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A fictitious domain method : from theory to fluid structure interaction applications

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ABSTRACT

The fat boundary method [1,2,4] was developed to easily handle perforated domains and was analyzed in the case of the Poisson equation. The methodology was then applied on Stokes or incompressible Navier-Stokes equations using projection methods. We present in this work an extension of the fat boundary method to the Stokes and Navier-Stokes equations. It starts from a reformulation of the fat boundary method of the Poisson problem into a saddle point problem involving Lagrange multipliers to ensure the weak continuity at the outer interface between the solution of the fictitious domain and solution in the underlying global domain. This formulation is then extended and analyzed for the Stokes equations. We propose an implementation of the method using the Feel++ library [3] to provide some verification that the methodology retains optimal convergence properties away from the holes for the global solution as well as for the local solution including the case of high order approximations. Finally we introduced in [2] an ALE framework with applications to fluid structure interaction which we apply to handle deformable particles in fluid flows via our fictitious domain method.

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