

ON THE OPTIMAL RESPONSE OF Q-VORTEX

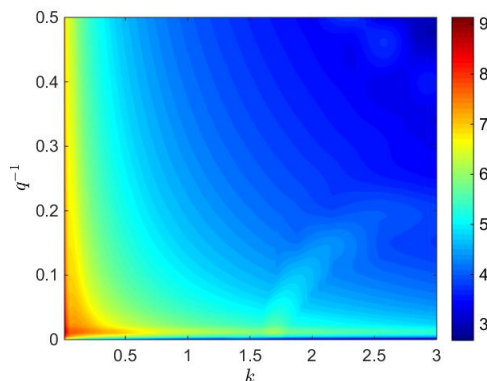
JESUS O. RODRIGUEZ-GARCIA (MECHANICAL ENGINEERING, THERMAL AND FLUIDS, UNIVERSITY OF MALAGA); FRANCISCO J. BLANCO-RODRIGUEZ (MECHANICS, UNIVERSITY OF CORDOBA); LUIS PARRAS (MECHANICAL ENGINEERING, THERMAL AND FLUIDS, UNIVERSITY OF MALAGA); CARLOS DEL PINO (MECHANICAL ENGINEERING, THERMAL AND FLUIDS, UNIVERSITY OF MALAGA)

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.

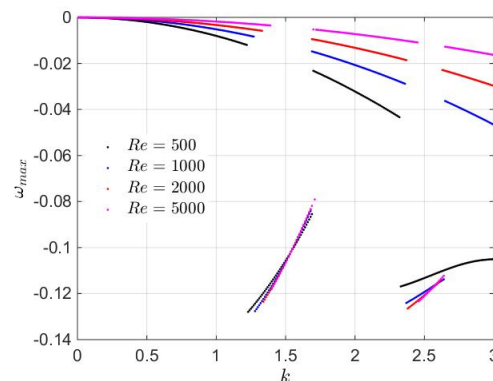
In this work, the optimal response of q -vortex (both axial vorticity and axial velocity can be modeled by a Gaussian profile) is studied by considering the time-harmonically forced problem with a certain frequency ω . We first reproduce Guo and Sun's results [2] for the Lamb-Oseen vortex (no axial flow) 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 wavenumber k . At smaller wavelengths, large response is excited by steady forcing. Regarding 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) $R_{\max}(k, 1/q)$ obtained at $m=1$ for Reynolds number $Re=5000$.



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