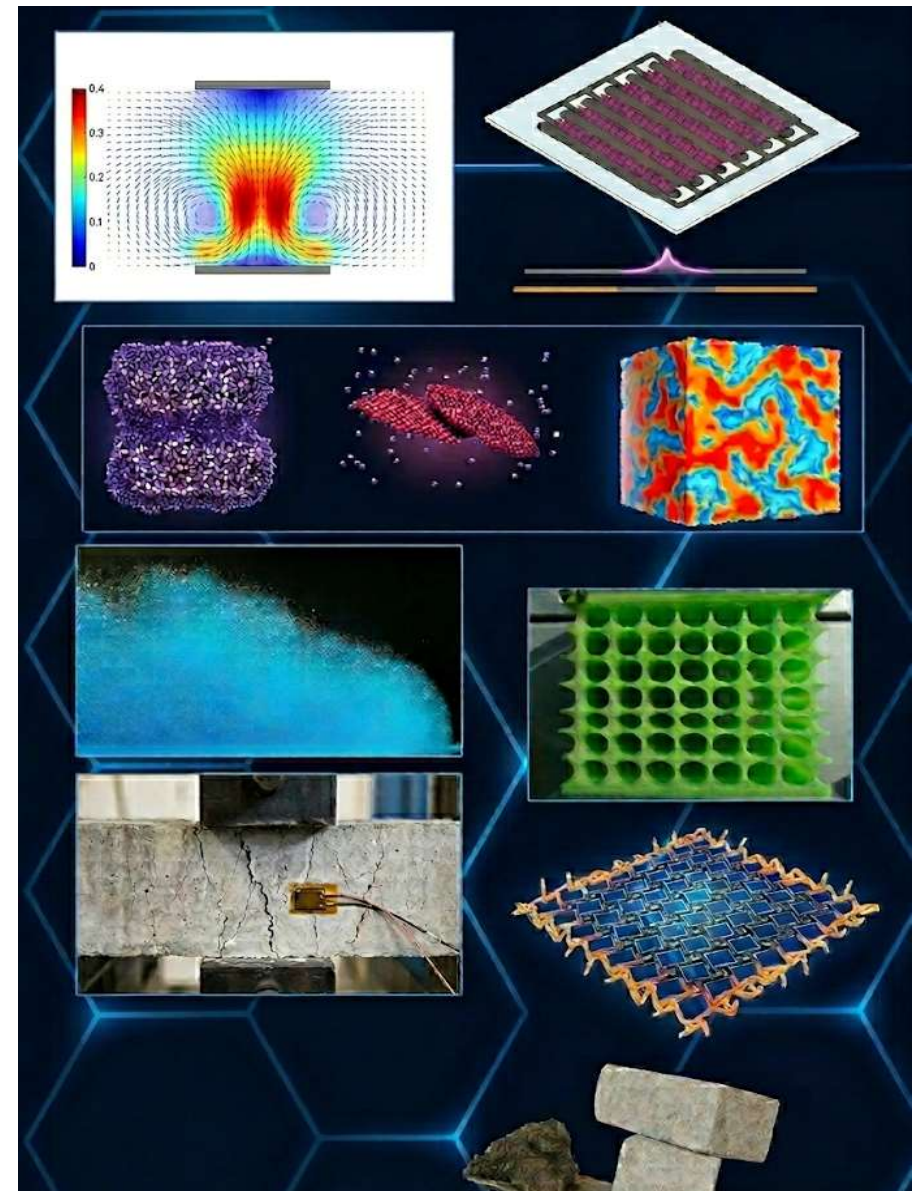


NEWSLETTER 54

EUROPEAN
MECHANICS
SOCIETY

Year 2024



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Addresses for EUROMECH Officers

President: Professor Marc Geers Department of Mechanical Engineering Eindhoven University of Technology
P.O. Box 513, 5600 MB Eindhoven, The Netherlands
E-mail: m.g.d.geers@tue.nl
Tel: +31 40 2475076

Vice President: Professor GertJan van Heijst Fluid Dynamics Laboratory, Department of Physics Eindhoven University of Technology
PO Box 513, 5600 MB Eindhoven, The Netherlands
E-mail: g.j.f.v.heijst@tue.nl
Tel.: +31 40 2472722

Secretary-General: Professor Jacques Magnaudet Institut de Mécanique des Fluides de Toulouse Allée du Professeur Camille Soula 31400 Toulouse, France
E-mail: jacques.magnaudet@imft.fr
Tel.: +33 (0)5 34 32 2807

Treasurer: Professor Stefanie Reese Institute of Applied Mechanics RWTH Aachen University Mies van der Rohe-Str. 1 D-52074 Aachen, Germany
E-mail: Stefanie.Reese@uni-siegen.de
Tel.: +49(0)241 80 2500 0

Newsletter assistant: Dr Sara Guttilla (E-mail: info@euromech.org)

Web page: <http://www.euromech.org>

EUROMECH Council Members 2024

MARC GEERS, Department of Mechanical Engineering, Eindhoven University of Technology, P.O. Box 513, 5600 MB Eindhoven, The Netherlands
■ E-mail: m.g.d.geers@tue.nl

GERT JAN F. VAN HEIJST, Eindhoven University of Technology, Phys. Dept., Fluid Dynamics Lab., P.O. Box 513, NL-5600 MB Eindhoven, The Netherlands
■ E-mail: g.j.f.v.heijst@tue.nl

JACQUES MAGNAUDET, Institut de Mécanique des Fluides de Toulouse, Allée du Professeur Camille Soula, 31400 Toulouse, France ■ E-mail: Jacques.Magnaudet@imft.fr

STEFANIE REESE, Institute of Applied Mechanics, RWTH Aachen University, Mies van der Rohe-Str. 1, D-52074 Aachen, Germany ■ E-mail: Stefanie.Reese@uni-siegen.de

PILAR ARIZA, Escuela Técnica Superior de Ingeniería, University of Seville, Camino de los Descubrimientos, 41092 Seville, Spain ■ E-mail: mpariza@us.es

ANNE JUEL, School of Physics & Astronomy, University of Manchester, Oxford Road, Manchester M13 9PL, UK ■ E-mail: anne.juel@manchester.ac.uk

ANKE LINDNER, Laboratoire de Physique et Mécanique des Milieux Hétérogènes, Sorbonne Université, Barre Cassan, Bat A, 1er étage Case 18, 7 quai Saint Bernard, 75005 Paris, France
■ E-mail: anke.lindner@espci.psl.eu

MARIA VITTORIA SALVETTI, University of Pisa, Department of Civil and Industrial Engineering, Largo Lucio Lazzarino, 56122 Pisa, Italy
■ E-mail: maria.vittoria.salvetti@unipi.it

OLE SIGMUND, Technical University of Denmark, Department of Mechanical Engineering, Koppels Allé 404, 134, 2800, Kgs. Lyngby, Denmark
■ E-mail: sigmund@mek.dtu.dk

GABOR STEPAN, Department of Applied Mechanics, Budapest University of Technology and Economics, Muegyetem rkp 3, Budapest, H-1111, Hungary
■ E-mail: stepan@mm.bme.hu

FERNANDO TAVARES DE PINHO, Departamento de Engenharia Mecânica, FEUP - Faculdade de Engenharia da Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal ■ E-mail: fpinho@fe.up.pt

Chairpersons of Conference Committees 2024

MATHIAS HEIL, Department of Mathematics, University of Manchester,
Oxford Road, Manchester M13 9PL, United Kingdom
■ E-mail: M.Heil@maths.man.ac.uk

JAVIER LLORCA, IMDEA Materials Institute, Eric Kandel, 2, Tecnoetafe,
28906 Getafe, Madrid, Spain ■ E-mail: javier.llorca@imdea.org

GAËTAN KERSCHEN, Department of Aerospace and Mechanical
Engineering, University of Liège, Allée de la Découverte, 9, B-4000 Liège,
Belgium ■ E-mail: g.kerschen@ulg.ac.be

GERHARD HOLZAPFEL, Institute of Biomechanics, Center of Biomedical
Engineering, Graz University of Technology, Kronesgasse 5-I, A-8010 Graz,
Austria ■ E-mail: holzapfel@tugraz.at

COLM-CILLE CAULFIELD, DAMTP, Centre for Mathematical Sciences,
Wilberforce Road, Cambridge CB3 0WA, United Kingdom
■ E-mail: C.P.Caulfield@damtp.cam.ac.uk

EUROMECH Conference Reports 2024

EMMC19 – 19th European Mechanics of Materials Conference

May 29–31, 2024, Madrid, Spain

Chairpersons: Prof. Javier Segurado and Prof. Carlos Gonzalez

Brief Summary

The 19th European Mechanics of Materials Conference (EMMC19) gathered researchers sharing a common interest in mechanics of materials from different perspectives including mechanical engineering, physics, biomechanics, applied mathematics, chemistry, etc. Contributions covered research at different length scales, including model development and validation, advanced experimental techniques and computational methods for mechanics of materials.

Financial support was provided by EUROMECH (€3,000), The Royal Society (€2,982), PSYLOTECH (€3,000), and TECHNODIGITAL SCHOOL (€1,000). The conference fee included a one-year EUROMECH membership (€30 value).

Participants

The total number of attendees was 552 participants; 524 persons paid their registration fees. 18 thematic parallel sessions were organized, coordinated by appointed session organizers.

Invited Speakers

Three plenary lecturers were selected by the EMMC scientific committee:

- Laura de Lorenzis (ETH Zurich): Material modeling in the era of AI: from sparse regression to the language of material laws;
- Davide Bigoni (University of Trento, Italy): Architected materials with tuned instabilities break the wall of hyperelasticity;
- Jon Molina (Universidad Politécnica de Madrid and IMDEA-Materials Institute): 4D printing of metallic alloys towards novel shape morphing medical devices.

Scientific Programme

18 thematic parallel symposia were organized on topics selected by the scientific committee:

S1: Processing-microstructure-mechanical behavior of polymers and biopolymers (34 participants); S2: Mechanics of composites: Experiments and modelling (39); S3: Mechanics of metals: Experiments and modelling (26); S4: Mechanics of architected materials (41); S5: Mechanics of multifunctional materials (14); S6: Advances in Additive Manufacturing (37); S7: Mechanics of soft materials and structures (38); S8: Fracture and damage (69); S9: Fatigue, reliability, and lifetime predictions (20); S10: Coupled problems in material mechanics (27); S11: Mechanics of biological materials & biomechanics (40); S12: Experimental mechanics and microstructural characterization (26); S13: Experimental nanomechanics (21); S14: Mechanics of porous and granular materials (26); S15: Advanced modelling techniques: Higher-order continua (17); S16: Advanced modelling techniques: Time and space scale bridging (28); S17: Mechanics of interfaces and phase transformations (16); S18: Data-driven mechanics of materials (27). A special session for the EuroMech best student presentation award was organized. Each symposium nominated one candidate for a 5-minute presentation before an expert committee.

Awards

Best Student Presentation: Nathan Vani (ESPCI-PSL)
 Accessit Best Student Presentation: Maryse Gille (Mines Paris-PSL)
 Best Poster (€500): Sylvain Vallot (Clement Ader)
 Accessit Best Poster: Margot Leclercq (ENS Paris Saclay)

Future Conferences

The next ESMC conference will be held in Lyon, France, July 2025 (Chairman: Eric Maire, INSA Lyon). The next EMMC conference will be organized in Florence, May 27–29, 2026, co-chaired by Roberto Brighenti, Marco Paggi, and Roberto Paronni.

EFDC1 – First European Fluid Dynamics Conference

16–20 September 2024, Aachen, Germany

Chairpersons: Prof. Wolfgang Schroeder

Brief Summary

The First European Fluid Dynamics Conference (EFDC1) is the merger of the European Fluid Mechanics Conference (EFMC) and the European Turbulence Conference (ETC). It took place in Aachen from 16 to 20 September 2024 and represented a landmark moment for the European fluid dynamics community.

The conference consisted of the Fluid Mechanics Prize lecture, 6 invited talks, 4 minisymposia, and numerous sessions in 56 scientific categories, resulting in a total of 165 scientific sessions. In addition to the scientific programme, a social programme highlighting Aachen's Charles the Great heritage and the cathedral was offered, along with a conference dinner on 17 September in the former market hall DAS LIEBIG.

Participants

Number of submitted abstracts: 1,257 (thereof 674 applications for the Young Scientist Award).

Number of accepted papers: 1,134; rejected: 123.

Number of presentations: 1,039.

Total number of participants (including RWTH staff): 1,096.

Countries with more than 50 participants:

France: 241 — Germany: 209 — United Kingdom: 94 — China: 85 — Italy: 74

— Netherlands: 62.

Awards

- Fluid Mechanics Prize: Tim Pedley.
- New Fluid Mechanics Fellows: Dwight Barkley, Eric Lauga, and John Tsamopoulos.
- Out of 674 Young Scientist Award applications, 125 were accepted for the final competition.
YSA Prize winners: Catherine Kamal (UCL, London) and Davide Selvatici (University of Twente).

Invited Speakers

Julien Chauchat, Aimee Morgans, Anke Lindner, Karen Mulleners, Gareth McKinley, and Christos Vassilicos.

Closing Remark

From the EFMC and ETC committee members, the general impression is that the merger of both conferences was considered a success. A second EFDC has already been announced to take place in Dublin in August 2025. It is to be decided by EUROMECH whether the EFDC concept will be pursued as an annual or bi-annual event.

EUROMECH Colloquia Reports 2024

EUROMECH Colloquium 630

Nonlinear Elasticity: Modelling of multi-physics and applications

25–28 March 2024, Edinburgh, UK

Chairperson: Prof. Yibin Fu

Co-Chairperson: Prof. Michel Destrade

Introduction

Nonlinear Elasticity has a long and distinguished history in modelling the mechanics of soft materials. Originally developed to capture the behaviour of rubber and polymers, it is currently experiencing a strong revival due to newly found applications in, for instance, the high-tech industry and healthcare. It is continuously being expanded to describe new materials and new multi-physics fields such as electromagnetic forces in dielectric elastomers, surface tension, residual stress, swelling and growth in hydrogels and biological soft tissues, etc. Novel problems are being attempted and understood with the development of advanced numerical, experimental, and theoretical techniques.

A leading light in this field has been provided for more than fifty years by Professor Ray Ogden FRS, who turned 80 on 19 September 2023. This Euromech Colloquium celebrated his achievements and used the occasion to review the state of the art and explore future directions of research for nonlinear elasticity.

The Colloquium received generous support from the Institute of Mathematics and its Applications (IMA), London Mathematical Society (LMS), and the International Centre for Mathematical Sciences (ICMS), in addition to Euromech.

Scientific Program Highlights

The Colloquium covered four main topics: biomechanics, buckling and instability, modelling and analysis of smart soft materials, and new insights into classical topics. These main topics were well covered and represented by the three keynote lectures:

- The development of a building block for a structural artery model by Gerhard Holzapfel (Technical University of Graz, Austria);
- Non-equilibrium stimuli-responsive soft materials, Lihua Jin (University of California, Los Angeles, USA);
- The magnetoelastic behaviour of elastomers filled with ferrofluid inclusions: Theory and numerical implementation, Oscar Lopez-Pamies (University of Illinois, Urbana-Champaign, USA).

Talks concerned with biomechanics addressed the issues of structural artery modelling, biochemomechanical coupling theory of lymph nodes, bone remodelling, tissue growth, and modelling of aortic aneurysms. Buckling and instability have always been important topics of nonlinearity. Problems addressed this time included instability of prestressed lattice structures, creasing, buckling of hydrogel beams with Mullins effect, dielectric composites with high phase contrast, tunable wave manipulation in hard-magnetic soft elastic metamaterials, theory for magnetoelastic thin shells, etc.

In addition to addressing modern challenges, a good number of talks were devoted to classical topics of nonlinear elasticity, to provide fresh new insights. Problems addressed included new formulations of nonlinear viscoelasticity, a new modelling strategy for rubber materials and their fracture, constitutive requirements that ensure non-occurrence of stress softening, Hertz contact, fibre-reinforced membranes with activated fibres, multiscale modelling of nearly incompressible polymer composites, Poynting effect, Love hypothesis, Cosserat model of elastic solids reinforced by curved and twisted fibres, circumferential shear, and solitary waves. Finally, there was also a talk giving the audience a taste of what machine learning can do in constitutive modelling.

Organization

The Colloquium was held over a three-and-a-half-day period. The ICMS provided an excellent venue for the event, with the hotels within walking distance, and very good facilities for discussions (e.g. black and white boards everywhere, a big coffee and lunch area, and a separate seminar room for breakout meetings). The technical and logistic support was first-rate, and the online talks were included seamlessly with top sound and video quality.

A hybrid mode was used to accommodate those who could not travel to Edinburgh easily. There were 58 in-person participants and another 60 people registered online. There were 41 talks (two of them online) and four posters.

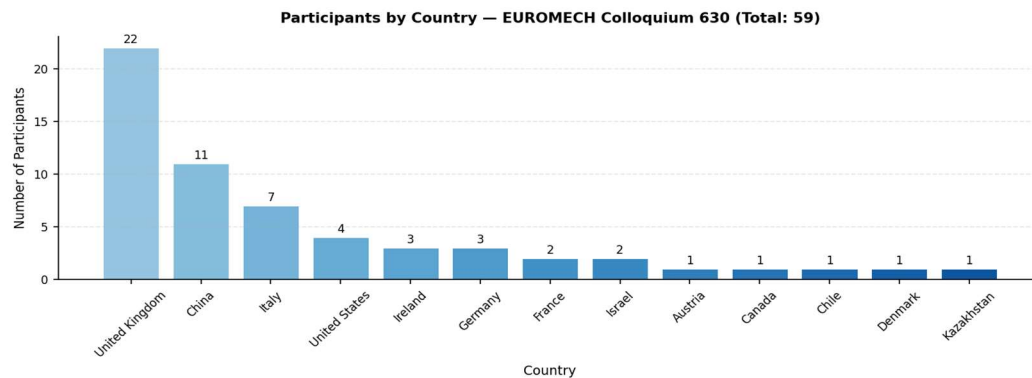
Number of EUROMECH members (reduced registration fee): 34

Number of non-members (full registration fee): 25

Total in-person participants: 59

Conclusion

In conclusion, the Colloquium served brilliantly its original purpose of reviewing the state of the art and identifying new research directions in nonlinear elasticity. The feedback from the questionnaire conducted at the end of the meeting was overwhelmingly positive. We thank Euromech, IMA, LMS, and ICMS for the financial support and ICMS for letting us use their beautiful venue and excellent facilities.



EUROMECH Colloquium 631

Control of skin friction and convective heat transfer in wall-bounded flows

18–20 March 2024, Madrid, Spain

Chairperson: Prof. Stefano Discetti

Co-Chairperson: Prof. Marios Kotsonis, Dr. Andrea Ianiro, Dr. Woutijn Baars

Introduction

Active control of wall-bounded flows is an everlasting and evergrowing topic of research in the fluid dynamics community. Skin friction drag reduction and convective heat transfer control are of paramount importance in an overwhelming number of applications, involving transportation means, renewable energy exploitation, industrial processes, turbomachinery for power generation and propulsion, etc.

Fast-paced advancement of experimental hardware and computational power have fostered, on the one hand, the establishment of efficient techniques for sensing and actuation, and on the other hand, the development of techniques to efficiently distill the information available from sensors and select the most effective control strategy. A grand challenge in spectrally-rich wall-bounded flows is the identification of effective open- and closed-loop control laws for both transitional and turbulent flows.

The EUROMECH Colloquium 631 aimed at discussing the state of the art of wall-bounded flow control, with an utter focus on active control of skin friction and convective heat transfer, addressing the main limitations, opportunities, and challenges ahead.

Scientific Program Highlights

The program included 5 keynote talks and 28 contributed presentations, split into 5 thematic sessions. Each session was opened by a corresponding keynote talk and closed by a round table of discussion. This arrangement resulted in a lively environment, with vibrant discussion and a very fruitful exchange of ideas.

The first thematic session was focused on active flow control. The session was opened by a keynote talk by Prof. Ganapathisubramani (University of Southampton, UK) on the interaction between synthetic jets and turbulent boundary layers. The session also included 6 contributions on experiments, simulations, and theoretical approaches for the active control of skin friction, transition, and turbulent statistics, covering actuation mechanisms based on spanwise forcing, plasma actuators for drag reduction, traveling surface waves, microbubble injection, and models for optimal laminar flow control.

The second session targeted passive control, in particular as a benchmark for active control. The keynote talk by Dr. Crouch (Boeing, USA) on laminar flow control provided an overview of the perspective and industrial vision of flow control applications in aeronautics. The session comprised 5 talks on riblets with different geometry, effects of surface texturing and wall corrugation, and on explainable artificial intelligence for the identification of coherent structures.

The third session addressed heat transfer enhancement, opened by a keynote talk by Prof. Bellani (Università di Bologna, Italy) on large-scale coherent structures in turbulent boundary layers relevant to heat transfer. The session featured 6 contributions, including data-driven methods, machine-learning-based control, and optimization with genetic algorithms.

The fourth session focused on sensing technology. Prof. Nakamura (National Defense Academy of Japan) opened with a keynote on spatially and temporally resolved heat transfer measurements. Five talks covered different aspects of sensing, including implementation in closed-loop control, machine learning for full-state estimation, and methods for determining average skin friction.

The final session targeted data-intensive strategies in wall-bounded flow control. The keynote lecture by Prof. Jiménez (Universidad Politécnica de Madrid, Spain) provided an overview of how large datasets from simulations can be used to distill models for the flow dynamics. The session comprised 6 talks on machine-learning-based flow control.

The colloquium also featured a course on infrared thermography for convective heat transfer measurements given by Dr. Castellanos (INTA, Spain).

Organization

The event took place over three days in Madrid, Spain. 41 participants attended from 12 countries. The registration fees included conference bags, 6 coffee breaks, 3 lunches, 1 welcome social event, 1 social dinner, and a hands-on course on infrared thermography.

Number of EUROMECH members (reduced registration fee): 12

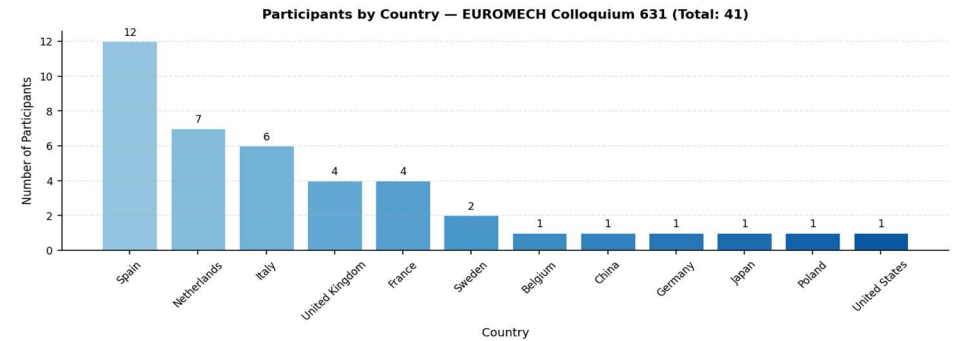
Number of non-members (full registration fee): 29

Total participants: 41

One of the highlights of the colloquium was the copious time allocated for informal discussion, including coffee breaks, ample lunch breaks, 5 round tables moderated by the conference chairs, and a good offer of social activities for mingling.

Conclusion

We gratefully thank EUROMECH for administrative and financial support. Furthermore we thank support by the ERC Starting Grants NEXTFLOW (grant n. 949085) and GloWing (grant n. 803082), and Proof of Concept Grant DeLaH (grant n. 101138326), funded by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program, and by Universidad Carlos III de Madrid (Spain) and TU Delft (The Netherlands). The invaluable support in the organization and management of all members of the Experimental Aerodynamics and Propulsion Laboratory of Universidad Carlos III de Madrid is kindly acknowledged.



EUROMECH Colloquium 633

Nonlinear Metamaterials and Smart Structures

27–29 May 2024, Lyon, France

Chairperson: Prof. Alireza Ture Savadkoohi

Co-Chairperson: Prof. Daniele Zulli,, Prof. Jaroslaw Latalski

Introduction

Metamaterials and advanced composites are modern materials engineered to benefit from mono- or multi-physics interactions. Typically they are designed to obtain novel functionalities or non-classical extraordinary structural properties that are not observed naturally, both in micro and macro scale behaviors. The customized unique features may comprise zero or negative mechanical properties such as Poisson's ratio, rigidity, mass, shear modulus, etc., or extreme values of electrical parameters like effective permittivity and permeability.

All these factors can contribute to response bandgaps, where the system halts to respond or responds in a controlled manner against external excitation, or to induced strains and energy localizations in structures. The design requirements can be extended to developing metamaterials with time-dependent and adaptive coefficients.

The core topic of this colloquium was "designing and exploiting induced adaptive or constant nonlinearities" in metamaterials and composite structures for improving their behaviors beyond the classical linear domains. The goal is to achieve desired responses such as shock/strain/noise mitigations, resonance shifting, energy localization and/or focalization phenomena.

Scientific Program Highlights

The colloquium hosted three keynotes:

– Prof. Davide Bigoni (University of Trento, Italy): Designing solids from structures;

– Prof. Varvara Kouznetsova (Eindhoven University of Technology, The Netherlands): Subharmonic energy exchange in non-linear locally resonant metamaterials;

– Prof. Pedro Ribeiro (University of Porto, Portugal): Using curvilinear fibres to enhance the dynamic response of composite panels.

The colloquium covered six sessions over three days, organized around the following thematic areas:

Architected mechanical metamaterials: Exploitation of nonlinearities in elastic and/or inelastic domains in microscale for creation of extraordinary responses in macroscale. Session presentations covered metastructures for vibration isolation, prestressed nonlinear resonant auxetic metamaterials, topology optimization of compliant structures, deep generative modeling for metamaterial design, and composite metamaterials for aerospace structures.

Smart materials and composites: Designing/programming nonlinearities for multiple state shock and vibration/wave control, sensing or for creation of intelligent inter-modal energy exchanges. Presentations addressed nonlinear dynamics of active shallow arches, multiscale modeling of metamaterial beams, real-time adaptation of hybrid nonlinear energy sinks, and digitally programmed nonlinear electroacoustic resonators.

Nonlinear waves: Studying and analyzing nonlinear waves in nonlinear metamaterials via analytical and numerical tools such as bifurcation theory, multiple scale method, etc. Topics included traveling localized waves in granular metamaterials, effective dynamics for transient elastic waves, and nonlinear metastructure design for energy localization.

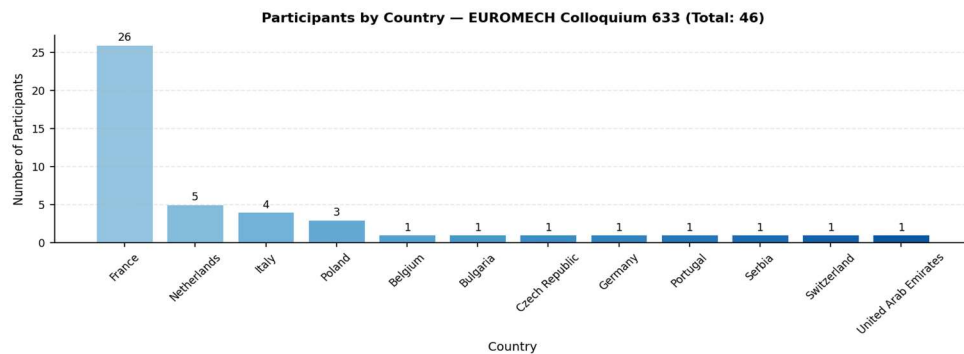
Computational mechanics and smart structures: Sessions also featured presentations on nonlinear vibrations of multistable piezoelectric shells, noise and vibration suppression in vibratory pile driving, magnetically controlled microstructural buckling, unified elasto-plasticity theory, metastructures designed for impact loading, and advanced manufacturing of polymer-based composite materials.

Organization

The colloquium hosted 46 participants from 12 countries. The event was organized at ENTPE in Lyon, France. Financial support was received from the Labex CeLyA of the Université de Lyon (€2,000) and the Lublin University of Technology (€2,000), in addition to EUROMECH. Participants were offered the book of abstracts, four coffee breaks, three lunches, a visit to the Basilique Notre-Dame de Fourvière, and a gala dinner at the Bulle-Restaurant de Fourvière.

Conclusion

The organizers would like to address their special thanks to EUROMECH (Officers: Prof. M. Geers, Prof. G. Jan Van Heijst, Prof. J. Magnaudet, Prof. S. Reese; Management Advisor: Dr. S. Guttilla), to the organizing institutes ENTPE-LTDS (France), University of L'Aquila (Italy), and Lublin University of Technology (Poland), to Labex CeLyA and Institut Carnot Ingénierie@Lyon, and to all PhD students who provided support during the event.



EUROMECH Colloquium 637

A multidisciplinary discussion on binder cohesion

15–17 May 2024, Vienna, Austria

Chairperson: Dr. Agathe Robisson

Co-Chairperson: Dr. Katerina Ioannidou, Dr. Teresa Liberto

Introduction

Cementitious materials play a central role in the construction industry, with concrete being the most widely consumed material worldwide after water. This colloquium brought together researchers from multiple disciplines — including chemistry, physics, materials science, and civil engineering — to discuss the fundamental challenges related to the cohesion and sustainability of cementitious binders.

The yearly worldwide consumption of concrete is estimated at 30 billion tons. The decarbonization of cement production is one of the grand challenges of the industry: in Austria, CO₂ linked to cement production comes 2/3 from limestones and 1/3 from fuel. The colloquium addressed both the fundamental science of cohesion and practical pathways toward more sustainable concrete.

Scientific Program Highlights

Session 1 — "Viewpoints on sustainability in construction and concepts of multifunctional cementitious materials" (chaired by R. Pellenq): Three introductory presentations were given by an academic expert (H. Van Damme, ESPCI Paris: "Civil engineering in the age of conflicting constraints"), an industrial expert (S. Spaun, VÖZ: "Roadmap for sustainable concrete in Austria"), and an architect (T. M. Room: "Resources on the building site"). The session also included contributions on building heritage and land usage, fluid transfers in bio-based construction materials, and the influence of coal fly ash carbonation on binding properties.

Session 2 — "Mechanics of cementitious materials in their fresh and early-age states" (chaired by A. Robisson): Presentations covered wetting of

complex fluids, setting of mineral foams, cement paste optimized for rheometric characterization, new insights into the rheological properties of superplasticized limestone calcined clay cements (LC3), and a new admixture generation to reduce the environmental impact of concrete.

A round table — "Present and future of the construction industry" (chaired by S. Spaun): The discussion focused on decarbonization roadmaps, new cementitious materials and low-carbon formulations, multifunctional concrete, and navigating policies and regulations. The low cost of cement and the cost pressure on the industry were identified as key obstacles to innovation.

Session 3 — "Physico-chemical characterization of cementitious materials" (chaired by T. Liberto): Topics included local measurement of the reactivity of hydraulic binders, high-resolution 3D imaging of cementitious materials, early hydration studied by analytical ultracentrifugation, SEM imaging and mesoscale modelling of cement hydration, and probing chemical reactivity in confined spaces.

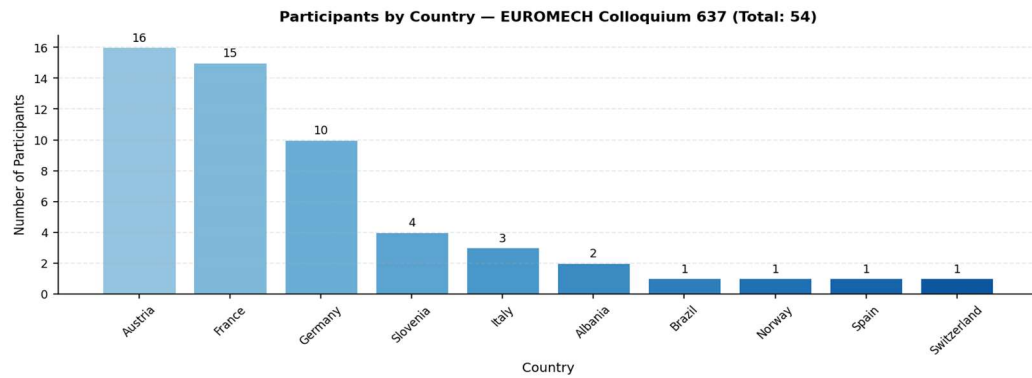
Session 4 — "Mechanics of cohesion in cementitious materials" covered total scattering techniques, sustainable resource utilization in lunar construction, functionally grading of cementitious materials in textile-reinforced concrete, and rheological challenges on the pathway to sustainable concrete.

Organization

The colloquium was held at the Vienna University of Technology (TU Wien) and included 54 participants from 10 countries. Financial support was received from Anton Paar, CNRS France, Schleibinger, and VÖZ (Austrian Cement Industry Association). Over the colloquium, 12 fire presentations and 3 poster sessions were organized. Following the colloquium, a visit of the TUW civil engineering labs was offered. Registration fees included the book of abstracts, 2 daily coffee breaks and 3 lunches, a guided visit of Josephinum (Medical History Museum) with a welcoming cocktail, and a gala dinner at Joseph II in the Schönbrunn Palace.

Conclusion

The colloquium successfully brought together a multidisciplinary community around the fundamental and applied challenges of cementitious binder cohesion. The breadth of perspectives — from molecular-scale computations to industrial sustainability roadmaps — provided a unique forum for advancing both the science and the practical pathways toward more sustainable and functional construction materials.



EUROMECH Colloquium 639

Microplastic dispersion pathways

6–8 May 2024, Lerici, Italy

Chairperson: Dr. Claudia Cenedese (WHOI, USA)

Co-Chairperson: Prof. Bruce Sutherland, Dr. Giuseppe Suaria

Introduction

The problem of predicting the pathways from sources to sinks of microplastics in rivers and the ocean is vast and multidisciplinary. Microplastic pollution has become one of the most pressing environmental challenges of our time, requiring coordinated efforts from researchers in fluid dynamics, oceanography, environmental science, and related fields.

Altogether there were 39 participants and 31 presentations from 11 countries. The full program is available in a separate document. Most importantly, there was ample time for informal discussions among the participants during coffee breaks, lunches and social activities.

Scientific Program Highlights

During and following many stimulating and diverse talks, attendees discussed the next steps going forward. Rama Govindarajan suggested a framework be developed to help synthesize ideas and provide focus for research endeavors, including developing zeroth order equations akin to ecological modelling.

A key outcome of the colloquium was the development of a conceptual box model framework that estimates fluxes of plastics from various sources to various reservoirs and sinks:

- Net sources: municipal waste, storm drains, runoff, dumping from land, dumping at sea, atmosphere;
- Reservoirs: rivers and estuaries, swash zone, near coast, western boundary currents, open ocean (near surface, thermocline, abyss);

- Sinks: river and estuary beds, beaches, near shore sediments, continental margins, abyssal floor.

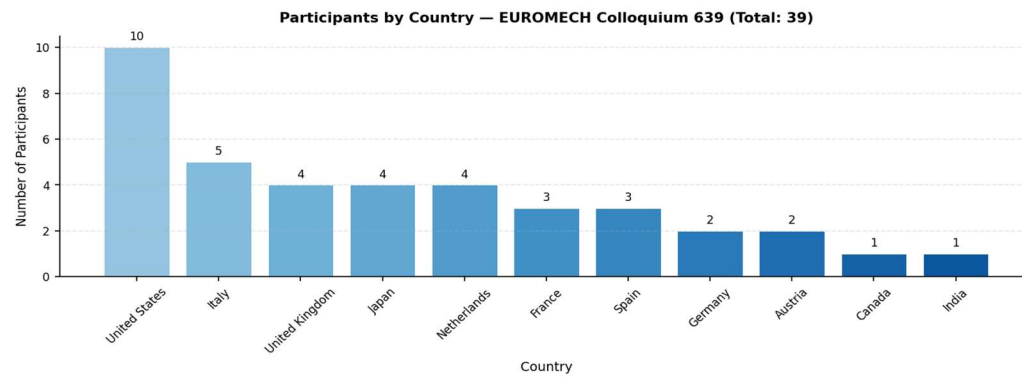
A suggestion put forward by Michael Denes following the discussion was to create a living document in which members of the community could upload and download references to published work related to various transport pathways. This document also includes links to observational databases (e.g. the Atlas of Ocean Microplastics) and modelling resources (e.g. PlasticParcels), accessible at: https://docs.google.com/document/d/12_tIDJdJO8gLpz0FfqIXMkZ9LcjbXFFyqbuQLm8HIBs/edit

Organization

The event was held at the picturesque location of Lerici, Italy, over three days. Registration fees included a digital book of abstracts, two daily coffee breaks and three lunches, one dinner and one mixer. No external funding beyond EUROMECH was obtained. The total of 39 participants included 1 EUROMECH member (reduced fee), 38 non-members (full fee), and 3 accompanying persons.

Conclusion

We thank Euomech for making the meeting possible and for financial and organizational support. The colloquium succeeded in bringing together the international community working on microplastic dispersion and provided a productive forum for identifying key priorities for future research and collaboration.



EUROMECH Colloquium 642

International Colloquium on Multiscale and Multiphysics Modelling for Advanced and Sustainable Materials

22–27 September 2024, Rome, Italy

Chairperson: Prof. Patrizia Trovalusci (Sapienza University of Rome)

Co-Chairperson: Prof. Adnan Ibrahimbegovic, Prof. Tomasz Sadowski

Introduction

The Colloquium chaired by Prof. Trovalusci (Sapienza University of Rome), Prof. Ibrahimbegovic (Alliance Sorbonne Université) 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, defined by 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. The objective was to bring together researchers (engineers, physicists, mathematicians) specialised in multiscale material modelling to simulate the mechanics of solids and the physics of matter, bridging the gap between Solids and Structural Mechanics and Material Science.

Scientific Program Highlights

Various types of complex materials are used in engineering practice: particle or fibrous composites; laminates; green composites; nanomaterials; architected materials; and multiphase materials with complex internal structures including

porosity, reinforcements, and particles of various shapes. Important macroscopic properties such as stiffness and strength are governed by multiphysics processes occurring at scales below the level of observation.

The main topics of the Colloquium were:

- Multiscale and multiphysics aspects of material modelling;
- Mathematical and computational foundations of multiscale approaches;
- Material classes: structural, multi-functional, nano/microstructured, 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; statistical and mesoscale modelling;
- Hierarchical/concurrent multiscale modelling; additive manufacturing 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.

Organization

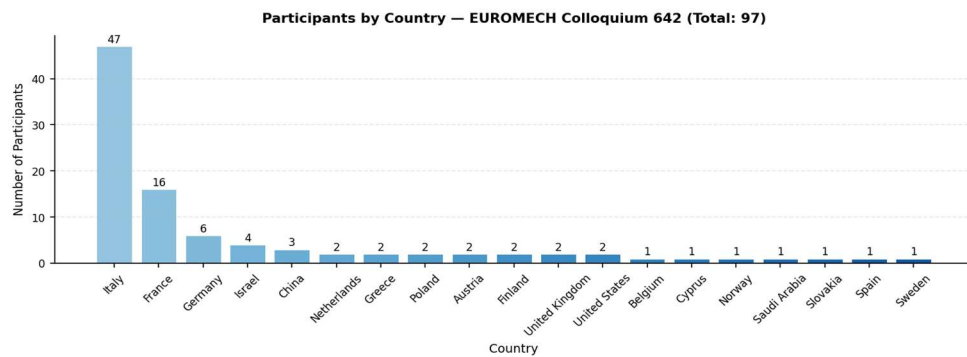
All sessions took place over five days (23–27 September 2024) at Sapienza University of Rome. 97 participants from 19 countries attended. A Welcome Cocktail was held on the opening day and a Gala Dinner on Thursday 26 September.

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 peer review, curated by Prof. Trovalusci, Prof. Sadowski, and Prof. Ibrahimbegovic, with editorial supervision by Dr. Ongaro, Dr. Pingaro, and

Dr. Colatosti. Selected contributions were also invited to the International Journal Composite Structures (Special Issue edited by Prof. Trovalusci, Prof. Ibrahimbegovic, Prof. Sadowski, and Prof. Fantuzzi), now in print.

Conclusion

The Colloquium successfully bridged the gap between Solids and Structural Mechanics and Material Science. The lively exchange among engineers, physicists, and mathematicians highlighted the interdisciplinary richness of the field, and the scientific outcomes — published in two high-impact venues — reflect the quality of the contributions presented.



EUROMECH Colloquium 643

Advances in peridynamic material modeling

25–27 September 2024, Venice, Italy

Chairperson: Dr. Vito Diana

Co-Chairperson: Prof. Florin Bobaru, Prof. Mirco Zaccariotto, Dr. Arman

Shojaei

Introduction

Peridynamics is a non-local continuum theory that has shown significant promise in modeling the behavior of materials subjected to extreme deformation and complex material phenomena. Unlike classical continuum mechanics, peridynamics is based on integro-differential equations without partial derivatives in space, and postulates that material points interact through pair-potentials (bond-based formulations) or multi-body potentials (state-based formulations). This non-local nature makes peridynamics particularly well-suited for modeling modern mechanical problems, such as the spontaneous formation of cracks or damage, as the governing equations remain valid at points or surfaces of discontinuity.

In the last decade, peridynamic equations have been extended to address diffusion-based problems and have been successfully applied to model coupled phenomena involving different physical processes, including corrosion damage, electrodeposition, and more.

Scientific Program Highlights

During this colloquium, recent advances in peridynamics research were discussed, including the development of new constitutive models for complex materials such as soft tissues, porous media, and composites. A significant focus was placed on recent developments and open questions in the peridynamic modeling of material degradation and size-dependent behaviors. Advancements in the numerical implementation of peridynamic models were also presented, including meshfree methods, GPU-based and parallel algorithms for large-scale simulations, and the integration of machine learning techniques.

Specific topics addressed in the talks included:

- Advances in peridynamic constitutive modeling;
- Pair-potentials and multi-body potentials formulations;
- Analytical solutions of peridynamic governing equations;
- Brittle and ductile fracture, material degradation;
- Local to nonlocal coupling;
- Heat transfer and diffusion problems;
- Multiphysics/coupled problems;
- Modeling of soft tissues, porous media and composites;
- Impact and fragmentation problems, hypervelocity;
- Machine learning for nonlocal models, connections to atomistic modeling;
- Size-dependent behaviors and multiscale analysis;
- Peridynamic models for micropolar elasticity;
- Wave propagation and dispersion properties;
- Discretization methods, computer codes, and fast algorithms.

Keynote Speakers:

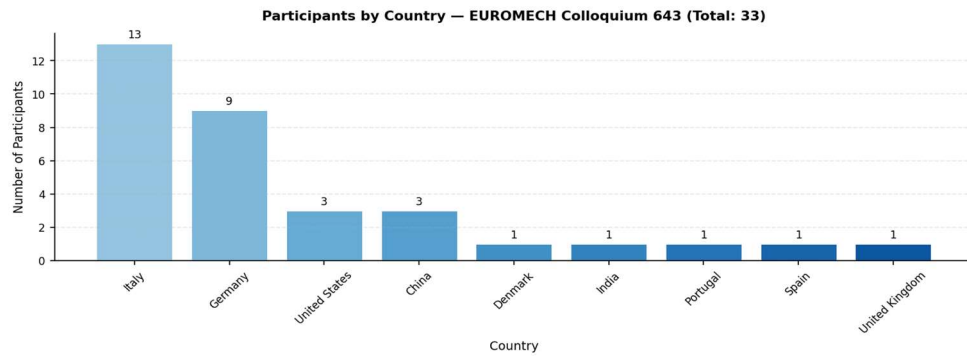
- Stewart A. Silling (Sandia National Laboratories, USA);
- Erdogan Madenci (University of Arizona, USA);
- John T. Foster (University of Texas at Austin, USA);
- Ugo Galvanetto (University of Padua, Italy);
- Erkan Oterkus (University of Strathclyde, UK);
- Ziguang Chen (Huazhong University of Science and Technology, China).

Organization

The colloquium was held in Venice, Italy, over three days. 33 participants from 9 countries attended, including 11 EUROMECH members and 22 non-members. The event offered a welcome aperitif, three lunches, two dinners, six coffee breaks, the book of abstracts, and an exclusive evening visit to the Scuola Grande di San Rocco. No additional external funding was obtained.

Conclusion

Overall, this colloquium provided a comprehensive overview of recent advances in peridynamics, highlighting its potential to address fundamental challenges in materials science and engineering, while fostering collaboration and the exchange of ideas among researchers in this field. Potential future directions explored included applicability in biomechanics and materials design, as well as the connections between peridynamics and other modeling approaches based on continuum mechanics.



EUROMECH Colloquium 644

Mechanics, Thermomechanics and Simulation of Short Fibre Reinforced Cementitious Composites

17–21 June 2024, Tallinn, Estonia

Chairperson: Prof. Heiko Herrmann

Co-Chairperson: Prof. Klaus Holschemacher

Introduction

Short Fibre Reinforced Cementitious Composites (SFRCC) are gaining rapidly more importance in civil engineering, most prominently Steel Fibre Reinforced Concrete (SFRC). This composite is already quite extensively employed in the construction industry, for example in floors resting on soil and even in some load-bearing structures, such as ceilings.

Short fibers are added to the composite at the mixing stage and cast together. The fibers are supposed to replace the reinforcement bars and carry the tensile load, thus changing the material properties from brittle to ductile. The challenge is that the material properties depend on the spatial spreading and orientation distribution of the fibers, which are influenced by the flow into the formwork. The addition of the short fibers makes the composite stochastically anisotropic and inhomogeneous, since several macro- and meso-scale properties depend on the spatial and orientational distribution of fibers.

Scientific Program Highlights

There were altogether 5 participants and 6 presentations. Each presentation was scheduled for one hour, which is much longer than on typical conferences and offered plenty of time for discussions and to present the topic in detail.

Topics that were discussed recurrently included:

- Fiber orientation analysis: One presentation gave a detailed introduction of bending strength experiments and their analysis regarding fiber orientations

using computed tomography and image analysis. Results showed bending strength varied significantly in correlation with local fiber amount and fiber orientations.

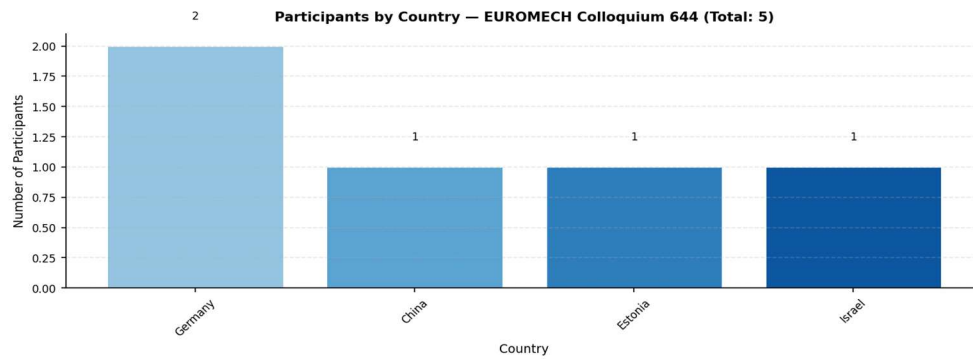
- Numerical simulations of fiber concrete casting: Fluid dynamical simulations of the casting process were demonstrated, showing the method is viable for explaining fiber orientations found in experiments and for planning the casting of fiber concrete.
- Influence of fiber orientations on cracking behavior and crack bridging: A talk explained how to detect cracks in computed tomography images of fiber concrete reliably and fast, important for understanding the crack bridging of fibers and their influence on post-cracking strength.
- Investigations of creep of steel fiber concrete: Creep in cracked fiber concrete happens more pronounced than in rebar reinforced concrete, making the understanding of correlations between amount of creep and fiber dosage, orientation and type important for sustainable structures.
- Numerical simulations of short fiber composites with high resolution based on measured fiber positions and orientations: Advanced high resolution simulations based on an octree refinement of the mesh and a scaled boundary element method were presented.
- Efficient use of fibers by producing layered elements.
- Recycling of fiber concrete: The emphasis on sustainability requires thinking not only about building costs but also about demolition and possible re-use of materials.

Organization

The colloquium was held at Tallinn University of Technology (TalTech), Estonia, over five days. 5 participants from 4 countries attended (1 EUROMECH member, 4 non-members). The event offered conference bags, coffee breaks, an ice-breaker dinner, a conference banquet, a social dinner, a guided walking tour through Tallinn Old Town, a tour of the university and civil engineering laboratories, and a nature walking tour through a bog at the edge of Tallinn.

Conclusion

Despite the small number of participants, the colloquium covered a broad selection of connected topics that were interesting for all participants. The discussions were lively and very friendly, based on a real interest in the topics of the other participants. We thank Euromech for making the meeting possible and for the financial support.



EUROMECH Colloquium 645

Nonlinear dynamics at zero Reynolds number

21–23 May 2024, London, UK

Chairperson: Dr. Eric Keaveny

Co-Chairperson: Dr. Blaise Delmotte

Introduction

Despite the linearity of the Stokes equations, nonlinearity is prevalent at zero Reynolds number due to the presence of interfaces, elastic structures and polymers, chemical concentrations, and electric fields, all of which have ramifications across many industrial and biological processes. In recent years, especially with the development of new experimental techniques for exploring microscale physics, there has been significant interest in understanding and categorising how these sources of nonlinearity interact with the long-ranged, configuration dependent, and non-local flows present at zero Reynolds number.

Instabilities that arise as a result of these mechanisms are responsible for important phenomena such as inertia-free mixing and transport in microscale devices, spontaneous force-free motion of colloidal particles and droplets, the generation of intra- and extracellular flow fields in organisms, as well as curious turbulence-like phenomena exhibited by active suspensions.

The focus of this colloquium was on nonlinearities that arise in the absence of inertia due to couplings with elastic structures and primarily elastic filaments, and coupling with chemical fields leading to phenomena such as phoretic motion. The colloquium aimed to attract both theoreticians and experimentalists in these exciting and sometimes connected areas, providing a forum for exchange of techniques and methodologies between researchers on different topics.

Organization

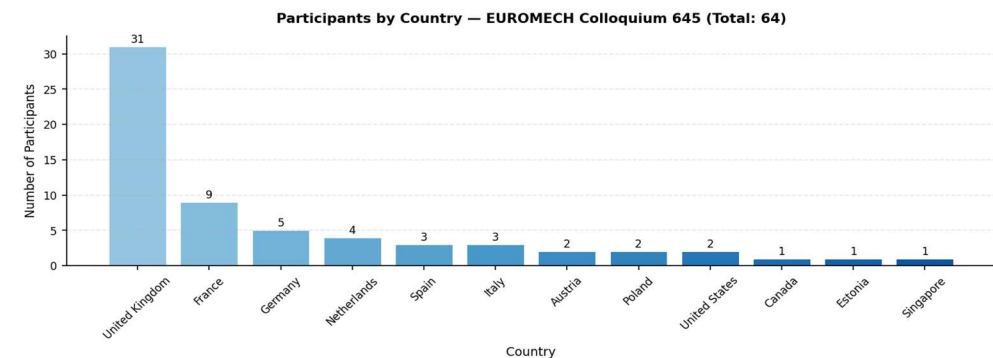
Altogether there were 56 participants and 40 presentations from 12 countries. The full programme is available on the Colloquium's website. The colloquium

was held at Imperial College London over three days. Financial support was received from LadHyX (€2,000), Imperial College London, and CNRS UMI Abraham de Moivre. The registration fees included an Imperial College tote bag, notepad and pen, 2 daily coffee breaks and 3 lunches, and a wine reception and gala dinner at 170 Queen's Gate Terrace.

[Note: The detailed scientific report for Colloquium 645 was not provided in the submitted report.]

Conclusion

We thank Euomech, Imperial College, and the other funding sources, for making the meeting possible and for financial and organizational support.



EUROMECH Colloquium 648

Collective Dynamics of Particles, Bubbles, and Droplets

20–22 May 2024, Toledo, Spain

Chairperson: Prof. Filippo Coletti

Co-Chairperson: Prof. Javier Rodríguez Rodríguez

Introduction

Particles, bubbles, and droplets are often small enough that the flow at the scale of the inclusion is predominantly viscous, even when the large-scale dynamics is inertial. This simplifies the governing equations and makes the problem somewhat more tractable. However, in many practical situations, the number of suspended objects is so large, and/or their concentration so high, that they can hardly be treated as isolated elements.

The choice between discrete and continuous representation of the dispersed phase is highly influenced by the tools available to the researcher, from the theoretical, experimental, and numerical standpoint. Those tools rapidly evolve in time, as the great relevance of this class of flows has motivated major recent advances. This Colloquium brought together international experts in multiphase dispersed flows, focussing on: (i) under which conditions can the discrete object dynamics be up-scaled to represent collective behaviour; (ii) the most suitable strategies for the continuous description of the dispersed phase in the various regimes; and (iii) which numerical and experimental methodologies are emerging as the most appropriate for dispersed flows.

Scientific Program Highlights

The colloquium on "Collective Dynamics of Particles, Bubbles, and Droplets" brought together leading experts to discuss the latest advancements in understanding the complex behaviors of particles, bubbles, and droplets in various fluid dynamics scenarios.

The opening talk on the preferential orientation and rotation of microfibers highlighted the significant impact these dynamics have on overall flow behavior. Discussions covered how particle shape affects clustering behavior during settling processes, and the growth of particles within Taylor–Couette turbulence. The behavior of massive, chiral particles in homogeneous isotropic turbulence revealed distinctive dynamic properties. Innovative experimental techniques were highlighted, including positron emission particle tomography to study dense suspensions and data-driven tools for analyzing Lagrangian turbulence.

Several talks focused on turbulence modulation, including high particle seeding effects on flow structure, and the dynamics of finite-size particles in homogeneous isotropic turbulence. The collective evolution of bubbles in regular and irregular pore networks was explored. The conference also delved into coalescence mechanisms of bubbles in turbulence, cavitation, boiling, condensation processes, and advances in modeling acoustic bubble cloud dynamics.

Further discussions covered the migration forces on solid particles moving parallel to deformable liquid-liquid interfaces, the counterintuitive "faster-is-slower" effect in noncohesive constricted suspension flows, dynamics of particle migration in pipe flows, the development of rigidity in shear-thickening suspensions, and the collapse behavior of submerged cohesive granular materials.

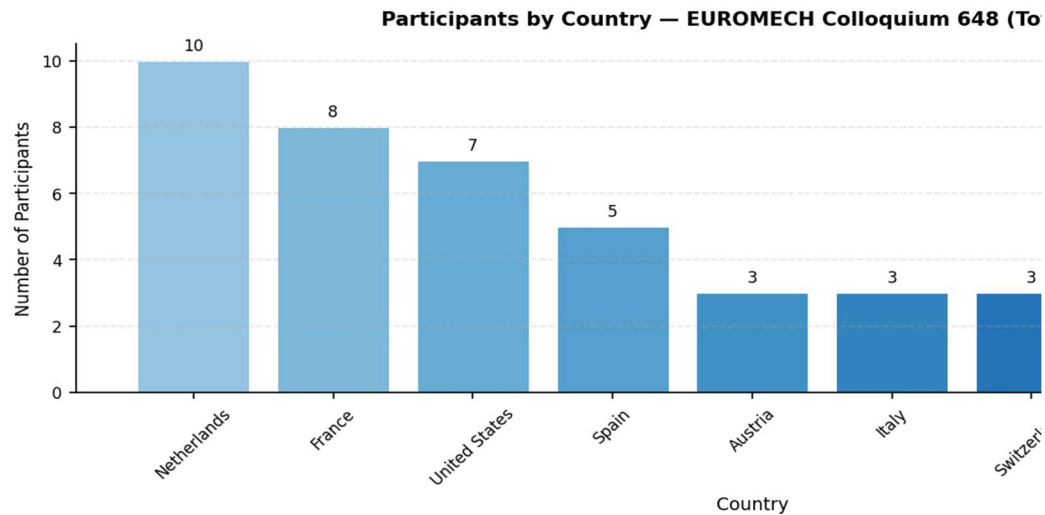
Organization

The conference spanned three days in Toledo, Spain. 41 participants from 9 countries attended. The structure featured a series of in-person talks with ample time for in-depth discussions following each presentation. Two cocktail receptions and numerous long coffee breaks were organized, creating a convivial atmosphere conducive to networking and informal discussions.

Conclusion

Overall, the colloquium provided a comprehensive overview of current research on the collective dynamics of particles, bubbles, and droplets, fostering

discussions and collaborations that are expected to drive future advancements in the field.



EUROMECH Colloquium 649

Metamaterials and Architected Materials for Novel Energy Harvesting Solutions

7–9 May 2024, London, UK Chairperson: Dr. Jacopo M. De Ponti (Politecnico di Milano) Co-Chairperson: Dr. Gregory J. Chaplain, Prof. Richard V. Craster, Prof. Andrea Colombi

Introduction

The aim of the EUROMECH Colloquium 649 was to bring together world-leading, complementary expertise in the theory, simulation, manufacturing, and experimental realisation of metamaterials and architected materials for novel

energy harvesting solutions. Altogether there were 39 participants and 32 presentations from 9 countries.

Metamaterials (MMs) and Phononic Crystals (PCs) offer unique opportunities to manipulate elastic and acoustic waves, stimulating the research for new avenues in energy harvesting. This colloquium focussed on both fundamental advances and practical applications of elastic metamaterials for energy concentration, harvesting, and conversion.

Scientific Program Highlights

Phononic crystals and elastic metamaterials for energy confinement: Several solutions to concentrate elastic/acoustic energy at the harvester spatial position were discussed, including: (a) gradient-index (GRIN) and Luneburg lenses, (b) multifunctional metastructures, (c) graded MMs involving adiabatic spatial modulation, (d) double-negative local resonance on negative group velocity dispersion curves, (e) elastic metasurfaces, (f) beyond-nearest-neighbour coupling (nonlocality), (g) localized modes in periodic and quasi-periodic media, (h) bound modes in the continuum (BICs).

Nonlinear elastic metamaterials: Nonlinear phenomena in elastic metamaterials were discussed to overcome the performance degradation of resonant-based energy harvesters operating away from resonant frequencies, especially for low-frequency applications. A new class of strongly nonlinear interactions sustaining soliton propagation was discussed; the particle-like nature of solitons offers a fundamentally different mechanism to achieve effective dynamics that break the strong link between unit cell size and operating frequency.

Topological elastic metamaterials: Dispersion topology has emerged as a principle governing unique wave transport phenomena through interface or edge modes that are impurity-immune. Curvature was explored as a route for the design of topological mechanical metamaterials and waveguides. The concept of topological rainbow trapping was also discussed, amalgamating the classical Su-Schrieffer-Heeger (SSH) model with graded elastic metasurfaces (metawedges), leading to one-dimensional graded-SSH metawedges that support multiple,

simultaneous, topologically protected edge states leveraged for elastic energy harvesting using the piezoelectric effect.

Tuneable elastic metamaterials: Metamaterial tuneability and reconfigurability were discussed as key requirements for real applications, including shunted piezoelectric (PZT) disks in unit cells, electroacoustic Topological Insulators, and photoresponsive polymers.

Energy harvesting methods: An alternative framework was discussed whereby intrinsic energy-harvesting characteristics are formally quantified independently of the forcing and the structure size, introducing the notion of a piezoelectric material rather than a finite piezoelectric structure. A new paradigm in self-powered devices was proposed, where sensing or processing tasks are directly powered by mechanical energy without mechanical-electronic transduction.

Metamaterial devices and optimization: The advancement of sensor technology for the IoT was discussed, with metamaterials enabling localisation and amplification of elastic waves for simultaneous energy harvesting and sensing. Rational pruning strategies for acoustic wave steering in disordered networks and Reinforcement Learning (RL) procedures as alternative approaches for metamaterial optimisation were also presented.

Analytical and numerical methods: Analytical solutions based on singular Green's functions and semi-analytical formulations for wave propagation along elastic plates, waveguides and half-spaces were discussed for efficient computations of scattering simulations and topological phenomena.

Organization

The colloquium was held in London, UK, over three days. 42 participants from 9 countries attended, including 15 EUROMECH members and 27 non-members. Financial support was received from the H2020 FET-proactive European project "Metamaterial Enabled Vibration Energy Harvesting (MetaVEH)" under Grant Agreement No. 952039, in addition to EUROMECH. Participants were offered

conference materials, 8 coffee/pastries breaks, 3 lunches, 1 drink reception, and 1 social dinner.

Conclusion

The list of participants, the full programme and the book of abstracts are available on the Colloquium website (<https://649.euomech.org/>). The colloquium successfully brought together complementary expertise from theory, simulation, manufacturing, and experimental realisation, fostering new collaborations across these domains.

