Applied Mathematics

CRM-McGill Applied Mathematics Seminar

Jan. 22, 2006, 2:35 pm Monday
At McGill, Burnside Hall 1205

"Efficient computation of acoustic sensing by means of adaptive finite elements"

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Coffee and refreshments will be served after the seminar

Abstract: Sensing by means of acoustic signals excited into a probed medium is of great importance for the non-invasive inspection in geophysical and biomedical applications. The numerical solution of problems arising from acoustic sensing poses great challenges such as the modeling of large variations of elastic properties of the probed medium, material diffractions, source-sensor effects and the need for a reflectionless truncation of the computational domain.

In our talk, we consider acoustic sensing in a borehole environment, which is routinely used in exploratory geophysics. To reliably and efficiently simulate such a problem, we developed an axisymmetric time-harmonic finite-element formulation that couples acoustic phenomena within a fluid-filled borehole with elasticity in the probed rock formations. Our formulation incorporates adaptivity of the element size and approximation order, which enables the efficient resolution of complex waveforms and material interfaces. Using a goal-oriented adaptation strategy, the discretization is optimized with respect to the solution at the sensor rather than with respect to the solution over the entire domain. No user interaction is necessary to control the adaptivity, since it is fully automatic. Finally, combining the Perfectly Matched Layer absorbing boundary condition with finite-element adaptivity effectively truncates the computational domain while minimizing reflections to a user-specified tolerance. We present several challenging benchmark problems that confirm the accuracy, reliability and efficiency of our method to compute the time and space response of complex waveforms excited into a fluid-filled borehole that penetrates layered media. This is joint work with David Pardo, Leszek Demkowicz and Carlos Torres-Verdín.

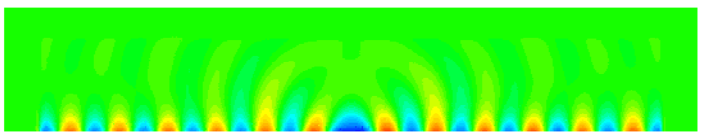

Figure 1: Elastic wave propagation along the borehole interface and in the probed rock formation.