Numerical modeling of dynamic rupture propagation

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A b s t r a c t : The finite-element method (FEM) is a representative of the low-order numerical methods widely used in seismology. We implemented the traction-at-split-nodes method to simulate the dynamic rupture propagation on seismic faults. We use an improved algorithm involving our adaptive smoothing algorithm of the so-called trial traction to reduce spurious high-frequency oscillation of the slip-rate.

Arbitrary-high-order-derivative – discontinuous-Galerkin method (ADER-DGM) is a relatively new numerical method which has been applied to seismic wave propagation in 2006. Since then the method has been significantly improved (for example, the application to structured and unstructured meshes, implementation of the adaptive time stepping, implementation of anisotropy).

The dynamic rupture propagation was implemented in the 2D version of the method by de la Puente et al. (2009) and only recently also in the 3D problem (Pelties et al., in preparation). The method seems to be very promising as the results are not polluted by the spurious high-frequency oscillations known from other numerical methods including the finite-element, finite-difference or spectral-element method. The origin of these oscillations is still not satisfactorily understood.

We briefly compare algorithms for dynamic rupture propagation in FEM and

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ADER-DGM, and we also compare numerical results obtained by both methods.

Another important aspect of the numerical simulation of rupture propagation is nucleation (initialization) of the rupture propagation. An artificial intervention is needed to nucleate the spontaneous rupture propagation. There are several ways how to do it, however, the way of the artificial nucleation may affect the rupture propagation itself. We focus on the effect of the artificial nucleation used for example by SCEC (Southern California Earthquake Center) and compare it with our approach. The results show that for a given size of the rupture area the occurrence of the super-shear rupture propagation depends on the used nucleation method.

Key words: finite-element method, arbitrary-high-order-derivative discontinuous-Galerkin method, dynamic rupture propagation, nucleation strategies

References

de la Puente, J., Ampuero, J.-P. and Käser, M., 2009. Dynamic rupture modeling on unstructured meshes using a discontinuous Galerkin method, *J. Geopys. Res.*, **114**, B10302, doi: 10.1029/2008JB006271