NUMERICAL MODELISATION OF TRANSIENT POROELASTIC WAVES

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Abstract. The propagation of waves in porous media has many crucial implications in applied mechanics, in situations where materials such as industrial foams, spongious bones or petroleum rocks have to be characterized, for example. The poroelastic models originally developed by Biot in 1956 [1, 2] include two classical waves (one "fast" compressional wave and one shear wave), in addition to a second "slow" compressional wave. The presence of this second wave, whose behavior depends highly on the frequency regime, makes the numerical modeling tricky. The numerical tool we have developed to approximate the Biot's models combines different methods:

- a forth order ADER scheme to handle accurately the wave propagation
- a second order Strang splitting of the system to obtain optimal CFL condition
- an efficient discretization of the fractional derivatives of order 1/2 that appear in the high frequency model
- an immersed interface method coupled with a local mesh refinement in space and time to account for heterogeneous media.

Numerous numerical experiments will be presented, including comparisons with exact solutions, propagation through multilayered porous media and multidiffusion problems.

Keywords: Biot's model, poroelastic waves, high-order finite differences, immersed interface method, mesh refinement, fractional derivatives

Mathematics Subject Classifications (2000): 35L05, 35L50, 65N06, 65N85, 74F10

References

[1] M. A. Biot, *Theory of propagation of elastic waves in a fluid-saturated porous solid. I: Low-frequency range*, J. Acoust. Soc. Am., 28-2 (1956), 168-178.

[2] M. A. Biot, *Theory of propagation of elastic waves in a fluid-saturated porous solid. II: High-frequency range*, J. Acoust. Soc. Am., 28-2 (1956), 179-191.

[3] G. Chiavassa, B. Lombard, *Time domain numerical modeling of wave propagation in 2D heterogeneous porous media*, J. Comput. Phys., 230-13 (2011), 5288-5309.

[4] G. Chiavassa, B. Lombard, *Wave propagation across acoustic /Biot's media: a finite-difference method*, Commun. Comput. Phys., in press (2012).

[5] G. Lefeuve-Mesgouez, A. Mesgouez, G. Chiavassa, B. Lombard, *Semi-analytical and numerical methods for computing transient waves in 2D acoustic / poroelastic stratified media*, Wave Motion, 49 (2012) 667-680.

[6] E. Blanc, G. Chiavassa, B. Lombard, *Biot-JKD model: simulation of 1D transient poroelastic waves with fractional derivatives*, submitted to J. Comput. Phys., (2012).

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