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DNS of a small particle in 3D flow

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ABSTRACT

The dynamics of rigid body particles in fluid flow are of a great interest in many fields of research and applied sciences. The direct numerical simulation of such flows for the three-dimensional case is still a challenging task. The situation is even more challenging for particle which size is several order of magnitude smaller than the size of the physical domain. The mesh resolution requirements make this kind of simulation very demanding in term of computer resources. In some situations, however, the motion of a very small particle will modify the flow field solely in the vicinity of the particle, and most of the flow in the physical domain is unaffected by the presence of the particle.

To take advantage of this, we use two computational domains. On the one hand the physical domain, referred to as the global domain, in which the flow is solved without the particle. This global flow solution is assumed to be time independent, then it has to be solved once, on a relatively coarse mesh, at a pre-processing step. On the other hand, a smaller domain is used to compute the local flow field around the particle. The position of the particle is fixed in this local domain which moves with the particle. The initial conditions are interpolated from the global domain into the local one, as well as the boundary conditions at each time step. Special care has to be taken for them to satisfy the mass conservation. For some situations, in addition to Dirichlet conditions, an outflow condition can be used on a part of the local domain boundary, thus fulfilling this requirement. But in general, Dirichlet conditions have to be used on the entire local domain boundary, and because of interpolation errors the mass conservation constraint is not guaranteed to be satisfied. To overcome this problem, the normal component of the interpolated velocity is corrected so that the net flow rate over the local domain surface is

zero. When the particle is close to the boundary of the global domain, part of the local domain may get out of the global domain. In that case, the velocity at the local nodes which are outside is imposed to be zero.

The code developed in [1] has been modified for this purpose. It is based on a finite element method with a fictitious domain formulation. Simulations are performed for different physical situations such as sedimentation and motion in shear flows. These results are compared to the results of [2].

REFERENCES

[1] C. Veeramani and P. D. Minev and K. Nandakumar. “A fictitious domain formulation for flows with rigid particles: A non-Lagrange multiplier version”. *Journal of Computational Physics*, Vol. **224**, 867-879, 2007.

[2] A. Carlsson and F. Lundell and L. D. Sderberg. “Fiber Orientation Control Related to Papermaking”. *J. Fluids Eng.*, Vol. **129**, 457-465, 2007.