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TWO-DIMENSIONAL INSTABILITIES OF A VISCOUS VORTEX DIPOLE

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Abstract Vortex dipole, vortex pair, Lamb–Oseen vortex, linear stability.

We extend the linear stability analysis of the inviscid Lamb–Chaplygin dipole (LCD) carried out by Brion *et al.* [1] to a family of viscous Lamb–Oseen dipoles (LOD) for varying aspect ratios a/b , where a is the characteristic radius of the vortices and b their separation distance.

Brion *et al.* have recently discovered a new family of modes which correspond to a large-wavelength instability with a maximum growth rate in the two-dimensional (2D) limit. Their study suggests that vortex shedding in the wake of the dipole is the leading physical mechanism of those instabilities. Though the LCD is a peculiar model of vortex dipole, since it does not exhibit a viscous trail and presents a singular vorticity distribution, Brion *et al.* compared their results with the more regular LOD defined by Sipp *et al.* [2] and confirmed the existence of a 2D instability of vortex dipoles.

Despite a similar structure, the instability of the LOD presents an oscillating symmetric mode and growth rates that are significantly different than the LCD. The present study investigates these differences by looking at the influence of the dipole aspect ratio on the characteristics of the unstable 2D modes. The results show that the growth rate of both antisymmetric and symmetric modes presents some nontrivial variations with a/b and Re (fig. 1): it increases with decreasing Reynolds number and a stationary antisymmetric branch emerges for low aspect ratios. The analysis of the time evolution of the modes allows to highlight the basic mechanisms at play.

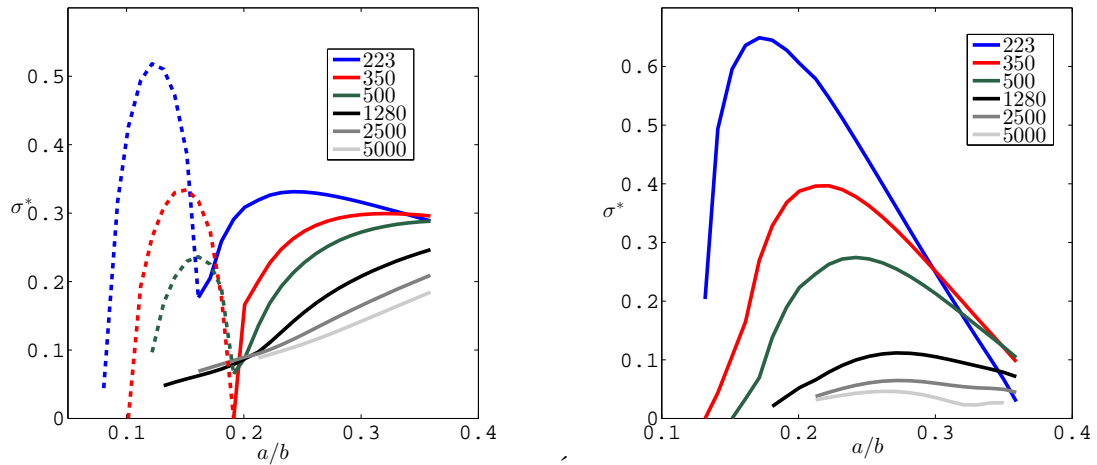


Figure 1: Growth rates normalized by dipole advection time as a function of the dipole aspect ratio a/b for different Reynolds numbers Re : oscillating antisymmetric modes (left) – the dashed lines represent the stationary antisymmetric modes – and stationary symmetric modes (right).

References

- [1] V. Brion, D. Sipp & L. Jacquin *Linear dynamics of the Lamb–Chaplygin dipole in the two-dimensional limit* (2014), *Phys. Fluid.* **26** (6), 064103.
- [2] D. Sipp, L. Jacquin & C. Cossu *Self-adaptation and viscous selection in concentrated two-dimensional vortex dipoles* (2000), *Phys. Fluid.* **12** (2), 245–248.