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 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

