The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

A multigrid Immersed Boundary Method for the CFD Solver Horses3D

Stefano Colombo[1,2]*, Esteban Ferrer[1,2], and Eusebio Valero[1,2]

[1] ETSIAE-UPM - School of Aeronautics, Universidad Politécnica de Madrid. Plaza Cardenal Cisneros 3, E-28040 Madrid, Spain

[2] Center for Computational Simulation, Universidad Politécnica de Madrid, Campus de Montegancedo, Boadilla del Monte, 28660, Madrid, Spain

One of the main bottleneck in high order simulations is the generation of high order meshes. The Immersed Boundary Method (IBM) [1] is a promising approach for overcoming such problem, indeed it allows to deal with complex geometries not requiring curved meshes. The IBM is handle through the volume penalization approach which consists in the application of a source term to the Navier-Stokes equations [2, 3]. The source term is applied on points lying inside the body that are identified thanks to a mask generated with a ray-tracing technique. The latter procedure can be easily automatized providing a fast and effective tool to get a solution starting from a CAD geometry. Moreover, IBM can be coupled with hp-refinement in the high order framework making it attractive for industrial applications.

In the present work we implement a volume penalization IBM for 3-dimensional simulation for the Horses3D solver [5]. Exploiting the capability of Horses3D, we have coupled the IBM with a multigrid method [4] in the Discontinuous Spectral Galerkin framework. Numerical experiments with different geometries are presented in order to validate the results obtained with Horses3D.

Keywords: *Immersed Boundary Method, Volume Penalization, Multigrid, Horses3D, Discontinuous Spectral Galerkin Methods*

REFERENCES

[1] R. Mittal and G. Iaccarino, Immersed Boundary Methods, *Annual Review of Fluid Mechanics*, Vol. **37**, pp. 239-261, 2005.

[2] J. Kou, S. Joshi, A. Hurtado-de-Mendoza, K. Puri, C. Hirsch, E. Ferrer, Immersed boundary method for high-order flux reconstruction based on volume penalization, *Journal of Computational Physics*, Vol. 448, 110721, 2022.

[3] J. Kou, A. Hurtado-de-Mendoza, S. Joshi, S. Le Clainche, E. Ferrer, Eigensolution analysis of immersed boundary method based on volume penalization: Applications to high-order schemes, *Journal of Computational Physics*, Vol. 449, 110817, 2022.

[4] A. Brandt and Oren E. Livne, Multigrid Techniques: 1984 Guide with Applications to Fluid Dynamics, Revised Edition, *SIAM*, 2011.

[5] Andrés M. Rueda-Ramírez, J. Manzanero, E. Ferrer, G. Rubio, E. Valero, A p-multigrid strategy with anisotropic p-adaptation based on truncation errors for high-order discontinuous Galerkin methods, *Journal of Computational Physics*, Vol. 378, pp 209-233, 2019. https://numath.dmae.upm.es/tools/horses3d/