EUROPEAN MECHANICS SOCIETY

Colloquium Final Report

N. 642 – International Colloquium on Multiscale and Multiphysics Modelling for Advanced and Sustainable Materials

Dates and location: **22/09/2024 - 27/09/2024, Rome, Italy**

Chairperson **Patrizia Trovalusci (Sapienza University of Rome)**

Co-Chairperson **Adnan Ibrahimbegovic(Alliance Sorbonne Universite), Tomasz Sadowski(Lublin University of Technology)**

Conference fees

- Early-bird registration **500.0 €**
- Early-bird Poster presentation **250.0 €**
- Early-bird Accompanying person **150.0 €**
- Late registration **570.0 €**
- Late registration Poster presentation **300.0 €**
- Late registration Accompanying person **170.0 €**
- Keynote registration **0.0 €**

What other funding was obtained? **To be completed**

What were the participants offered? **We offered 1 Welcome Cocktail on the Opening Day of the Colloquium, Sunday September 22, 2 Coffee Breaks per day from Monday September 23 to Thursday September 26, one Coffee Break on the last day of the Colloquium, Friday September 27, and one Lunch per day, from Monday September 23 to Friday September 27. A Gala Dinner was also offered on the evening of Thursday September 26.**

Each participant was offered a kit with cotton bag, A5 notepad, pen, pencil, folder, conference programme and certificate of participation.

Keynote Speakers were also offered university hotel accommodation.

Participants were offered the opportunity to publish Accepted Abstracts and Full papers on the Springer Series Advanced Structured Materials https://www.springer.com/series/8611

Selected talks will also be invited to submit a contribution to dedicated Special Issues of International Journals (after standard peer-reviewing process):
- Composite Structures https://www.sciencedirect.com/journal/composite-structures

- Journal of Materials Science: Materials Theory, https://www.springeropen.com/collections/mmmcm

- Advanced Modeling and Simulation in Engineering Sciences (AMSES), https://amses-journal.springeropen.com/

- Mechanics of Size-Dependent Materials and Structures Springer Topic Collection of SN Applied Sciences, https:// link.springer.com/collections/jbbaajdjig.

Number of members of Euromech (reduced registration fee) **53**

Number of non-members of Euromech (full registration fee) **44**

Applicants (members)

- Daniela Addessi
- Holm Altenbach
- Fabrice Barbe
- Raffaele Barretta
- Riccardo Barsotti
- Tarak Ben Zineb
- Igor Berinskii
- Davide Bernardini
- Matteo Bruggi
- Francesco Cannizzaro
- Carlo Massimo Casciola
- Andrea Chiozzi
- massimo cuomo
- Nico De Marchi
- Giuseppe Failla
- Paolo Fuschi
- Ugo Galvanetto
- jean-françois GANGHOFFER
- Håkan Hallberg
- Thomas Hochrainer
- Adnan Ibrahimbegovic
- Mikhail Itskov
- Mahmood Jabareen
- Panayiota Katsamba
- Sandra Klinge
- Giovanni Lancioni
- Jean-Baptiste Leblond
- Frederic Lebon
- Marco Lepidi
- Sonia Marfia
- Michele Marino
- Michelina Monaco
- Carole Nadot-Martin
- Greta Ongaro
- Anna Pandolfi
- Annamaria Pau
- Marco Pingaro
- Aurora Angela Pisano
- Paolo Podio-Guidugli

- Valentina Salomoni
- Reuven Segev
- Laurent Stainier
- Georgios Stavroulakis
- George Stefanou
- Jean Sulem
- Giuseppe Tomassetti
- Patrizia Trovalusci
- Giuseppe Vairo
- Paolo Sebastiano Valvo
- Hans van Dommelen
- Marcello Vasta
- Peter Wriggers
- Julien Yvonnet

Applicants (non members)

- Imene Abidi
- Benoit Appolaire
- Anna Ask
- Viacheslav Balobanov
- Daniela Boldini
- Luis Bonilla
- Laurence Brassart
- Matthew Cartmell
- Emilio Nicola Maria Cirillo
- Maeva Cottura
- Kostas Danas
- Maria Laura De Bellis
- Orkun Furat
- Tomasz Garbowski
- Pierfrancesco Gaziano
- Davide Noè Gorini
- Alex Hansen
- Christian Hellmich
- Heng Hu
- Marcin Kamiński
- Pierre LADEVEZE
- Lorenzo Leonetti
- Zhanyu Li
- Matti Lindroos
- Egidio Lofrano
- Thierry J. Massart
- Anil Misra
- Marco Montemurro
- Antonino Morassi
- Amy Novick-Cohen
- CARMELO PANNITTERI
- Antonina Pirrotta
- Luca Placidi
- Pedro Ponte Castañeda
- Emanuele Reccia
- Jan Rots
- Giuseppe Ruta
- Vladimir Sladek
- Nandini Priya Thatikonda

- Meral Tuna
- Marzia Sara Vaccaro
- Jianxiang Wang
- Henning Wessels
- Gabriel Wittum

Scientific Report

To be completed

Number of participants from each country

Country	Participants
Germany	6
Italy	47
Sweden	1
France	16
Poland	2
Slovakia	1
United States	2
Netherlands	2
Israel	4
United Kingdom	2
Greece	2
Austria	2
Finland	2
Norway	1
China	3
Saudi Arabia	1
Belgium	1
Spain	1
Cyprus	1
Total	**97**

Please send this report in electronic form to the Secretary General of EUROMECH, within one month after your Colloquium.

Scientific report Colloquium 642

The Colloquium chaired by Prof. Trovalusci (Sapienza University of Rome), Prof. Ibrahimbegovic (Alliance Sorbonne Universite) and Prof. Sadowski (Lublin University of Technology) was focused on the "Multiscale and Multiphysics Modelling of Complex Materials", with attention to the constitutive aspects concerning complex materials, so defined for the presence of internal structure at different scales (nano/micro/meso) and non-linear constitutive behaviour (plasticity, damage, fracture, etc.). Particular interest concerned the modelling of non-classical/non-local continuous models, which keep memory of the internal structure and whose field equations contain lengths of internal scale which allow avoiding, in numerical solutions, problems of convergence and dependence on the adopted discretisation.

The Colloquium served as a platform for presenting and discussing various advanced computational, experimental, and analytical techniques for examining the behaviour of complex materials and structures. The objective was to bring together researchers (engineers, physicists, mathematicians) who specialised in multiscale material modelling to simulate the mechanics of solids and the physics of matter. The goal was to bridge the gap between Solids and Structural Mechanics and Material Science in modelling of complex materials. Theoretical, computational and experimental approaches were prominently featured, and presentations covered a wide range of topics related to either material or structural modelling.

Various types of complex materials, made of different constituents, are used nowadays in engineering practice: particle or fibrous composites; laminates; green composites with natural fillers and industrial or urban recyclable materials; nanomaterials; architectured materials; in general complex multiphase materials with a complex internal structure including: porosity, reinforcements in the form of short fibres and particles of various properties, shapes and sizes, filled in different matrices.

It is widely recognised that important macroscopic properties such as stiffness and strength are governed by multiphysics processes (e.g., damage due to heat transfer or fluid penetration, crack propagation under thermal shock in ceramic/metallic matrix composites, etc.) which occur at one to several scales below the level of observation. A thorough understanding of how these processes influence the reduction of stiffness and strength is a key to the analysis of existing, and the design of improved, complex materials.

In this framework, the interest and suitability of multiscale strategies bridging different material scales were highlighted, as well as their engineering applications. The focus was set on computational issues, while still highlighting the underlying conceptual and theoretical basis. Advances in multiscale modelling and analysis were directly relevant to materials with a wide range of microstructural scales, such as metals, or to those with random microstructures, like ceramic matrix composites or cementitious composites.

The main topics of the Colloquium are summarised below:

-Multiscale and multiphysics aspects of material modelling
-Mathematical and computational foundations of multiscale approaches
-Material classes: structural, multi-functional, nano/microstructured materials, bioinspired and soft

materials
-Material properties: elasticity, fracture, damage, plasticity, thermo-mechanics, viscosity
-Non-standard/non-local continuous formulations for materials with microstructure
-Multiscale design and optimisation
-Multi-objective homogenisation-based topology optimisation
-Atomistic/molecular models and applications to continuum mechanics problems
-Statistical and mesoscale materials modelling
-Hierarchical/concurrent multiscale modelling approaches
-Additive manufacturing, architected materials and metamaterials
-Data-driven material design and Artificial Intelligence
-Synergistic coupling of experiments with multiscale modelling

A total of 80 contributions were presented, including 10 keynote lectures, and a poster session dedicated to young researchers. All sessions took place over the days from 23 to 27 September, 2024. The accepted abstracts and full papers were published in the *Springer Series Advanced Structured Materials* (https://link.springer.com/book/10.1007/978-3-031-84379-2), after a peer-reviewing process. The Special Issue was curated by Prof. Trovalusci, Prof. Sadowski, and Prof. Ibrahimbegovic, who coordinated the overall selection and organisation of the contributions. Additionally, the published papers were carefully supervised and curated by Dr. Ongaro, Dr. Pingaro, and Dr. Colatosti, ensuring the quality and coherence of the content.
Selected contributions were invited to submit full papers to the International Journal *Composite Structure*s (https://www.sciencedirect.com/special-issue/10DRHVDTK7S). The Special Issue, which was edited by Prof. Trovalusci, Prof. Ibrahimbegovic, Prof. Sadowski, and Prof. Fantuzzi, is now in print.