

Control design by stability analysis: an overview and a possible integration in reduced-order models

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A large number of research papers in the literature have been dedicated to the use of adjoint-based sensitivity and global stability analysis for both characterising and controlling instabilities in fluid mechanics. The control design strategy based on global stability analysis can be rigorously applied to flows in laminar regime showing self-sustained instabilities. However, there is a large interest in the application of the same methods for the control of turbulent flows characterized by dominant and coherent vortical structures as, for instance, the quasi-periodic shedding of vortices in turbulent wakes. This is possible by postulating the marginal stability of mean flows, which is a valid assumption for several cases of interest. Moreover, the mentioned methods are flexible as they can be applied directly to experimental measurements.

In the first part of this presentation, after having concisely introduced the methods, we will illustrate some examples of application to the analysis and control of complex flows. In this respect we will also show that the assumption of marginal stability of mean flow can be used to estimate several characteristics the flow, specifically for a turbulent wake. In the second part of this presentation we will outline a possible strategy to integrate results from stability and sensitivity analysis into Galerkin reduced-order models in order to improve their prediction capability for passive controls of self-sustained instabilities. We will present some results in this respect for a laminar flow manifesting a symmetry-breaking pitchfork bifurcation.