Open position for a Post-Doc at *ENSTA*

POEMS/IMSIA

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Advanced Fast BEM solver to model long period seismic waves on realistic configurations (funded by ANR MODULATE)

▷ **Scientific Context.** The development of efficient approaches to simulate seismic wave propagation in complex geological structures is crucial to predict the consequences of large earthquakes. It is a very active field due to (i) the complexity of the system to model and (ii) the need of efficient tools for large spatial scale problems. Such tools are particularly necessary to understand intense long-period ground motions usually generated at large distances from the source. These long-period ground motions primarily consist of surface waves that arise when seismic waves encounter sedimentary deposits [6]. The MODULATE project (funded by ANR) aims at developing a methodology based on the physics of surface waves, to describe the evolution of the spectral content of the ground motion at a site located in a sedimentary basin. 3D numerical soil-structure models that capture the particular dynamic features of actual large-scale structures will be developed to assess their performance when subjected to the synthetic ground motions. The results of the project will allow the development of tools and guidelines to be used by the earthquake engineering community for more resilient designs of large-scale infrastructures.

Standard numerical approaches to simulate seismic waves [9] range from domain methods as finite differences (FDMs) and finite elements (FEMs) methods to boundary element methods (BEMs). The main advantage of the BEM is that only the domain boundary is meshed leading to a drastic reduction of the number of degrees of freedom [1]. The second advantage is that radiation conditions at infinity are exactly taken into account in the formulation for scattering problems. Currently, 3D simulations with standard BEMs are limited to simplified configurations. Standard BEMs indeed lead to a fully-populated influence matrix, and are thus severally limited regarding problems with complex geometries or higher frequency range.

The introduction of Fast BEMs, such as the Fast Multipole-Accelerated BEMs or the $\mathcal{H}$-matrices-Accelerated BEMs, allows one to overcome the drawback of the fully-populated matrix by introducing a fast, reliable and approximate method to compute the linear integral operator [4, 5]. Recent advances on fast BEMs have demonstrated their capabilities to model seismic wave propagation in 3D heterogeneous geological structures and are now mature to start dealing with more realistic configurations [7] (see the software COFFEE[1] developed at ENSTA). This post-doc is part of an effort towards the development of tools to simulate real-life problems in the framework of the MODULATE project.

[1] https://uma.ensta-paristech.fr/soft/COFFEE/

▷ **Objectives.** The objective of this post-doc is to pave the way from an academic solver to a fully operational methodology to assess the effect of actual seismic events [8]. Depending on the background of the candidate, the work could be decomposed into the following steps:

(i) Improvement of the fast BEM formulation based on the elastic half-space fundamental solutions [3].

(ii) Definition of an efficient high-performance computing strategy.

(iii) Introduction of various models of realistic sources.

(iv) Study of the optimal strategy to truncate geological structures of infinite extent [2].

(v) Benchmarking of these advanced methodologies with respect to realistic configurations and seismological data.

This work will be performed in collaboration with colleagues from various institutions: CentraleSupelec (MSSMAT), BRGM (French geological survey, Seismic risk team), University of Patras (A.S. Papageorgiou), Géodynamique & Structure (GDS).

▷ **Knowledge.** Solid backgrounds in wave propagation modeling and applied mathematics are expected. A good knowledge in scientific programming will be appreciated.

▷ **Contact and location.** The post-doc will take place at ENSTA Paristech (Palaiseau, France). It will be supervised by Stéphanie Chaillat (POEMS team) and Jean-François Semblat (IMSIA team).
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References

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