



Understanding the seismic wave propagation inside and around an underground cavity from a 3D numerical survey

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Motivated by the need to detect an underground cavity within the procedure of an On-Site-Inspection (OSI) of the Comprehensive Nuclear Test Ban Treaty Organization (CTBTO), which might be caused by a nuclear explosion/weapon testing, we aim to provide a basic numerical study of the wave propagation around and inside such an underground cavity. One method to investigate the geophysical properties of an underground cavity allowed by the Comprehensive Nuclear-test Ban Treaty is referred to as “resonance seismometry” - a resonance method that uses passive or active seismic techniques, relying on seismic cavity vibrations. This method is in fact not yet entirely determined by the Treaty and so far, there are only very few experimental examples that have been suitably documented to build a proper scientific groundwork. This motivates to investigate this problem on a purely numerical level and to simulate these events based on recent advances in numerical modeling of wave propagation problems.

Our numerical study includes the full elastic wave field in three dimensions. We consider the effects from an incoming plane wave as well as point source located in the surrounding of the cavity at the surface. While the former can be considered as passive source like a tele-seismic earthquake, the latter represents a man-made explosion or a vibroseis as used for/in active seismic techniques. Further we want to demonstrate the specific characteristics of the scattered wave field from a P-waves and S-wave separately. For our simulations in 3D we use the discontinuous Galerkin Spectral Element Code SPEED developed by MOX (The Laboratory for Modeling and Scientific Computing, Department of Mathematics) and DICA (Department of Civil and Environmental Engineering) at the Politecnico di Milano. The computations are carried out on the Vienna Scientific Cluster (VSC).

The accurate numerical modeling can facilitate the development of proper analysis techniques to detect the remnants of an underground nuclear test, help to set a rigorous scientific base of OSI and contribute to bringing the Treaty into force.