A HYBRID GALERKIN FINITE ELEMENT METHOD FOR SEISMIC WAVE PROPAGATION IN FRACTURED MEDIA

Janaki Vamaraju, Mrinal K Sen, Jonas De Basabe and Mary Wheeler

Department of Geological Sciences
The University of Texas at Austin

ABSTRACT

The discontinuous Galerkin Finite Element Method (DGM) is a promising approach for modeling wave propagation in fractured media. It allows for discontinuities in the displacement field to simulate fractures or faults in a model. The approach is based on the interior-penalty formulation of DGM, and the fractures are simulated using the linear-slip model, which is incorporated into the weak formulation. On the other hand, the Spectral Element Method (SEM) can be used to simulate elastic wave propagation in non-fractured media. SEM uses continuous basis functions which do not allow for discontinuities in the displacement field. However, the computation cost of DGM is significantly larger than SEM due primarily to increase in the number of degrees of freedom. Here we propose a Hybrid Galerkin FEM (HGM) for elastic wave propagation in fractured media that combines the salient features of each of the algorithm resulting in significant reduction in computational cost compared to a stand-alone DGM. We employ DGM in areas containing fractures and SEM in regions without fractures. The coupling between the domains at the interfaces is satisfied in the weak form through interface conditions. The degree of reduction in computation time depends primarily on the density of fractures in the medium. In this paper, we formulate and implement HGM for seismic wave propagation in fractured media. Using realistic 2D/3D numerical examples, we show that our proposed HGM outperforms a stand-alone DGM with reduced computation cost and memory requirement while maintaining the same level of accuracy.

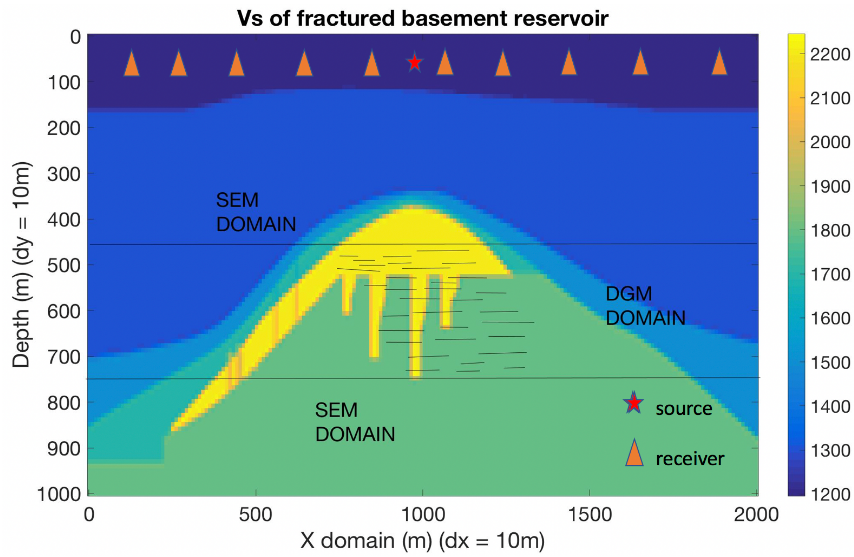

Figure 1: P-wave velocity distribution of the fractured basement reservoir

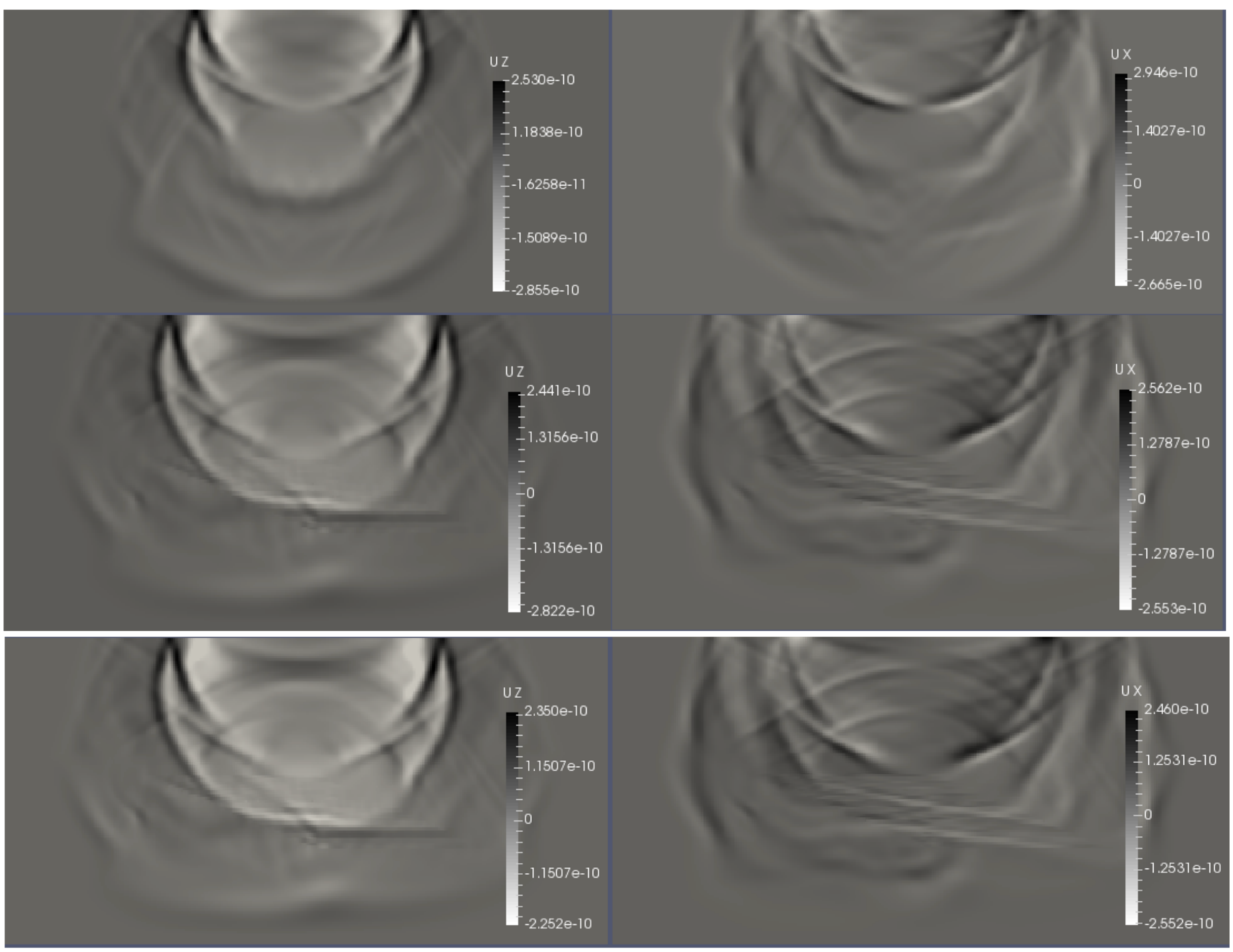

Figure 2: Snapshots at t=0.37s top: vertical component (left panel) and horizontal component (right panel). non-fractured reservoir (HGM) middle: fractured basement reservoir (HGM) bottom: fractured basement reservoir (DGM)