Structural sensitivity calculated with a local stability analysis

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Giannetti and Luchini[1] calculate the structural sensitivity of the steady, but unstable, planar flow behind a cylinder at Re = 50. This reveals that the instability is driven by two regions of the flow, which are situated on either side of the recirculation bubble. This agrees well with the experimental data of Strykowski and Sreenivasan[2].

The structural sensitivity is obtained by combining two global modes of the flow. The first is the direct global mode, which is obtained by linearizing the Navier–Stokes equations and then calculating the most unstable 2D eigenfunction of that operator. The second is the adjoint global mode, which is obtained from the adjoint linearized Navier–Stokes equations via a second, similar, calculation.

In flows that evolve slowly, the direct global mode can be obtained with a local stability analysis[3], which is less computationally-expensive than calculating the 2D eigenfunction.

In this paper we show that, without further calculations, the local stability analysis also gives the adjoint global mode. In brief, the direct and adjoint global modes both have the same global frequency, the same wavemaker position and the same k^+ and k^- branches. The direct global mode is calculated from the k^- branch upstream of the wavemaker position and the k^+ branch downstream. We show that the adjoint global mode is calculated from the k^+ branch upstream and the k^- branch downstream. These global modes can then be combined, following the method of Giannetti and Luchini, to give the structural sensitivity of the flow.

We demonstrate this for the Ginzburg–Landau equation and for a slowly-evolving confined wake flow[4] at Re = 100. The structural sensitivity of the confined wake flow is shown in Figure 1.

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[1]Giannetti and Luchini, *J. Fluid Mech.* **581**, 167 (2007).

[2]Strykowski and Sreenivasan, *J. Fluid Mech.* **218**, 71 (1990).

[3]Huerre and Monkewitz, *Annu. Rev. Fluid Mech.* **22**, 473 (1990).

[4]The base flow was provided by Tammisola, Lundell and Södeberg, KTH, Sweden.

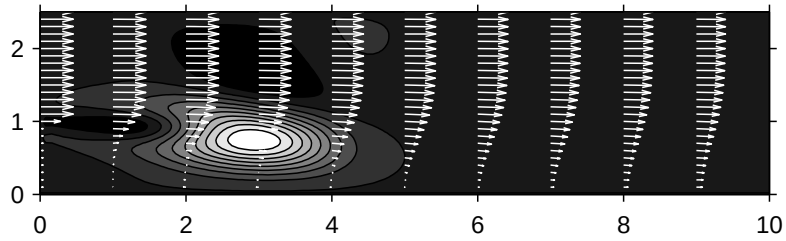

Figure 1: Arrows: velocity vectors of a confined wake flow at Re = 100. Contours: the structural sensitivity of this flow, calculated with a local stability analysis.