Splitting methods for direct simulation of multiphase flows

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Abstract

The talk will be devoted on some aspects of the discretization of the incompressible Navier- Stokes equations for flows with fluid (drops and bubbles) or solid particles.

For simulation of particulate flows we present a development of the fictitious domain method for fluid-structure interaction problems which avoids the need to use Lagrange multipliers for imposition of the rigid body motion. Instead, it resolves the interaction force between the two phases explicitly. As a result, the end-of-step fluid velocity is a solution of an integral equation. The most straightforward way to resolve it is via an iteration although a direct approach is also possible. The method is implemented in parallel using the PetSc library and allows for trully large-scale computation of particulate flows. Its capabilities will be demonstrated on a wide range of flows involving rigid bodies of various shapes.

For the simulation of flows containing fluid particles we shall present a method which locally adapts the grid around the boundary but does not change the connectivity of the grid. It can be considered as an ALE scheme because at each time step we align the free boundary with finite element faces. On the other hand, the structure of the grid remains unchanged. The algorithm uses a fixed background grid, but at each time step it finds the closest to the free boundary grid points and projects them onto the boundary without changing the structure

of the grid. Of course it requires recomputation of part of the matrices, but their structure remains unchanged (this recomputation is unavoidable if an optimal approximation is to be achieved). The time discretization is done by means of a velocity correction scheme which utilizes non-conforming elements for the projection step. The mass conservation is guaranteed by means of one Lagrange multiplier per each distributed phase which imposes the condition that the mass of this phase is preserved. The method is validated on a wide range of free boundary problems