A LBM/IBM/FEM coupled method for FSI Simulation on high Reynolds turbulent flow

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The Lattice-Boltzmann Method (LBM) has attracted a high interest over the last decade because of the simplicity of its numerical implementation combined with the use of cartesian grid and good numerical performances in parallel architectures. In this work, we couple the LBM with the Immersed Boundary Method (IBM) to simulate moving and deformable bodies in fluid flows. We use the Finite Element Method (FEM) to compute the deformation of the immersed structures, for the simulation of two-way fluid structure interactions.

The use of LBM for High Reynolds turbulent and/or compressible flow is still a challenging topic, mainly because of robustness/stability issues. We propose a coupled software using ProLB for the LBM/IBM simulation (with a shear-improved Smagorinsky LES model for the turbulent part) combined with the Nastran Software for the FEM simulation. The coupling task is operated by the CSsim Software. The development of this coupled software is part of the European Falcon project (https://falconproject.eu/) which aims to simulate fluid-structure interaction phenomena on wings and aeronautical structures in realistic conditions. Here, we present results on several academic test cases: the flow around a fixed and moving cylinder, as well as the Hron&Turek[1] test cases for low and high Reynolds flow. Finally, a high-scale 3D case of a flexible thin plate in a turbulent flow shows promising results for the study of a deformable wing in a high velocity flow.

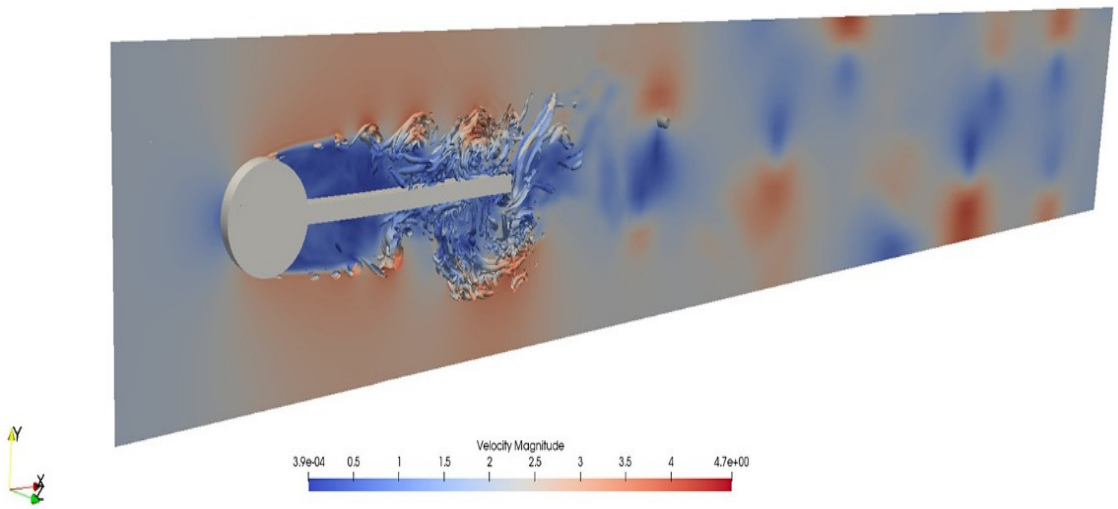

Figure 1: Hron&Turek Test case from references[2],

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1Hron&Turek, *Lecture Notes in Computational Science and Engineering* **Volume 53, pages 371–385**, (2006) (https://doi.org/10.1007/3-540-34596-5_15)
2Cheylan et al., *Journal of Computational Physics* **Volume 492**, (2023) (https://doi.org/10.1016/j.jcp.2023.112418)