An Immersed Boundary Lattice Green's Function method for External Flows

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ABSTRACT

We present a novel numerical framework, the immersed boundary lattice Green's function (IBLGF) method [1], to solve incompressible flows on unbounded domains. The IBLGF method employs a highly scalable immersed boundary method in conjunction with an adaptive block refinement approach that limits the computational domain to vortical regions that dominate the flow evolution e.g. in proximity to the immersed body surface and in its wake, as depicted in figure (1). This advantageous feature is obtained thanks to the use of lattice Green's functions (LGFs) to determine solutions to the Poisson-like problems arising in the discretisation of the incompressible Navier-Stokes equations. The LGF is a discrete operator that is equivalent to the continuous Green's function, which implicitly incorporates the correct farfield boundary conditions, thereby removing the need for artificial boundary conditions that are a common source of errors in traditional computational fluid dynamics (CFD) codes. The method is particularly efficient for large scale computations, as it makes use of a recently formulated kernel-independent, interpolation-based fast multipole method (FMM). In addition, the IBLGF method uses a second-order finite volume scheme on a staggered Cartesian mesh. This provides crucial topological, mimetic and conservation properties that allow the correct discrete representation of the physical problem. In this talk, we give a brief overview of the IBLGF framework and we present its main capabilities by showing some practical external flow examples that are common in aerodynamic applications. We also highlight how this method, in conjunction with a Large-Eddy Simulation (LES) model and adaptive mesh refinement (AMR), can provide an excellent framework for high Reynolds number flows, thus overcoming one of the main limitations of immersed boundary-based approaches.

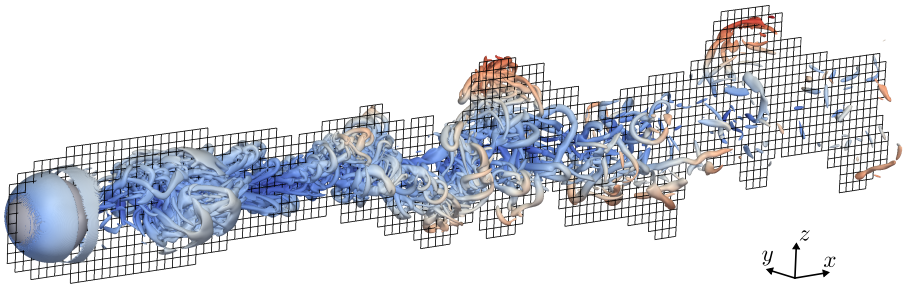

Figure 1: Incompressible flow past a sphere at Re = 3700. Iso-surfaces of constant Q-criterion and underlying adaptive block refinement.

REFERENCES

[1] Liska, S., and Colonius T. A fast immersed boundary method for external incompressible viscous flows using lattice Green's functions. *arXiv preprint arXiv*: 1604.01814 (2016).