Numerical modeling of earthquake ground motion

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Mathematical and numerical modeling can be used to better understand the physics of earthquakes, improve the design of site-specific structures and facilities, and enhance seismic risk maps. Three-dimensional, physics-based numerical simulations of earthquake ground motion are a powerful tool to study the ground motion induced by earthquakes in regions threatened by seismic hazards. The distinguishing features of a numerical method designed for seismic wave propagation phenomena are: *accuracy*, *geometric flexibility* and *scalability*. To be accurate, numerical methods must keep dissipative and dispersive errors low. Geometric flexibility is required since the computational domain usually features complicated geometrical shapes as well as sharp discontinuities of mechanical properties. Additionally, earthquake models are typically characterized by domains whose dimension, ranging from hundreds to thousands square kilometers, is very large compared with the wavelengths of interest. This typically leads to a discrete problem featuring several millions of unknowns. As a consequence, numerical algorithms must be scalable in order to efficiently exploit high performance computers.

In this talk we present a high-order discontinuous Galerkin scheme on hybrid (non-conforming) grids for the numerical solution of three-dimensional wave propagation problems in heterogeneous media. We analyze the stability and the theoretical properties of the resulting scheme and present some validation benchmarks to verify the accuracy and performance of the proposed approach. We also present some simulations of real large-scale seismic events in three-dimensional complex media: from far-field to near-field including soil-structure interaction effects. The numerical results have been obtained with the open-source numerical code SPEED (https://speed.mox.polimi.it).