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The ADER-DG method for seismic wave propagation and earthquake rupture dynamics

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We will present the Arbitrary high-order DERivatives Discontinuous Galerkin (ADER-DG) method for solving the combined elastodynamic wave propagation and dynamic rupture problem. The ADER-DG method enables high-order accuracy in space and time while being implemented on unstructured tetrahedral meshes. A tetrahedral element discretization provides rapid and automatized mesh generation as well as geometrical flexibility. Features as mesh coarsening and local time stepping schemes can be applied to reduce computational efforts without introducing numerical artifacts. The method is well suited for parallelization and large scale high-performance computing since only directly neighboring elements exchange information via numerical fluxes. The concept of fluxes is a key ingredient of the numerical scheme as it governs the numerical dispersion and diffusion properties and allows to accommodate for boundary conditions, empirical friction laws of dynamic rupture processes, or the combination of different element types and non-conforming mesh transitions.

After introducing fault dynamics into the ADER-DG framework, we will demonstrate its specific advantages in benchmarking test scenarios provided by the SCEC/USGS Spontaneous Rupture Code Verification Exercise. An important result of the benchmark is that the ADER-DG method avoids spurious high-frequency contributions in the slip rate spectra and therefore does not require artificial Kelvin-Voigt damping, filtering or other modifications of the produced synthetic seismograms. To demonstrate the capabilities of the proposed scheme we simulate an earthquake scenario, inspired by the 1992 Landers earthquake, that includes branching and curved fault segments. Furthermore, topography is respected in the discretized model to capture the surface waves correctly.

The advanced geometrical flexibility combined with an enhanced accuracy will make the ADER-DG method a useful tool to study earthquake dynamics on complex fault systems in realistic rheologies.