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A poly-grid approach for wave propagation modelling in highly heterogeneous media by using a Chebyshev spectral element method

C. Su and G. Seriani
OGS, Italy (suchang02@gmail.com)

Many physical problems require the modelling of wave phenomena in media having variable properties, while highly accurate algorithms are needed in order to avoid unphysical effects. Often the property fluctuations may be very high compared to the minimum wavelength, leading to an extremely large problem, since a grid resolution down to the finest scales is required and the much larger wavelength scale of interest cannot be exploited in order to reduce the computational burden. Here, like in multiscale methods, efficiency can be increased only by solving the macroscopic behavior without solving explicitly the microscopic one. Spectral element methods (SEM) have excellent properties of accuracy and flexibility in describing complex models and are used as well for wave modelling. In the standard SEM approach, the computational domain is discretized by using very coarse meshes and constant-property elements, which makes it inappropriate for solving the above mentioned problem. A convenient solution approach is provided by a poly-grid Chebyshev spectral element method, which allows to overcome this limitation. The domain decomposition is built by using composite elements having a set of local grids, or poly-grid. The main grid is used for wave propagation, whereas the remaining auxiliary grids are used for describing the physical parameters. As a consequence, SEM accuracy and efficiency is maintained in wave field computations while dealing with small scale property fluctuations. Moreover, interfaces between different materials can be easily handled internally to each element without the need of their edges be aligned with the interfaces.