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Numerical survey of pressure wave propagation around and inside an underground cavity with high order FEM

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The research on purely numerical methods for modeling seismic waves has been more and more intensified over last decades. This development is mainly driven by the fact that on the one hand for subsurface models of interest in exploration and global seismology exact analytic solutions do not exist, but, on the other hand, retrieving full seismic waveforms is important to get insides into spectral characteristics and for the interpretation of seismic phases and amplitudes. Furthermore, the computational potential has dramatically increased in the recent past such that it became worthwhile to perform computations for large-scale problems as those arising in the field of computational seismology.

Algorithms based on the Finite Element Method (FEM) are becoming increasingly popular for the propagation of acoustic and elastic waves in geophysical models as they provide more geometrical flexibility in terms of complexity as well as heterogeneity of the materials. In particular, we want to demonstrate the benefit of high-order FEMs as they also provide a better control on the accuracy. Our computations are done with the parallel Finite Element Library NGSOLVE ontop of the automatic 2D/3D mesh generator NETGEN (http://sourceforge.net/projects/ngsolve/).

Further we are interested in the generation of synthetic seismograms including direct, refracted and converted waves in correlation to the presence of an underground cavity and the detailed simulation of the comprehensive wave field inside and around such a cavity that would have been created by a nuclear explosion. The motivation of this application comes from the need to find evidence of a nuclear test as they are forbidden by the Comprehensive Nuclear-Test Ban Treaty (CTBT). With this approach it is possible for us to investigate the wave field over a large bandwidth of wave numbers. This again will help to provide a better understanding on the characteristic signatures of an underground cavity, improve the protocols for OSI field deployment and create solid observational strategies for detecting the presence of an underground (nuclear) cavity.