Research Topic for the ParisTech/CSC PhD Program

Field (cf. List of fields below): Mathematics / mechanics

Subfield: Computational mechanics

Title: Wave propagation in highly heterogeneous media

ParisTech School: ENSTA

Advisor(s) Name: J-F Semblat / S. Chaillat
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(Lab, website): IMSIA / POEMS

Short description of possible research topics for a PhD:
Wave propagation in highly heterogeneous 3D elastic media is a topic of strong interest in seismology, for non-destructive testing, etc. The goal is to investigate elastic wave propagation in highly heterogeneous structures along several tens to hundreds of wavelengths. The numerical complexity (mesh size and refinement) is a crucial issue as well as the radiation conditions at infinity.
The recent advances in fast BEM modelling allows for an efficient and accurate estimation of wave propagation in large 3D media (with respect to the wavelength). Since high velocity contrasts lead to important mesh refinement at interfaces, the numerical complexity is consequently much higher that it may be for smooth heterogeneities. The goal of this PhD is to propose a weak formulation for the BEM/BEM coupling of highly heterogeneous media in the framework of the Fast Multipole Accelerated BEM developed at ENSTA ParisTech in the last recent years. Efficient preconditioning methods will also be investigated.
The accuracy and the complexity of the proposed methods will be assessed in the field of seismology for various theoretical and actual configurations. A verification as well as a validation strategy from actual observations will be performed.

Required background of the student: numerical methods (FEM, BEM), wave propagation

A list of 5(max.) representative publications of the group: (Related to the research topic)
Chaillat S., M. Darbas, and F. Le Louër (2017). Fast iterative boundary element methods for high-frequency scattering problems in 3D elastodynamics. Journal of Computational Physics, 341:429–446.

Meza-Fajardo KC, Semblat JF, Chaillat S., Lenti L. (2016). Seismic-Wave Amplification in 3D Alluvial Basins: 3D/1D Amplification Ratios from Fast Multipole BEM Simulations Bulletin of the Seismological Society of America, 106(3): 1267-1281.

Chaillat S., M. Bonnet (2014). A new Fast Multipole Formulation for the elastodynamic half-space Green's tensor. Journal of Computational physics, 258:787–808.

Chaillat S., J.F . Semblat, and M. Bonnet (2012). A preconditioned 3-D multi-region fast multipole solver for seismic wave propagation in complex geometries. Communications in Computational Physics, 11: 594-609.

Semblat J.F., Pecker A. (2009). Waves and Vibrations in Soils: Earthquakes, Traffic, Shocks, Construction Works, IUSS Press, 500 pages.
