An embedded Dirichlet formulation for 3D continua

Abstract:
This paper presents a new approach for imposing Dirichlet conditions weakly on non-fitting finite element meshes. Such conditions, also called embedded Dirichlet conditions, are typically, but not exclusively, encountered when prescribing Dirichlet conditions in the context of the eXtended Finite Element Method (XFEM). The methods key idea is the use of an additional stress field as the constraining Lagrange multiplier function. The resulting mixed/hybrid formulation is applicable to 1D, 2D and 3D problems. The method does not require stabilization for the Lagrange multiplier unknowns and allows the complete condensation of these unknowns on the element level. Furthermore, only non-zero diagonal-terms are present in the tangent stiffness, which allows the straightforward application of state-of-the-art iterative solvers, like Algebraic Multigrid (AMG) techniques. Within this paper, the method is applied to the linear momentum equation of an elastic continuum and to the transient, incompressible Navier-Stokes equations. Steady and unsteady benchmark computations show excellent agreement with reference values. The general formulation presented in this paper can also be applied to other continuous field problems.