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A COUPLED HIGH-ORDER CONTINUOUS/DISCONTINUOUS GALERKIN FORMULATION FOR SIMULATION OF 3D FLUID-DRIVEN CRACK PROPAGATION

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Abstract. Hydraulic fracturing is a method used in the petroleum industry to enhance the oil and gas extraction from conventional and unconventional reservoirs. The numerical simulation of this process requires the modeling of fluid-driven crack propagation, which involves several coupled phenomena [1]: (i) pressurization and fluid flow within fractures; (ii) mechanical deformation of a solid medium, usually rock, produced by the fluid pressure loading of fracture surfaces; and (iii) crack propagation in the solid medium and fluid filling of interstitial spaces.

The numerical approach proposed in this work is based on (i) a combination of a high-order discontinuous Galerkin (DG) discretization of the continuum problem and cohesive zone models of fracture to describe the physics of the solid and a crack propagation responding to laws of fracture mechanics [2, 3]; (ii) a high-order continuous Galerkin (CG) discretization of the Reynolds lubrication equation in curved surfaces to model the fluid flow within the fractures; (iii) a boundary coupling strategy to deal with the fluid-solid interaction; and (iv) a front-tracking algorithm to address the fluid filling of fracture surfaces.

In Figure 1 we show four snapshots of fluid-driven crack propagation in a rectangular prism initially pre-cracked and pressurized in half of its middle plane. A mesh of 192 cubic DG tetrahedral elements (11520 dofs) is used in the discretization of the displacement field of the solid body, while 16 cubic CG triangular elements (91 dofs) are needed to discretize the pressure of the fluid domain when the planar fracture surface is completely filled with fluid. Notice that the displacement of the solid medium is amplified by a factor of 40 and that the simulation captures the advance of the fluid front.

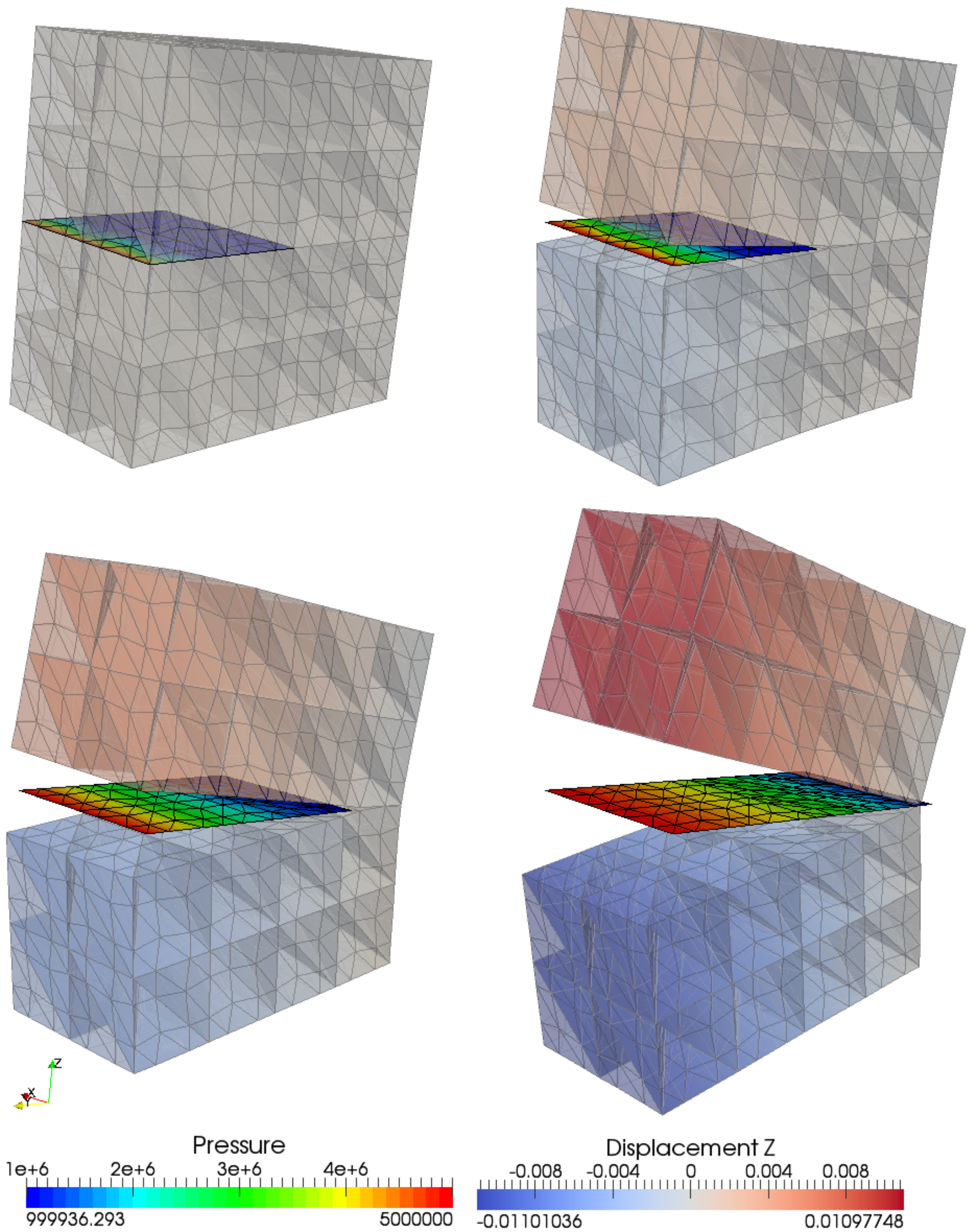

Figure 1: Snapshots illustrating the fluid-driven crack propagation in a rectangular prism initially pre-cracked and pressurized in half of its middle plane. The displacement field of the solid body is amplified by a factor of 40. The fluid pressure distribution is shown in the planar surface, which evolves as the crack tip advances and the fluid is filling the fracture surface.

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