Numerical Propagation of Elastic Waves in Fractured Media

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ABSTRACT

The propagation of elastic waves has many applications in science and engineering. For example, in exploration geophysics, seismic surveys are the main source of data to find hydrocarbon reservoirs. Other examples are non-destructive evaluation of materials in mechanical engineering and dynamic evaluation of structures in civil engineering. In all of these cases it is important to take into account the effects of fractures and cracks. These produce a discontinuity in the displacement field that is inversely proportional to the fracture stiffness.

There is a variety of wave phenomena related to the presence of fractures. Sets of aligned fractures have been associated with velocity anisotropy [3]. Furthermore, phase-shifting, frequency-filtering, scattering of the reflected, transmitted and converted waves and fracture interface waves have also been observed in practice (*e.g.* [2]).

There are two main approaches to incorporate the effects of fractures: Using equivalent medium theories or using a numerical scheme to incorporate discrete fractures in the simulations. There have been many theories proposed in the literature that predict the effective media parameters associated with a particular fracture distribution. All of these models make different assumptions about the fractures, in particular they usually assume small, circular, non-intersecting cracks. Despite their advantages, they have limited applicability because of the large number of assumptions. Regarding the numerical schemes to incorporate the fractures, different approaches have been proposed in the literature. The main advantage of these is that they require few assumptions and therefore they have a broad applicability and are useful to validate the equivalent medium theories.

We propose a new scheme that incorporates fractures using the linear-slip model into a discontinuous Galerkin method [1]. This approach can be used to simmulate a wide variety of wave phenomena related to fractures. We calibrate our results against an analytic solution for a single elongated horizontal fracture and show numerical examples using 2D and 3D models with one fracture and two orthogonal fractures.

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