High fidelity simulation of vortex induced vibrations for flow control and energy harvesting

Oriol Lehmkuhl[1], Daniel Pastrana[2], Juan Carlos Cajas[3], Ivette Rodríguez[4] and Guillaume Houzeaux[5]

Geophysical flows from wind to oceanic currents represent a clean source of energy widely available. Structures based on vortex-induced vibrations are one of the mechanisms for harvesting part of this energy in the range of frequencies where flow-induced vibrations originate a strong coupling between the oscillating body and the fluctuating wake. In the VIVALdI PRACE project, high fidelity simulations of a cylindrical body oscillating in a free-stream from sub-critical to super-critical Reynolds number have been carried out for first time by means of wall-resolved LES using thousands of CPUs. The work aims at shedding light in the interactions of the cylinder with the fluid and specially with the boundary layer, but also the characterisation of the wake topology. We have focus on study the influence of the Reynolds number and the range of frequencies in which vortex induced vibrations reinforce the aerodynamic forces on the cylinder. In addition to this, for the cases corresponding to the critical and supercritical Reynolds numbers were the wake width is reduced as a consequence of the instabilities in the boundary layer, localised roughness is added to the cylinder surface in the location where boundary layer is forced to separate from the cylinder so as to passively control flow separation and transition to turbulence to widen the wake. The main idea behind the use of these passive devices is to maximise the ratio of the amplitude of oscillations to the cylinder diameter (A/D). This is the first time this kind of simulations have been performed at this level of modelisation, being a step forward in the understanding of the physics of fluid-structure interaction in the range of industrial applications. The talk will summarise the main conclusions of VIVALdI project, showcasing the principal observations and results obtained. Finally, future directions to further research and the application of the technology to real world devices will be discussed.

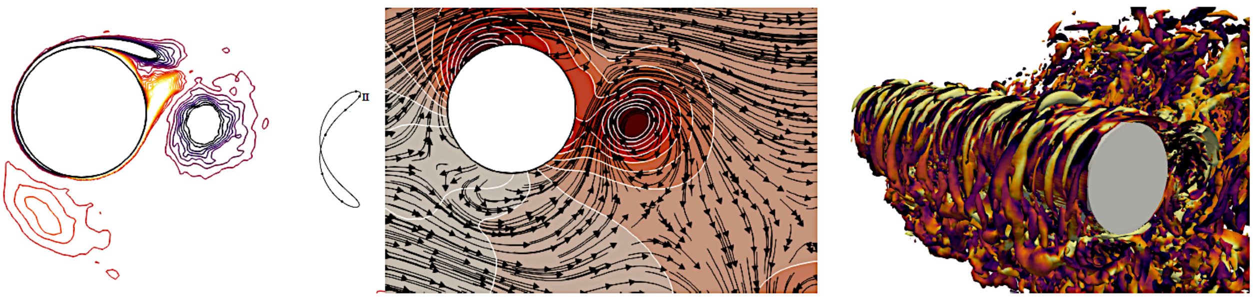

Figure 1. Span-phase-average iso-contours of span-wise vorticity at sub-critical regime and U* = 5.5 (left column) and pressure (center column). Instantaneous flow visualisation by means of Q = 3.0 iso-surfaces coloured by stream wise vorticity (right column).

[1] Barcelona Supercomputing Center, oriol.lehmkuhl@bsc.es

[2] Barcelona Supercomputing Center, daniel.pastrana@bsc.es

[3] Universidad Nacional Autónoma de México, carlos.cajas@enesmerida.unam.mx

[4] Universitat Politecnica de Catalunya, ivette.rodriguez@upc.edu

[5] Barcelona Supercomputing Center, guillaume.houzeaux@bsc.es