Global and Asymptotic stability analysis: the "inviscid" structural sensivitity field

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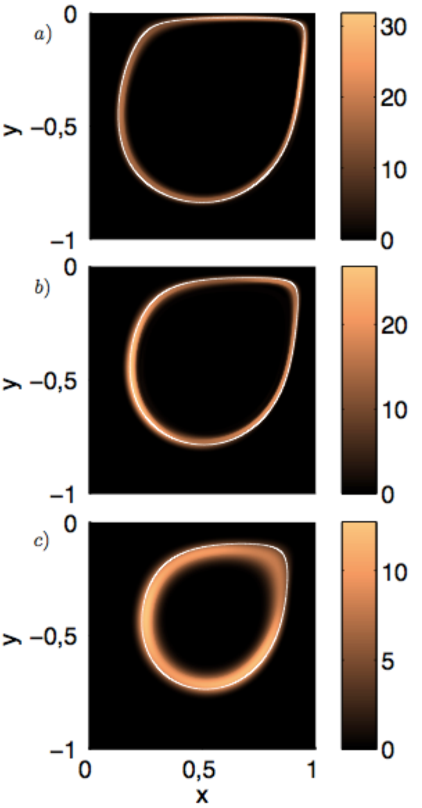

Figure A: Comparison between optimal streamlines of WKBJ eigenmodes (short-wave analysis) and inviscid structural sensitivity maps related to (Global) eigenvalues: a) 0.36 + i0.00; b) 0.14 + i0.20; c) 0.07 + i0.00. Parameter settings: Re{BaseFlow}=1370 (where the considered cavity flow first undergoes a pitchfork 3d bifurcation), Re{Stability} =300000 & k = 93.5 (spanwise wavenumber).

We present a numerical study of viscous and inviscid linear instability arising in incompressible flows past a square open cavity. The structural sensitivity analysis (introduced in Giannetti & Luchini 2007) localizes the wavemaker inside the cavity, concentrated around a closed orbit. The spatial distribution of this field suggests the possibility to use a local theory to describe the evolution of the instability and provide a more quantitative evidence for the mechanism from which arises. An appealing approach in this context is offered by the short-wavelength approximation (WKBJ) developed by Bayly 1988. Three different branches are identified by this local analysis. The streamline related to the maximum inviscid growth rate is found to be the same around which the structural sensitivity field is concentrated. We associate at each WKBJ mode different frequencies related to the possible resonances occurring on the same streamlines. The eigen-frequencies of these harmonics, computed by global stability analysis, are in very good agreement with the asymptotic results. Furthermore, we show that the 'inviscid' structural sensitivity map (i.e. the structural sensitivity field based on direct and adjoint eigenmodes computed at a higher Reynolds number than the base flow) can predict each critical orbit that provides the main contribution to the propagation of the three WKBJ instabilities. We observe that each critical WKBJ orbit presents a corresponding concentrated inviscid structural sensitivity spatial map (see Figure A).

Giannetti, F. & Luchini, P. 2007 Structural sensitivity of the first instability of the cylinder wake. J. Fluid Mech. 581, 167–197.

Bayly, B. J. 1988 Three-dimensional centrifugal-type instabilities in inviscid two-dimensional flows. Phys. Fluids 31, 56–64.

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