CFA/VISHNO 2016

Non-periodic homogenization for the elastic wave equation in 3D

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CFA2016/106
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The homogenization technique developed in mechanics in the late seventies enables to compute the effective properties of finely-periodic materials for the elastic wave equation. In the recent years, this technique has been adapted to non-periodic media, allowing for the determination of long-wavelength equivalent properties of complex (i.e containing many different sizes of heterogeneities) elastic models. The resulting homogenized media only hold smooth variations of elastic properties which considerably ease the numerical computation of wave propagation. They indeed prevent from complex meshes and extremely small time-steps associated with small heterogeneities. We here present the first implementation of the non-periodic homogenization of 3D media. This implementation is based on a Finite Element analysis. Using i) a finely-layered model for which an analytical solution is available to compare with, ii) a highly diffractive medium made of small cubes with random properties and iii) a realistic geological model, we emphasize the accuracy and the high potential of the method. Computing the effective properties of these media with our code and then using these properties in a wave propagation solver is indeed much faster (possibly several orders of magnitude) than performing the wave propagation in the original media directly. Another code, based on Fast Fourier Transforms, is also discussed.