the flow past tube bundles, high-rise buildings and trucks, among the others. The archetype of such flows is represented by the flow past a single circular cylinder which is a classical topic in fluid mechanics. Besides this latter, flows over two or more cylinders in various arrangements have also received considerable attention being prototypical of wake interference phenomena [1]. A well known example is represented by the flow past two identical circular cylinders in side-by-side configuration. For such case complex interactions between the two wakes occur, yielding to different flow patterns that significantly depend on the Reynolds number, Re, and even more on the non-dimensional gap spacing between the two cylinder surfaces, $g = g^*/D^*$ (where D^* is the cylinder diameter) [2]. Exploiting two-dimensional direct numerical simulations, up to six different flow patterns have been identified in the parameter ranges of $40 \leq Re \leq 160$ and $g \leq 5$, [3]. In particular, in addition to the *in-phase* and the *anti-phase* synchronization of the vortex shedding past the two cylinders, mainly occurring for $g > 1$, asymmetric flow states develop in an intermediate range of gap sizes, showing either steady or unsteady (*flip-flopping*) deflection of the gap flow. Similar behaviors have been described experimentally in the work of Williamson by means of flow visualizations [4].

The talk addresses the onset of these various flow instabilities within the parameter ranges $Re \leq 100$ and $0.1 \leq g \leq 3.0$ by means of numerical simulations. More precisely three main topics are discussed. First, the linear global stability of the symmetric base flow is revisited and new results concerning the structural sensitivity of the leading global modes are described, [5]. In addition, preliminary results related to the stability analysis of the steady asymmetric base flow are presented. Second, mode selection in the neighbourhood of a codimension-two bifurcation point is investigated by performing a *center manifold* reduction of the incompressible Navier-Stokes equations using a different approach with respect to that of multiple time-scales. Finally, a new bifurcation scenario describing the origin of the so-called flip-flopping behaviour is proposed and explained.

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