Global stability analysis of a three dimensional separated flow

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ABSTRACT

The linear stability analysis of a fully three-dimensional separated flow is investigated in this work. Recent advances in computational methods, such as the time-stepping methods, brought the global stability analysis of flows with nearly arbitrary complexity within reach of current computational technology. However, only a few global stability analyses of fully three-dimensional flows have been reported to date. The first one has been exposed by Tezuka and Suzuki (2006) [1] in the case of the flow around a spheroid. One may also refer to a more recent work by Bagheri et al. (2009) [2] where the authors investigated the global stability analysis of a jet in crossflow.

In this context, we analyze the linear flow dynamics over a $3D$ backward facing step at low Reynolds numbers. The $3D$ incompressible Navier-Stokes equations are linearized about a base flow chosen as a steady solution. Next, the linear dynamics of the flow is assessed. As a first step, we compute the global eigenmodes to investigate the ability of the flow to self-sustain perturbations. As a second step, the transient dynamics of the flow are examined by a receptivity analysis. In particular, we look for the optimal harmonic flow responses to all the possible harmonic forcings, as done by Monokrousos et al. (2010) [3], see figures 1 and 2. We conclude that our flow exhibits a substantial ability to amplify upstream perturbations. In particular, a broad-band of preferred frequencies is exposed. It should be mentioned that we did not use any time-stepping method in our work. A particularity of this work is that our numerical methods are based on direct inversions of large and sparse matrices.

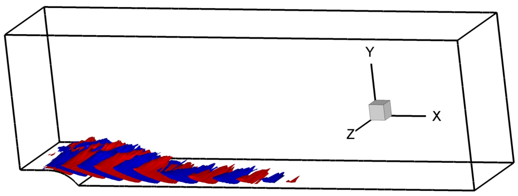

Figure 1. Streamwise velocity of an optimal harmonic forcing.

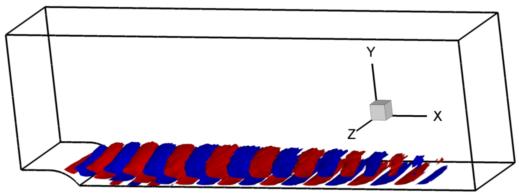

Figure 2. Streamwise velocity of its associated harmonic response.

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