PROPOSITION DE STAGE – MASTER 2 DET

Dynamique des fluides, Energétique et transferts
Université Toulouse 3 Paul Sabatier - Toulouse INP - INSA Toulouse - ISAE SUPAERO – IMT Mines Albi

Titre: Study of the linear stability of vortex induced vibrations of multiple freely oscillating bodies

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Lieu de stage: Institut de Mécanique des Fluides de Toulouse (IMFT)

Durée / période: 6 mois

Candidature [CV, lettre de motivation, notes et classement, références] à envoyer à : Théo Mouyen, theo.mouyen@imft.fr

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Sujet

One of the recent interests in the field of fluid structure interactions is the harvest of energy from submerged structures that are either moving or deforming. For instance, the VIVACE project ([1]) proposes the extraction of energy from marine currents at low speeds using arrays of spring mounted cylinders.

The case of a single oscillating cylinder has received considerable attention (see [4]). However, the analysis of the physical mechanisms behind the fluid-structure instabilities of multiple interacting bodies remains vastly unexplored. For this purpose, we have developed a Linearised Arbitrary Lagrangian Eulerian (L-ALE) method as well as an impedance-based stability criterion to investigate the dynamics of multiple freely-oscillating cylinders. The L-ALE method rationalises the Eulerian motion of the flow with the Lagrangian displacement of the fluid-solid interface. The motion y_n of the n-th cylinder in the transversal direction is governed by the following equation

$$\ddot{y}_n + \frac{4\pi\gamma_n}{U_n^*}\dot{y}_n + \left(\frac{2\pi}{U_n^*}\right)^2 y_n = \frac{2C_{y_n}(t)}{\pi m_n^*} \text{ for } n = 1, \dots, N \quad (1)$$

where U_n^* is the reduced velocity, $C_{y_n}(t)$ is the vertical force coefficient and m_n^* the mass ratio between the cylinder and fluid densities.

Figure 1 shows the vorticity field of the leading eigenmodes for a tandem of cylinders with a spacing of $L/D = 1.5$ and a reduced mass of $m^* = 2.5$ at $Re = 60$. An exhaustive parametric study for the tandem configuration is already ongoing.

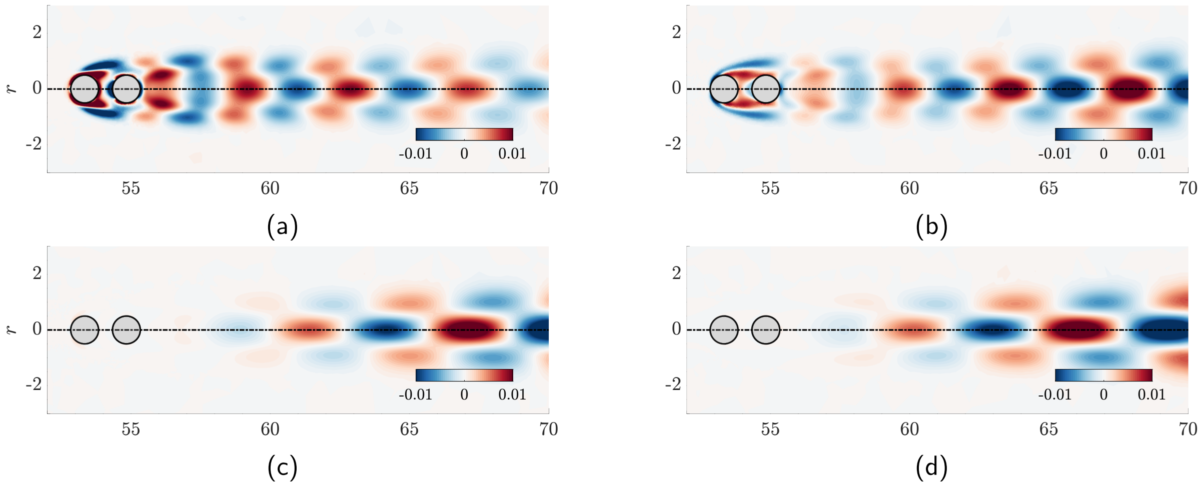

Figure 1: Vorticity of the two leading modes at $Re = 100$ and $U^* = 6$ for a reduced mass of $m^* = 2.546$ (a,c) and of $m^* = 20$ (b,d): FEMI (a,b), FEMII (c,d).

The goal of this internship is double. First, the intern will use of the current methods to explore the stability of another 2-body configuration called the "side-by-side" configuration (studied for fixed bodies by [2]). Secondly, the intern will implement the torsional moment equation in the existing code in order to investigate the stability of pitching plates/foils [3].

Requirements Intermediate programming skills, knowledge numerical analysis, fluid dynamics and computational fluid dynamics (CFD) are appreciated. A good knowledge of the `Matlab` programming language is required and prior knowledge of `FreeFEM++` is highly appreciated. A good mastery of the English language is essential.

References

[1] M. M. Bernitsas, K. Raghavan, Y. Ben-Simon, and E. Garcia. Vivace (vortex induced vibration aquatic clean energy): A new concept in generation of clean and renewable energy from fluid flow. *Journal of offshore mechanics and Arctic engineering*, 130(4), 2008.

[2] M. Carini, F. Giannetti, and F. Auteri. First instability and structural sensitivity of the flow past two side-by-side cylinders. *Journal of fluid mechanics*, 749:627–648, 2014.

[3] P. Negi, A. Hanifi, and D. S. Henningson. On the onset of aeroelastic pitch-oscillations of a naca0012 wing at transitional reynolds numbers. *Journal of Fluids and Structures*, 105:103344, 2021.

[4] C. H. Williamson, R. Govardhan, et al. Vortex-induced vibrations. *Annual review of fluid mechanics*, 36(1):413–455, 2004.