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

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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.

This poster presents an analysis of the mixed finite element method applied to coupled 1D-3D porous media flow problems. Due to the high dimensional gap, the solutions will be singular around the inclusion. As a result, the problem eludes the standard H^1 framework, and weighted Sobolev spaces must be employed instead. We prove existence of a solution to the continuous and discrete model, obtain weighted error rates for the method, and present simulation results.

References

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Primary authors: Prof. NORDBOTTEN, Jan (University of Bergen); KUMAR, Kundan (University of Bergen); GJERDE, Ingeborg Gåseby (University of Bergen)

Presenter: GJERDE, Ingeborg Gåseby (University of Bergen)

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