ÉCOLE DOCTORALE SCIENCES DE LA TERRE

Subject offered for a contract starting in October 2013

SUBJECT TITTLE: ***3D Direct Solution Method for lithological discontinuities that do not coincide with the numerical grid***

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Host lab/ Team : **GPX**

Financing: GPX/IPGP

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There have been many methods proposed to improve accuracy and/or efficiency of calculating seismic wavefields. The Finite Difference Method (FDM) is widely used in local/high-frequency industry-oriented problems because it is relatively straightforward to solve the strong form of equation of motion on regular, staggered grids. The novel techniques are well tuned and are of good performance. However, the discontinuity treatment is limited to the numerical gridding, i.e. we can consider only step-function-like discontinuities. On the other hand, the Finite Element Method (FEM) or FEM-like methods (the Spectral Element Method, SEM, Patera, 1984; Komatitsch & Vilotte, 1998; the Arbitrary High-order discontinuous Galerkin method, ADER-DG, Käser & Dumbser, 2006) enjoyed their increasing popularity in numerical seismology, demonstrating advantages for the problem of global wave propagation. We are now able to accurately calculate for any type of topology of discontinuity, although meshing procedure itself is very expensive. However, the shortcoming of these methods are that this sophisticated mesh designing is not much helpful for waveform inversion since we do not know about the Earth structure in detail except surface topography or bathymetry. In order to conduct waveform inversion with complicated lithological discontinuities, it is desirable to develop and realise an efficient and accurate numerical method for computing synthetic seismograms for media with elastic discontinuities, which do not coincide with the computational grid.

The Direct Solution Method (DSM) is a Galerkin weak form method (Strang & Fix, 1973; Geller & Ohminato, 1994), tuned to achieve optimal accuracy (Geller & Takeuchi, 1995). It has succeeded in particular in seismology, and it is still the only methodology that can reach as high frequencies as 2Hz for the spherical Earth model. It is in general a FEM-like method but it does not use trial functions. Mizutani (2002) was the preliminary attempt to achieve optimally accurate operators for sources and discontinuities that do not coincide with the numerical grid using DSM. However, it is limited to 2D SH test case with just one discontinuities. Thus we propose to extend the theory to 2D/3D fully anisotropic case and realise the DSM calculation in 2D/3D domain and to realise preliminary waveform inversion for several standard models.

A student with strong background in physics, numerical modelling and theoretical seismology are encouraged to apply. The student will receive training in seismic modelling and will work closely in collaboration with the GPX industry partners and seismology groups at IPG Paris and University of Tokyo. They will integrate in the dynamic GPX group and will actively participate in broad range of research carried out at IPG Paris.