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CROUZEIX-RAVIART MULTISCALE FINITE ELEMENT METHOD FOR STOKES FLOWS IN HETEROGENEOUS MEDIA

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A CFD modelling of the whole nuclear reactor core is very difficult due to the high heterogeneity of the domain and a huge demand of computational resources. Therefore our work presents one Multiscale Finite Element Method (MsFEM) [1] which is capable to solve multiscale features of flow without confining itself to fine scale calculations.

When computing multiscale basis functions, the approximation of boundary conditions on coarse element edges influences critically the accuracy of the MsFEM method. The non-conforming Crouzeix-Raviart MsFEM has been proposed in [2]. In the construction of Crouzeix-Raviart multiscale basis functions, the conformity between coarse elements is only weakly enforced, i.e. merely the average of the “jumps” of these functions vanishes at coarse element edges. This leads to a natural boundary condition on coarse element edges, which relaxes the sensitivity of the method to complex patterns of obstacles, without having to use oversampling methods.

Based on [2], we have implemented and tested Crouzeix-Raviart MsFEM in TrioCFD [3] to solve the Stokes flow in a genuine heterogeneous media. The Crouzeix-Raviart multiscale basis functions are computed in triangular and tetrahedral meshes by the Finite Volume Element Method and belong to P1NC-P0 FEM spaces. Convergence studies of enclosed and open-channel flows with arbitrary patterns of obstacles and non-homogeneous boundary conditions show good qualitative and quantitative agreements with the reference solution even with a rather coarse mesh. The advantages of Crouzeix-Raviart MsFEM are especially significant when obstacles are dense and intersections with coarse element edges exist.

Since assemblies in nuclear reactor cores are periodically placed, we are extending the method for cases with periodically placed obstacles by enriching the multiscale basis functions and also for Navier-Stokes flows with not too large Reynolds numbers.

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