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A sharp immersed boundary method based on penalisation and its application to moving boundaries and turbulent rotating flows

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Abstract

This paper presents an Immersed Boundary Method (IBM) for handling flows in the presence of fixed and moving solids with complex geometries. The method is based on a penalisation approach and designed to preserve the sharpness of the immersed boundaries. Corrections of the boundary conditions are implemented at the interface to improve the accuracy of the solution in comparison to first-order methods and avoid the rasterisation issue on Cartesian grids.

The current IBM is developed in the OpenFOAM® library (-v 2.2) and its accuracy is first verified against the Wannier flow case. It is then applied to the flow in presence of fixed and moving circular obstacles. The computational results show good agreement with equivalent standard body-conforming simulations and other high order published IBM, and demonstrate as well that improvements can be achieved by correcting the boundary conditions for both velocity and pressure on the interface. Finally, the method is assessed by reference to a realistic engineering application involving rotating flow: a single-phase mixer. In this case, the method is coupled to a DES model for turbulence modelling, and results show again good comparison with experimental results.

Keywords:
Immersed Boundary Method, penalisation method, OpenFOAM®, DES turbulence model, mixing