



## ON THE OPTIMAL RESPONSE OF Q-VORTEX

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Wingtip vortices represent a hazard for the stability of the following airplane in airport highways. These flows have been usually modeled as swirling jets/wakes, which are known to be highly unstable and susceptible to breakdown at high Reynolds numbers for certain flow conditions, but different to the ones present in real flying airplanes. A very recent study [1] based on Direct Numerical Simulations (DNS) shows that a large variety of helical responses can be excited and amplified when a harmonic inlet forcing is imposed.

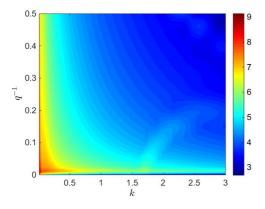
In this work, the optimal response of *q*-vortex (both axial vorticity and axial velocity can be modeled by a Gaussian profile) is studied by considering the time-harmonically forced problem with a certain frequency  $\omega$ . We first reproduce Guo and Sun's results [2] for the Lamb-Oseen vortex (no axial flow) to validate our numerical code. In the axisymmetric case m = 0, the system response is the largest when the input frequency is null. The axial flow has a weak influence in the response for any axial velocity intensity. We also consider helical perturbations |m| = 1. These perturbations are excited through a resonance mechanism at moderate and large wavelengths as it is shown in Figure 1. In addition, Figure 2 shows that the frequency at which the optimal gain is obtained is not a continuous function of the axial flow, the unstable response is the largest when the axial velocity intensity, 1/q, is near to zero. For perturbations with higher azimuthal wavenumbers |m| > 1, the magnitudes of the response are smaller than those for helical modes. In order to establish an alternative validation, DNS has been carried out by using a pseudospectral Fourier formulation [3] finding a very good agreement.

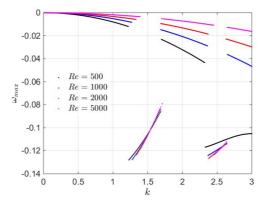
## References

[1] Guo, Z.-W., Sun, D.-J., Optimal response in the Lamb–Oseen vortex. *Physics Letters A* **375** (36) 3191–3195 (2011).

[2] Viola, F., Arratia, C., Gallaire, F., Mode selection in trailing vortices: harmonic response of the non-parallel Batchelor vortex. *Journal of Fluid Mechanics* **790**, 523–552 (2016).

[3] Delbende, I., Chomaz, J.-M., Huerre, P., Absolute/convective instabilities in the Batchelor vortex: a numerical study of the linear impulse response. *Journal of Fluid Mechanics* **355**, 229–254 (1998).





Maximum gain response (decimal logarithm) Rmax(k, 1/q) obtained at m=1 for Reynolds number Re=5000.

Frequency  $\omega$  at which the maximum response is obtained at m=1 and 1/q=0.