Contribution ID: **518** Type: **Poster + 3 Minute Pitch**

Mixed methods for 1D-3D coupled flow models in porous media

Wednesday, 16 May 2018 16:58 (2 minutes)

The physical processes governing flow and transport in porous media span a wide array of spatial scales. Furthermore, in many applications it would be computationally intractable to resolve each scale of interest. To still capture the effects of the smaller-scale processes, one option is to couple together models of different dimensionality. In e.g. vascularized tissue and root networks, the arteries and roots have negligible radius compared to their own lengths. They can therefore be viewed as 1D inclusions embedded in the 3D domain, and the system modeled using a coupled 1D-3D flow model.

We consider the use of mixed finite element methods to solve 1D-3D coupled porous media flow problems. Due to the high dimensional gap between the models, the solutions of this system will be singular to the point of eluding the standard H^1 framework [1]. Existence proofs and convergence rates therefore require special consideration. In this talk, we will use weighted Sobolev spaces to prove the existence of a solution to both continuous and discrete mixed formulation. We then perform a numerical analysis of the problem and present simulation results.

References

C. D'Angelo. Finite Element Approximation of Elliptic Problems with Dirac Measure Terms in Weighted Spaces: Applications to One- and Three-dimensional Coupled Problems,
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Primary authors: GJERDE, Ingeborg Gåseby (University of Bergen); Prof. NORDBOTTEN, Jan (University of Bergen); KUMAR, Kundan (University of Bergen)

Presenter: GJERDE, Ingeborg Gåseby (University of Bergen)

Session Classification: Parallel 8-B

Track Classification: MS 2.25: Hierarchical Flow Modelling in Biological Systems