INTERNSHIP PROPOSAL

Instability of helical vortices, application to a turbine wake

ADVISORS

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TOPIC

Type : Numerics.
Keywords : vortex, helical symmetry, instability.
Technical pre-requisites : Basilisk, Unix, FORTRAN.

LOCATION

Institut Jean le Rond ∂'Alembert
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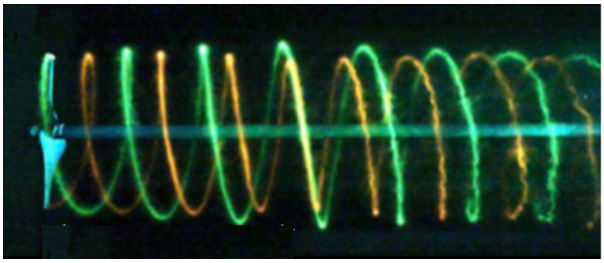

Instabilities in a two-helical-vortex system [1].

CONTEXT

While wind energy is developing at a sustained rate, there is a need for detailed studies on the influence of rotating machines on their downstream environment. If engineering rules exist to estimate velocity deficit and wake recovery, very few studies are devoted to investigate the nature of the transition that occurs in helical vortex systems generated by rotors [2]. The main reason is the complexity of the helical geometry, and the huge range of length scales at play, from the rotor diameter down to the small-scale deterministic instability structures inside vortex cores. Instability codes based on three-dimensional flow solvers can be used occasionally [3], but systematic studies are out of reach due to lengthy computations. Yet, determining the fine mechanisms of transition is necessary to elaborate strategies towards wake control. The present work is a fundamental yet useful step towards the characterization of instabilities growing in such flows.

CONTENT

The work will be devided in two parts. The first part will consist in studying how various linear instabilities of a helical vortex are modified when varying flow parameters, mainly helical pitch and internal flow intensity in the vortex core. This will be done using an existing numerical code implementing the resolution of the Navier–Stokes equations linearized in the vicinity of a flow with helical symmetry [4]. The case of a turbine wake will also be investigated, where the base flow is made of three interlaced tip vortices and a central counter-rotating vortex (the hub vortex). The second part will consist in simulating the growth dynamics of the above instability modes into the nonlinear regime, using the Basilisk solver [5].

During this internship, we propose
a) to read the bibliography pertinent to helical symmetry as well as instability studies of helical vortices
b) to run the linear simulations and classify the dominant types of instability in the parametric space
c) to set up initial and boundary conditions in the Basilisk flow solver to perfom the nonlinear simulations.

CANDIDATES

Candidates should have an interest in DNS and stability theory.

A PhD thesis may be proposed after the Internship on this subject or a related one.

[1] Abraham, A., Castillo-Castellanos, A. and Leweke, T. 2023 Simplified model for helical vortex dynamics in the wake of an asymmetric rotor. *Flow* **3**, E5.
[2] Ivanell, S., Mikkelsen, R., Sørensen, J.N., Henningson, D. 2010 Stability analysis of the tip vortices of a wind turbine. *Wind Energy* **13**(8), 705.
[3] Brynjell-Rahkola, M., Henningson, D.S. 2020 Numerical realization of helical vortices : application to vortex instability. *Theor. Comp. Fluid Dynam.* **34**, 1.
[4] Delbende, I., Rossi, M. and Daube, O. 2012 DNS of flows with helical symmetry. *Theor. Comp. Fluid Dynam.* **26**(1), 141.
[5] Popinet, S. 2009 An accurate adaptive solver for surface-tension-driven interfacial flows. *J. Comput. Phys.* **228**, 5838.