

Spotlights in Computational Physics and Engineering (SCoPE)

Invited lectures on:

Metamaterials: a continuum modelling approach

Rizzi*

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Abstract

Metamaterials, a captivating and innovative category of materials, have garnered significant attention due to their extraordinary mechanical properties. Microstructures and intricate geometric arrangements engineered these materials, showcasing traits such as extreme lightweightness, negative Poisson's ratio, chirality, band gaps, dispersion, Bragg-scattering, local resonance, and even apparent negative mass density. Exploring characteristics from dynamic and static perspectives reveals their versatility.

In particular, static metamaterials find applications in various fields. Key static features include a high stiffness-to-weight ratio, negative Poisson's ratio enabling simultaneous expansion in both directions, and tuneable properties adaptable to specific aims through microstructure parameter adjustments.

On the other hand, dynamic metamaterials aim to tailor mechanical properties for unconventional dynamical behaviours. Notable dynamic features include vibration control for applications like designing advanced acoustic devices, noise reduction, wave propagation control, tailored dynamic responses for impact protection or energy absorption, and shock absorption capabilities. One promising approach to model metamaterials involves employing generalized continua, extending conventional continuum mechanics to effectively capture the intricate microstructures and unconventional material responses inherent in them.

The lectures are structured as follows:

1. Equilibrium equations and boundary conditions for the Cauchy model and the relaxed micromorphic model (a model that belongs to the micromorphic family) will be obtained by means of variational principle. The positive definiteness, the energy conservation and the Galilean invariance. A particular kind of boundary condition for micromorphic models will be proposed.
2. Analytical solutions for the Relaxed Micromorphic Model (RMM) in statics will be presented for the following test: simple shear, uniaxial extension, cylindrical bending, and torsion of a cylindrical rod.
3. Introduction to the dynamics of metamaterials: how to obtain the dispersion relation and characterise their properties.
4. Solutions in dynamics: semi-finite size and finite size examples in dynamics.

When and Where?

- ▶ 14.03.2024, 10:00-12:00, Maison du Nombre, MNO 1.030
- ▶ 15.03.2024, 10:00-12:00, Maison du Nombre, MNO 1.030

Invitee: Gianluca Rizzi*

GIANLUCA RIZZI has been a postdoctoral researcher at the Chair of Continuum Mechanics, Technical University of Dortmund, since 2021. Before joining Dortmund, he worked as a postdoctoral researcher at the GEOMAS laboratory, INSA Lyon. His research interests revolve around modelling metamaterials using generalized continua both in statics and dynamics.



Selected Publications

- ▶ J. Voss, G. Rizzi, P. Neff, A. Madeo Modeling a labyrinthine acoustic metamaterial through an inertia-augmented relaxed micromorphic approach. *Mathematics and Mechanics of Solids*, 28(10), 2177-2201, (2023).
- ▶ M.V. d'Agostino, G. Rizzi, H. Khan, P. Lewintan, A. Madeo, P. Neff The consistent coupling boundary condition for the classical micromorphic model: existence, uniqueness and interpretation of parameters. *Continuum Mechanics and Thermodynamics*, 34(6), 1393-1431, (2022).
- ▶ G. Rizzi, G. Hütter, H. Khan, I.D. Ghiba, A. Madeo, P. Neff. Analytical solution of the cylindrical torsion problem for the relaxed micromorphic continuum and other generalized continua (including full derivations). *Mathematics and Mechanics of Solids*, 27(3), 507-553, (2022).
- ▶ G. Rizzi, H. Khan, I.D. Ghiba, A. Madeo, P. Neff. Analytical solution of the uniaxial extension problem for the relaxed micromorphic continuum and other generalized continua (including full derivations). *Archive of Applied Mechanics*, 1-17, (2021).
- ▶ G. Rizzi, G. Hütter, Madeo, P. Neff. Analytical solutions of the cylindrical bending problem for the relaxed micromorphic continuum and other generalized continua. *Continuum Mechanics and Thermodynamics*, 33, 1505-1539, (2021).
- ▶ G. Rizzi, G. Hütter, Madeo, P. Neff. Analytical solutions of the simple shear problem for micromorphic models and other generalized continua. *Archive of Applied Mechanics*, 91(5), 2237-2254, (2021).