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A novel cutcell method and its application to the incompressible Navier-Stokes equations

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The cutcell method provides an excellent tool to perform high-fidelity simulations of flows in complex geometries due to its reliance on Cartesian grids, which greatly reduces the complexity of the mesh generation process.

An energy-conservative cutcell method is proposed based on the discrete calculus of Morinishi [1] to discretize the incompressible Navier-Stokes equations by means of the Marker-And-Cell (MAC) method where vector field components are located at face centers and scalar fields at cell centers. This approach retains the compact stencil and the strong coupling between the pressure and velocity fields of the original MAC scheme.

Validation of the method is performed for cell-centered and face-centered fields for Neumann and Dirichlet boundary conditions [2]. Time-advancement is performed with an implicit-explicit Runge-Kutta scheme. Two strategies are compared to solve the resulting Differential-Algebraic Equations: an iterative solution of the pressure-velocity system with a dedicated preconditioner, and an approximate solution by means of a prediction-correction algorithm. The accuracy of the transfers is investigated by comparing the pressure trace and the viscous drag in flows around rigid solids to the results of the Immersed Boundary Projection Method [3].

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