Applied Mathematics

CutFEM: Discretizing Geometry and Partial Differential Equations

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Many advanced modelling problems in biology, engineering and geological applications can be described by partial differential equations (PDEs) posed on and coupled through domains of possibly different topological dimensionality. A prominent use case are flow and transport problems in porous media when large-scale networks of fractures and channels are modelled as 2D or 1D geometries embedded into a 3D bulk domain. Another important example is the modeling of cell motility where reaction-diffusion systems on the cell membrane and inner cell are coupled to describe the active reorganization of the cytoskeleton. But with complex lower-dimensional and possibly evolving geometries, traditional PDE discretization technologies are severely limited by their strong requirements on the domain discretization.

In this talk, we focus on the cut finite element (CutFEM) framework as one possible and versatile approach to discretize coupled PDE systems on complicated domains, with a particular emphasis on solving PDEs on embedded manifolds. Along with presentation we will give a number of numerical examples which illustrate the theoretical properties of the framework as well its applicability to a wide range of a complex modelling problem including PDEs on embedded 1D/2D domains coupled to their 3D ambient space.

This is joint work with Erik Burman (University College London, UK), Peter Hansbo (Jönköping University, Sweden), and Mats G. Larson (Umeå University, Sweden).