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Towards a nonlinear nonlocal (fractional) poromechanic models

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Modeling transients of pressure, temperature, pollutants in porous fluid saturated rocks is a rather difficult task. In particular, (i) nonlinear rock parameters bring to nonlinear evolution equations and (ii) local variability of these parameters needs to to be properly investigated.
In this context, recently, some theoretical results about 1-D nonlinearities have been found in some articles (e.g., Merlani et al., 2011; Garra & Salusti, 2013; Caserta et al., 2015; 2017; Droghei & Salusti, 2015; Garra et al., 2015). By analyses of the symmetry of considered evolution equations, the solutions are essentially functions of x2/t (with x the 1-D space in linear, radial or cylindrical coordinate systems..... and t the time). One can feel that these early results are far from constituting a general solution of full nonlinear models but some new ideas are obtained.....Moreover, from Garra et al. (2015) one can see that fractional derivatives (space or time averages of usual punctual derivatives) can be of some utility about the second problem (ii), namely to overcame the well known local variability of the rock intrinsic parameters. Indeed if one doesn't consider punctual space derivatives but a space average values in a rather large geological zone, such local variability can somehow be simplified. This kind of fractional differential models are however difficult to handle being related to a very complex mathematical treatment. One can, however, remark how fractional derivatives of polynomials are proportional to another polynomial, thus models of nonlinear fractional equations can have relatively simple solutions, a facts of remarkable practical utility. This kind of analysis can thus be applied to some poro-mechanic problems, of interest as new analyses of classical transient problems as thermal pressurization, micro-earthquake clouds evolution, pollutant nonlinear diffusion, deep oil drilling, or classical building conservation.
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