Giannetti, Flavio; **Luchini, Paolo**

Structural sensitivity of the first instability of the cylinder wake. (English) Zbl 1115.76028

J. Fluid Mech. 581, 167-197 (2007).

Summary: The stability properties of the flow past an infinitely long circular cylinder are studied in the context of linear theory. An immersed-boundary technique is used to represent the cylinder surface on a Cartesian mesh. The characteristics of both direct and adjoint perturbation modes are studied, and the regions of the flow more sensitive to momentum forcing and mass injection are identified. The analysis shows that the maximum of the perturbation envelope amplitude is reached far downstream of the separation bubble, whereas the highest receptivity is attained in the near wake of the cylinder, close to the body surface. The large difference between the spatial structure of the two-dimensional direct and adjoint modes suggests that the instability mechanism cannot be identified from the study of either eigenfunctions separately. For this reason a structural stability analysis of the problem is used to analyse the process which gives rise to the self-sustained mode. In particular, the region of maximum coupling among the velocity components is localized by inspecting the spatial distribution of the product between the direct and adjoint modes. Results show that the instability mechanism is located in two lobes placed symmetrically across the separation bubble, confirming the qualitative results obtained through a locally plane-wave analysis. The relevance of this novel technique to the development of effective control strategies for vortex shedding behind bluff bodies is illustrated by comparing the theoretical predictions based on the structural perturbation analysis with the experimental data of *P. J. Strykowski* and *K. R. Sreenivasan* [J. Fluid Mech. 218, 71–107 (1990)].

MSC:

76E09 Stability and instability of nonparallel flows in hydrodynamic stability

76D25 Wakes and jets

76M25 Other numerical methods (fluid mechanics) (MSC2010)

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linear theory; immersed-boundary technique; self-sustained mode

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