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

Immersed boundaries in hypersonic flows with considerations about high-fidelity and massive parallelism

Florent Nauleau[1], Thibault Bridel-Bertomeu[2], Héloïse Beaugendre[3] and Fabien Vivodtzev[4]

[1] CEA-CESTA, Le Barp, France, florent.nauleau@cea.fr
[2]CEA-CESTA, Le Barp, France, thibault.bridel-bertomeu@cea.fr
[3] Université de Bordeaux - Bordeaux, France, heloise.beaugendre@math.u-bordeaux.fr
[4] CEA-CESTA, Le Barp, France, fabien.vivodtzev@cea.fr

Keywords: *Hypersonics, Immersed Boundary Method, High Order Reconstruction, Large Eddy Simulation*

In this presentation, we first discuss a new reconstruction method for sharp immersed boundaries within a strongly compressible viscous flow prone to discontinuities [1]. The technique we exhibit is based on a weighted least-square reconstruction, and relies on an ENO-like construction to stay mathematically consistent even in the presence of strong discontinuities.

As for any least-square-based reconstruction, it can be shown empirically that the number of neighbors used in the reconstruction is directly related to the condition number of the least-square matrix. An optimum number of neighbors is then reached when the condition number reaches its asymptotic value as the number of neighbors increases. In three-dimensional configurations it is found that the number of neighbors has to be quite high to ensure the stability of the least-square problem inversion. It causes obvious issues with MPI communications since handling large enough halos to cover for such large stencils is non-realistic. We therefore introduce an algorithm designed for a hybrid MPI/OpenMP environment and based on migrable tasks and on the consensus algorithm developed by Francez *et al.* [2] that can be used to remedy the former shortcoming.

Finally, we discuss the premises of the implementation of high-fidelity subgrid models that are to work in conjunction with the immersed boundary algorithms. In this prospective part of the work, we discuss the feasability of embedding turbulent wall laws into the aforementioned immersed boundary reconstruction algorithm to try and counteract the low accuracy due to non-body-fitted meshes.

REFERENCES

[1] Bridel-Bertomeu, T. Immersed boundary conditions for hypersonic flows using ENO-like least-square reconstruction. *Computers & Fluids*, 2021, **215**.

[2] Francez, N., & Rodeh, M. Achieving distributed termination without freezing. *IEEE Transactions on Software Engineering*, 1982, **3**, 287-292.