A Lagrangian VOF tensorial penalty method for the DNS of resolved particle-laden flows. Application to fluidized beds

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The direct numerical simulation of particle flows is investigated by a Lagrangian VOF approach and penalty methods of second order convergence in space for incompressible flows interacting with resolved particles on a fixed structured grid. A specific Eulerian volume of fluid method is developed with a Lagrangian tracking of the phase function while the solid and divergence free constraints are ensured implicitly in the motion equations thanks to fictitious domains formulations, adaptive augmented Lagrangian approaches and viscous penalty methods. A specific strategy for handling particle collisions and lubrication effects is also presented. Various dilute particle laden flows are considered for validating the models and numerical methods. Convergence studies are proposed for estimating the time and space convergence orders of the global DNS approach. Finally, two dense particle laden flows are simulated, namely the flow a cross a fixed array of cylinders and the fluidization of 2133 particles in a vertical pipe.The numerical solutions are compared to existing theoretical and experimental results with success.