Karlsruhe Institute of Technology

Seminar series of the Graduate School GRK 2078

Referee: **Prof. Patrizia Trovalusci**
Department of Structural and Geotechnical Engineering
Sapienza University of Rome

Date: Tuesday, February 28, 2023

Time: 14:00-15:00h

Location: Online / ZOOM

Title: **Discrete-Continuos Models for Microstructured Materials: Non Classical/Non-Local Descriptions, with applications to composites and masonry**

Abstract

The mechanical behaviour of materials with microstructure strongly depends on their microstructural features. In particular, in the modelling of these materials, such as particle composites that are polycrystals with interfaces or with thin or thick interfaces, as well as rock or masonry-like materials, the discrete and heterogeneous nature of the matter must be taken into account, because interfaces and/or material internal phases dominate the gross behaviour. And this is definitely ascertained. What is not still completely recognized, is the possibility of preserving memory of the microstructure, and of the presence of material length scales, resorting to non-classical/non-local continuum descriptions [1, 2, 3].
The classical/local Cauchy continuum (grade1), lacking in material internal scale parameters, does not seem appropriate for describing the macroscopic behaviour in problems dominated by the material internal size, such as strain/stress localisation phenomena, occurring even in the elastic regime in the presence of geometrical or load singularities (cracks/holes/inclusions, concentrated loads) [4, 5, 6, 7]. Moreover, the absence proper kinematical descriptors inhibit the possibility of taking into account of the orientation of micro-heterogeneities (inclusions/voids) and to adequately represent anisotropic behavior [4, 7]. Especially for materials made of particles of prominent size and/or strong anisotropy anisotropic media, the resort to non-classical/non-local continuum descriptions is then required.
This talk wants to firstly focus on the origins of multiscale modelling, related to the original discrete(molecular)-continuous models, developed in the 19th century to give explanations ‘per causas’ of elasticity (Cauchy, Voigt, Poincare), in order to find conceptual guidelines for deriving discrete-to scale-dependent continua, that are essentially non-local models with internal length and dispersive properties [1, 2].

Then, a discrete-to-scale dependent continuous formulation, developed for particle composite materials basing on a generalized version of Voigt's molecular/continuum approach, is proposed [8, 9, 10]. Finally, with the aid of some numerical simulations - concerning ceramic matrix composites (CMC), microcracked media and masonry assemblies – focus will be on the advantages of the micropolar modelling with respect to other non-classical/non-local continuum formulations [4, 5, 6, 7, 11].

References:

[1] I. A. Kunin (1984), On foundations of the theory of elastic media with microstructure, Int. J. Engng. Sci., 22(8-10):969-968.
[2] P. Trovalusci (2014), Molecular approaches for multifield continua: origins and current developments. CISM (Int. Centre for Mechanical Sciences) Series, 556: 211-278, Springer.
[3] P. Trovalusci, Ed. (2016), Materials with Internal Structure. Multiscale and Multifield Modeling and Simulation, Springer Tracts in Mechanical Engineering, Vol.18:109-131, Springer.
[4] N. Fantuzzi, P. Trovalusci, S. Dharasura (2019), Mechanical behaviour of anisotropic composite materials as micropolar continua, Frontiers, **59** (6):1-11 (https://doi.org/10.3389/fmats.2019.00059).
[5] M. Tuna, L. Leonetti, P. Trovalusci, M. Kirka (2019), 'Explicit' and 'implicit' non-local scale dependent continuous descriptions for a plate with a circular inclusion in tension, Meccanica (https://doi.org/10.1007/s11012-019-01091-3).
[6] M. Tuna, P. Trovalusci (2020), Scale dependent continuum approaches for discontinuous assemblies: 'explicit' and 'implicit' non-local models", Mech. Res. Comm, **103**, 103461, (https://doi.org/10.1016/j.mechrescom.2019.103461).
[7] N. Fantuzzi, P. Trovalusci, R. Luciano (2020), Multiscale analysis of anisotropic materials with hexagonal microstructure as micro-polar continua, Journal for Multiscale Computational Engineering, x(x): 1–29, 2020. In print.
[8] P. Trovalusci, V., Varano,, G. Rega (2010), A generalized continuum formulation for composite materials and wave propagation in a microcracked bar, J. Appl. Mech., 77(6):061002/1-11.
[9] P. Trovalusci, A. Pau (2014), Derivation of microstructured continua from lattice systems via principle of virtual works. The case of masonry-like materials as micropolar, second gradient and classical continua" Acta Mech., 225(1):157-177
[10] V. Settimi, P., Trovalusci, G. Rega (2019), Dynamical properties of a composite microcracked bar based on a generalized continuum formulation, Cont. Mech. Thermodyn., **31**(6):1627-1644
[11] M. Colatosti, F. Shi, N. Fantuzzi, P. Trovalusci, Mechanical characterization of composite materials with rectangular microstructure and voids, Archive of Applied Mechanics, 202210.1007/s00419-022-02142-0, 2022

You are cordially invited to take part in the event.

Prof. Dr.-Ing. Thomas Böhlke
(Spokesperson of GRK 2078)