NONLINEAR EVOLUTION OF HARMONICALLY FORCED PERTURBATIONS ON A WINGTIP VORTEX.

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Wingtip vortices are created by flying airplanes due to lift generation. The vortex interaction with the trailing aircraft has sparked researchers' interest to develop an efficient technique to destroy these vortices. Different models have been used to describe the vortex dynamics and they all show that, under real flight conditions, the most unstable modes produce a very weak amplification. Another linear instability mechanism that can produce high energy gains in short times is due to the non-normality of the system [1]. Recently, it has been shown that these non-normal perturbations also produce this energy growth when they are excited with harmonic forcing functions [2].

In this study, we analyze numerically the nonlinear evolution of a spatially, pointwise and temporally forced perturbation, generated by a synthetic jet at a given radial distance from the vortex core. This type of perturbation is able to produce high energy gains in the perturbed base flow (10^3), and is also a suitable candidate for use in engineering applications. The flow field is solved for using fully nonlinear three-dimensional direct numerical simulation with a spectral multidomain penalty method model. Our novel results show that the nonlinear effects are able to produce locally small bursts of instability that reduce the intensity of the primary vortex.

[1] A Antkowiak, P Brancher. Transient energy growth for the Lamb–Oseen vortex. Phys. Fluids 16 (1), L1-L4 (2004).
[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).