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LARGE-EDDY SIMULATION AND EVALUATION OF THE TURBULENT FLUID-STRUCTURE INTERACTION BENCHMARK FSI-PFS-2A

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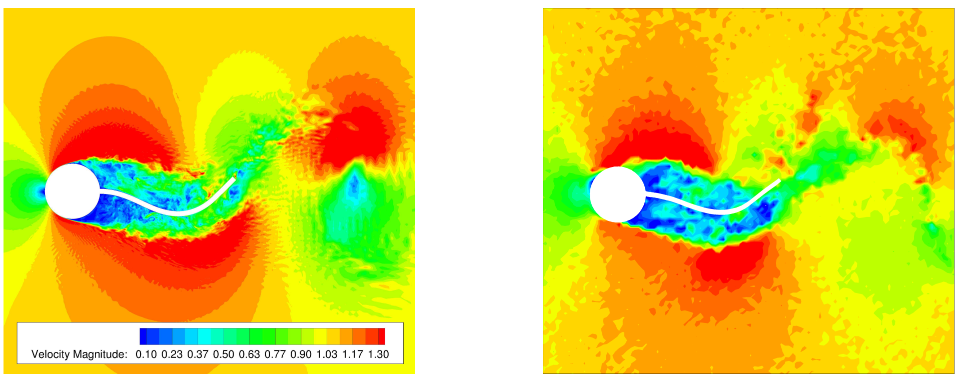
Fluid-structure interactions (FSI) are induced by the coupling between an unsteady fluid flow and the motion or deformation of a structure. Technical applications are numerous such as heart valves, wind turbines or lightweight tents to mention only a few. Due to enhanced numerical algorithms and the strong increase of the computational power in the last decades, it is now feasible to simulate multi-physics real-world problems and, consequently, to support engineers during the design or optimization process. For this purpose a variety of numerical models (e.g. [1]) are currently developed to predict different FSI applications. To evaluate and improve these complex non-linear computations, experimental studies with reliable reference data are highly necessary. Therefore, several experimental test cases were recently developed at PfS Hamburg:

- FSI-PfS-1a [2] consists of a fixed rigid cylinder with a flexible rubber plate clamped at the backside. This geometrical setup is exposed to a constant flow at Re = 30,470 which is in the subcritical regime. The flexible structure deforms in the first swiveling mode and the deflections are small and quasi-2D.
- FSI-PfS-2a [3] is the logical development of FSI-PfS-1a. The geometrical setup is very similar, but a rear mass is attached behind the flexible plate. The flow regime is identical. Due to this geometrical modification the flexible structure deforms in the second swiveling mode and the deflections are larger than for FSI-PfS-1a and fully 2D (see Fig. 1(b)).

A complementary experimental and numerical investigation has been presented for FSI-PfS-1a in [2]. The goal of the current contribution is to present the study carried out for FSI-PfS-2a. The simulations carried out for FSI-PfS-2a (see Fig. 1(a)) are performed with the same framework as for FSI-PfS-1a, i.e., a partitioned semi-implicit coupling procedure especially developed for the prediction of membranous or shell structures in turbulent flows [1]. In order to correctly capture turbulent structures in the flow an eddy-resolving scheme, i.e., the Large-Eddy Simulation (LES), is used in the CFD solver FASTEST-3D. To reach a high order of accuracy and to minimize the CPU-time the structure is modeled by a dedicated CSD solver Carat++ [4]. Both solvers are coupled by a third program, CoMA, which is responsible for the mapping and data exchanges in both directions.

To compare the numerical results with experimental data, an averaging process described in [2] is necessary to filter out the turbulent fluctuations visible in the numerical as well as in the experimental data (see Fig. 1). As in the experiment the computations show a quasi-periodic deformation behavior in the second swiveling mode. Therefore, a phase-averaging procedure on the results makes sense and allows a detailed comparison of the flow and the structure deflection between the simulations and the measurements.



(a) Numerical results

(b) Experimental results [3]

Figure 1: Instantaneous velocity magnitude in a turbulent flow: LES predictions and PIV measurements.

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