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NEXD: A Software Package for High Order Simulation of Seismic Waves using the Nodal Discontinuous Galerkin Method

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Numerical simulations are a key tool to improve the knowledge of the interior of the earth. For example, global simulations of seismic waves excited by earthquakes are essential to infer the velocity structure within the earth. Numerical investigations on local scales can be helpful to find and characterize oil and gas reservoirs. Moreover, simulations help to understand wave propagation in boreholes and other complex geological structures. Even on laboratory scales, numerical simulations of seismic waves can help to increase knowledge about the behaviour of materials, e.g., to understand the mechanisms of attenuation or crack propagation in rocks.

To deal with highly complex heterogeneous models, the Nodal Discontinuous Galerkin Method (NDG) is used to calculate synthetic seismograms. The main advantage of this method is the ability to mesh complex geometries by using triangular or tetrahedral elements together with a high order spatial approximation of the wave field. The presented simulation tool NEXD has the capability of simulating elastic, anelastic, and poroelastic wave fields for seismic experiments for one-, two- and three-dimensional settings. In addition, fractures can be modelled using linear slip interfaces. NEXD also provides adjoint kernel capabilities to invert for seismic wave velocities. External models provided by, e.g., Trelis can be used for parallelized computations. For absorbing boundary conditions, Perfectly Matched Layers (PML) can be used. Examples are presented to validate the method and to show the capability of the software for complex models such as the simulation of a tunnel reconaissance experiment.

The software is available on GitHub: https://github.com/seismology-RUB