An extension of the immersed boundary method based on the distributed Lagrange multiplier approach: Theory and applications

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We present an extended immersed boundary methodology utilizing a semi-implicit direct forcing approach developed for the simulation of incompressible flows in the presence of periodically moving immersed bodies. The methodology utilizes a Schur complement approach to enforce the kinematic constraints of no-slip for immersed surfaces. The methodology is split into a pre-computing stage and a time integration stage, both of which take advantage of the general parallel file system (GPFS) for efficient writing and reading of large amounts of data.

The method accurately meets the no-slip kinematic constraints on the surfaces of immersed oscillating bodies. The developed methodology was extensively verified by applying it for the simulation of a number of representative natural convection flows in the presence of stationary immersed bodies of spherical and cylindrical geometries as well as for the isothermal flows developing in the presence of oscillating spheres. The physical characteristics of the generated flows in terms of the time evolutions of the total drag coefficient and the torque are presented as a function of Grashof and Reynolds values. The vortical structures inherent in the generated flows are visualized by presenting the isosurfaces of the λ_2 criterion.