Virtual Element Methods for subsurface flow and transport simulations in fractured media

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ABSTRACT

Large scale subsurface flow and transport simulations are characterized by several modeling, numerical, and computational difficulties. In particular we focus on geometrical complexities of fractured media, uncertainty of geometrical and hydro-geological parameters, and large scale problems.

When considering realistic problems in the fields of enhanced Oil & Gas production, geothermal applications, geological storage of either nuclear waste or carbon dioxide, a large number of simulations at the scale of a geological basin are typically necessary. In order to properly take into account the strong and highly variable directionality of the underground flows, an explicit representation of the rock fractures crossing the basin is required, as fractures provide preferable flows paths.

The rock fractures usually intersect each other in a dense and chaotic way, yielding geometries which display all the typical problematic features for space discretizations. In this context, the possibility to apply a Galerkin method for the discretization of the differential models governing the relevant phenomena, with general polygonal elements, is of paramount importance. In this respect, the Virtual Element Method can yield a huge flexibility thanks to the introduction of almost arbitrary polygonal or polyhedral elements.

In this talk we present some useful approaches that can be applied to underground flow and transport simulations, based on a Virtual Element discretization. The issues addressed concern topics among the following: suitable mesh generation processes on fractures circumventing the usual mesh conformity constraints; stability issues; conditioning of projection matrices on elements with huge aspect ratios; *a posteriori* error estimates; mesh adaptivity; convection diffusion problems; mixed formulation of the flow problem.

Several simulations in realistic configurations clearly assess the large potentialities of the approach based on virtual elements with respect to the robustness and the numerical efficiency; these are two key issues for performing simulations in stochastically generated configurations.

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