IUTAM Symposium on

Generalized continua emerging from microstructures

19–23 July 2021
Paris, France
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The mechanics of generalized continua has become a well-established field of continuum mechanics of materials and structures, with many applications in computational mechanics. It includes gradient approaches (strain gradient media or gradient of mechanical variables like plastic strain or damage parameters) and higher order continua that rely on the introduction of additional kinematic degrees of freedom (Cosserat or micromorphic theories for instance). It is now well-accepted that such approaches are necessary in particular for the analysis of strain localization phenomena, up to fracture. They are also very effective for the description of size effects in the linear and nonlinear mechanical behavior of materials and structures. However, the formulation of such models very often remains purely phenomenological even though the origin of the generalized contributions is attributed to the underlying microstructure.

The objective of this symposium is to bring together experts in the field of generalized continua and homogenization methods in order to elaborate strategies for the construction of higher order theories starting from the detailed knowledge of the properties of the microstructure. The main features of the microstructure are very often of discrete nature: defects in crystalline solids or granular media, beam networks or unit cells in architectured materials or composites. How to predict size effects and the associated effective characteristic lengths from the collective behavior of defects under load or from the unit cell deformation fields in periodic media?

Fruitful discussions are expected between experts in the development of thermodynamically consistent phenomenological strain gradient theories and specialists of homogenization and coarse graining methods. The targeted material and structural properties are the static elastic-plastic and damage responses but also the dynamic behavior of architectured materials. The dispersion of waves in heterogeneous materials like metamaterials can be described successfully by generalized continuum models. We expect that the meeting of experts from different communities will result in common or alternative strategies to address scale bridging from microstructures to generalized continua. Generalized continuum models can be only validated by comparison and identification with field measurements which are now striving in experimental mechanics: crystal lattice orientation and dislocation density field by diffraction, strain field measurements by digital image correlation. This experimental information will be presented in the Symposium.

**Conference topics**

- Theory of generalized continua
- Instabilities and localization
- Strain gradient plasticity
- Crystal plasticity
- Homogenization and generalized continua
- Discrete defects in solids
- Computational mechanics of generalized continua
- Metamaterials
- Geomaterials
- Gradient damage and fracture
- Phase field approaches
Scientific Committee

- P. Gumbsch (KIT, Karlsruhe, Germany)
- G. Hu (Beijing Institute of Technology, China)
- V. Kouznetsova (TU Eindhoven, The Netherlands)
- J. Kysar (Columbia, New York, USA)
- D. McDowell (GeorgiaTech, Atlanta, USA)
- G. Milton (University of Utah, Salt Lake City, USA)
- C. Niordson (DTU, Lyngby, Denmark)

**IUTAM representative:** N. Fleck (Cambridge, UK)

Conference chair

Samuel Forest (CNRS Research Director, Centre des Matériaux, Mines ParisTech) and Francesco dell’Isola (Director of MEMOCS, Sapienza Università di Roma)

Local organizing committee

Samuel Forest, Sandrine Laurent-Fontaine, Aldo Marano (Mines ParisTech), Jean–Michel Scherer (LMS Ecole Polytechnique)

Symposium website

[https://iutam-2021-gc.sciencesconf.org](https://iutam-2021-gc.sciencesconf.org)
## Detailed program

**Monday 19 July 2021**

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
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<tbody>
<tr>
<td>12:00</td>
<td><strong>Registration and welcome (mini) lunch at Mines ParisTech</strong></td>
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</table>
| 13:45  | *Introduction of the Symposium and presentation of the IUTAM*  
Samuel Forest and Henryk Petryk |
| 14:00  | *Explicit harmonic structure of bidimensional linear strain-gradient elasticity*  
Nicolas Auffray |
| 14:30  | *Multiphase continua for fiber-reinforced materials*  
Jérémie Bleyer |
| 15:00  | *Local micromorphic non-affine anisotropy*  
Sebastian Skatulla |
| 15:30  | *Microtwist elasticity: Zero modes and polarization in kagome lattices*  
Hussein Nassar |
| 16:00–16:30 | **Coffee break**                                                                                   |
| 16:30  | *Gradient materials: The different behavior of free boundaries of a body and the fictitious cut around some subbody*  
Arnold Krawietz |
| 17:00  | *Modelling contact interactions of generalized continua: microblock contact model for a Cosserat body*  
Stanislaw Stupkiewicz |
| 17:30  | *Three-dimensional solids and structures within strain gradient elasticity: numerical methods and model comparisons*  
Jarkko Niiranen |
| 18:00–19:30 | **Get together cocktail and buffet**                                                                |
Crystal plasticity
8:30  A FFT-based approach for Mesoscale Field Dislocation Mechanics: applications to internal length scale effects in polycrystals and steel matrix composites
Stephane Berbenni

9:00  A mesoscale continuum approach of dislocation dynamics and the approximation by discontinuous Galerkin methods
Christian Wieners

9:30  Modeling plastic slip localization within polycrystals
Aldo Marano

10:00 On the control of elastic gaps in Gurtin-type strain gradient crystal plasticity theories using uncoupled dissipation assumption
Mohamed Jebahi

10:30–11:00  Coffee break

11:00  Microstructural aspects of gradient-enhanced crystal plasticity
Henryk Petryk

11:30  Plastic flow and dislocation strengthening in a continuum formulation of dislocation dynamics
Katrin Schulz

12:00  Analytic solutions for strengthening of a strain gradient plasticity material reinforced by small elastic particles
Jonas Faleskog

12:30–14:00  Lunch buffet at Mines ParisTech

Strain gradient plasticity
14:00  Distortion gradient plasticity modelling of the small-scale behaviour of metals under non-proportional loading
Lorenzo Bardella

14:30  A phase field fracture and strain gradient plasticity-based model for predicting hydrogen embrittlement
Emilio Martinez-Paneda

15:00  Niordson

15:30  Enhanced Strength of Cu-Gr-Cu nanolaminate
Jeff Kysar

16:00–16:30  Coffee break

16:30  The evolution of Hooke’s law under finite plastic deformations for fiber reinforced materials
Albrecht Bertram

17:00  A stochastic solver based on the residence time algorithm for crystal plasticity models
Jaime Marian

17:30  Gradient models for softening thermo-plasticity at large strain
Jerzy Pamin
### Homogenization and generalized continua

<table>
<thead>
<tr>
<th>Time</th>
<th>Title</th>
<th>Speaker</th>
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<tbody>
<tr>
<td>8:30</td>
<td><strong>Green functions and integral representation of anisotropic second gradient continua</strong>&lt;br&gt;The case of pantographic lattices</td>
<td>Claude Boutin</td>
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<tr>
<td>9:00</td>
<td><strong>Predictive strain-gradient homogenization of a pantographic material</strong>&lt;br&gt;with compliant junctions and experimental evidence</td>
<td>Arthur Lebée</td>
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<tr>
<td>9:30</td>
<td><strong>Nonlinear gradient models in hyper-elasticity:</strong>&lt;br&gt;from slender structures to architectured materials</td>
<td>Claire Lestringant</td>
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<td>10:00</td>
<td><strong>Direct FE2 for concurrent multiscale modelling of heterogeneous thin plate structures</strong></td>
<td>Leong Hien Poh</td>
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<td>10:30–11:00</td>
<td><strong>Coffee break</strong></td>
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Thursday 22 July 2021

Instabilities and generalized continua
8:30  Generalized continuum models confronted to cell-commensurate instabilities in structured media
Christelle Combescure
9:00  Capturing microscopic and macroscopic instabilities in mechanical metamaterials by micromorphic computational homogenization
Ron Peerlings
9:30  Determination of homogenized continua behaviors from actual printed microstructures
Maxence Wangermez
10:00 A gradient-extended large-strain anisotropic damage model with crack orientation director
Stephan Wulfinghoff

10:30–11:00  Coffee break

11:00  Energetic versus dissipative gradient damage models: A comparative analysis
Djimedo Kondo
11:30  Thermal pressurization of earthquake faults under large co-seismic slip using Cosserat continuum
Ioannis Stefanou
12:00  A granular-based elasto-plastic–damage energy formulation for strain gradient solids
Luca Placidi
12:30–14:00  Lunch buffet at Mines ParisTech

Fracture of materials
14:00  Development, implementation and application of a second-gradient model for porous ductile solids
Jean-Baptiste Leblond
14:30  An FFT framework for simulating non-local ductile failure in heterogeneous materials
Javier Segurado
15:00  A strain-gradient plasticity model of ductile failure in porous single crystals
J.M. Scherer
15:30  Damage in periodic composite materials resulting from a micromechanics-based phase field approach
Marco Paggi
16:00–16:30  Coffee break

Diffusion and phase field methods
16:30  Mass transport and shape changes in nonhomogeneous sintering
Sinisa Mesarovic
17:00  B. Appolaire
17:30–18:00  A phase-field enhanced Cosserat model for prediction of microstructure evolution
Anna Ask
Metamaterials
8:30 Some perspectives on the Willis equations
Graeme Milton
9:00 Interfacial wave between two acoustic bianisotropic materials
Gengkai Hu
9:30 An examination of primitive causality in linear generalized continuum theories
Venkata Mutnuri
10:00 Elastic wave propagation in non-centrosymmetric and chiral architectured materials: insights from strain gradient elasticity
Giuseppe Rosi
10:30–11:00 Coffee break
11:00 An enriched continuum framework for metamaterial panels obtained through computational homogenization and model order reduction
Varvara Kouznetsova
11:30 Wave propagation control in active metamaterial with shunted piezoelectric microstructure
Maria Laura De Bellis
12:00 Local material symmetry group for first- and second-order strain gradient materials with application to fluids and subfluids
Victor Eremeyev
12:30 Piola transformation of stress and double stress in second gradient continua
Francesco dell’Isola
13:00–14:00 Lunch buffet at Mines ParisTech

End of the IUTAM Symposium
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USA  5
Poland  4
The Netherlands  2
China  1
Denmark  1
Finland  1
India  1
Russia  1
Singapore  1
Spain  1
Sweden  1
United Kingdom  1
The IUTAM Symposium will take place at Mines ParisTech, in the center of Paris, close to the Luxembourg Garden.

**Address:** Mines ParisTech, 60 Boulevard Saint-Michel, 75006, Paris, France
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- How to get to Mines ParisTech from Public transportations:
  Mines ParisTech can be accessed by regional train line (RER B), by metro or by bus. The closest train/bus stations are listed on the Symposium webpage.

- How to get to Mines ParisTech from Paris Airports: Both Paris airports are connected to the RER line B, which is directly connected to Mines ParisTech. To reach it, take the RER B and get off at the Luxembourg station (see above).

  - To reach Paris from Orly airports, you will find indications on the webpage of the symposium
  - To reach Paris from Charles de Gaulle airport, you will find indications on the webpage of the symposium
One of the largest collections in the world: 100000 samples, 4000 exposed (cf. British museum, Freiberg museum), in connection with Museum d’histoire naturelle.

René-Just Haüy: Founder of crystallography
the ceiling of the majestic staircase leading to the museum