NEWSLETTER 51

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EUROPEAN MECHANICS SOCIETY

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EUROMECH Conference Reports 2021

EMMC16 – 16th European Mechanics of Materials Conference

Oxford, UK, 4-6 April 2022
Chairperson: Antoine Jerusalem,
Co-Chairperson: Laurence Brassart, Alan Cocks

The 18th European Mechanics of Materials Conference (EMMC18) gathered researchers sharing a common interest in the field of mechanics of materials, yet working in a variety of application domains: material science, mechanical and civil engineering, but also biomechanics, geophysics, … Contributions providing a better understanding of complex phenomena associated to mechanical response of materials at all scales, from atomistic to structural sizes, were presented. The scope of the conference covered experimental, analytical and computational modelling approaches, and contributions combining several approaches were particularly encouraged.

Three plenary lecturers (selected by the EMMC scientific committee) were invited:

- Prof. Chiara Daraio (California Institute of Technology), "Irregular Architected Materials with Programmable Properties"
- Prof. Vicky Nguyen (The Johns Hopkins University), "Viscoelastic Behavior of Liquid Crystal Elastomers"
- Prof. Samuel Forest (MINES Paristech PSL University), "Slip vs kink bands in metallic single and polycrystals and their impact on fatigue crack initiation and propagation"

18 thematic parallel symposia, on topics selected by the scientific committee, were coordinated by appointed symposia chairs.

Competitors for the Euromech best student presentation awards spoke in each of the 18 symposia. Finalists were first shortlisted with the collaboration of the symposium cochairs through the submitted abstracts, and the symposia's champions' presentations were attended by at least (some exceptional cases only one) two members of the jury (composed of two members of the EMMC committee – Laurent Delannay and Lorenzo Bardella, one of the LOC chairs – Laurence Brassart, and one plenary speaker – Samuel Forest). The condition for entry was having graduated/graduating after April 2020.
The winner was:

- Filippo Masi for the paper entitled: Multiscale modeling of inelastic microstructured materials with Thermodynamics-based Artificial Neural Networks (TANN)

An additional competition for Best Poster was held across all symposia. The 13 finalists submitted a poster (displayed in the North Examination School, where lunch was held on each of the three days) and a two-minute video presentation.
The winner was selected by the LOC chairs:

- Vincent Martin, for the poster entitled: 316 L Steel MIM-like 3D Printing

In addition to the prize money offered by EuroMech (500 EUR / award) the awardees received a certificate and an Oxford pen/keyring giftset.

ENOC10: European Non linear Oscillation Conference

Lyon, France, 17-22 July 2022
Chairperson: Claude Henri Lamarque
Co-Chairperson: Régis Dufour, Fabrice Thouverez

Scope

Although the brand name ENOC (European Nonlinear Oscillations Conference) is still used as the historical abbreviation, the European Nonlinear Dynamics Conferences aim at covering the complete field of Nonlinear Dynamics, including Multibody and Stochastic Dynamics and coupling to Stability, Identification, Control and (Structural) Optimization. During the last few decades, the area of nonlinear dynamics has been evolving in a revolutionary way, with applications to a wide variety of engineering systems, which was made possible by the use of sophisticated computational techniques employing powerful concepts and tools of dynamical systems, bifurcation and chaos theory, infinite dimensional systems, and continuous systems.

Three main general issues characterize the present research framework:

- the need to overcome the limitations inherent in the archetypal few-degree-of-freedom models mostly analyzed in the past via analytical approaches and to deal with real systems;
- the increased interest towards exploiting nonlinear dynamics modeling and analysis for designing materials, physical and engineering systems and designing and controlling their nonlinear and complex behavior;
- responding to societal and major environmental and energy challenges

The aim is towards:

(i) developing more reliable reduced-order models for the analysis of the actually high-dimensional systems and processes encountered in most technical applications;
(ii) obtaining further meaningful hints for model validation from calibrated experimental investigations;
(iii) generalizing concepts and techniques for the analysis of new complex behaviors;
(iv) exploring implications of nonlinearity and dynamical regimes (periodic, quasi-periodic, chaos) in design and operating conditions of advanced systems, as well as needs and features for their control.

ENOC 2022 aimed at bringing together a wide variety of specialists with the purpose to show the latest achievements, to prospect future directions for development, to exchange experience, and to stimulate further interaction both theory and applications of nonlinear dynamics.

This has been done also to overcome the difficulties of in-person meeting due to the pandemic. ENOC 2022 has been organized despite of all the difficulties so that scientists from many countries could meet each other.

Let us remember Paul Valery (French poet):
« La guerre, un massacre de gens qui ne se connaissent pas, au profit de gens qui se connaissent mais ne se massacrent pas ».
« War is the slaughter of people who do not know each other, to the benefit of people who know each other and do not massacre each other ».
Let's try to keep meeting.

ENOC 2022 was structured through 22 Mini-Symposia (MS) on major and challenging topics, organized by well-recognized scientists also acting as chairpersons of those MS. Several of the MS followed the successful scheme of earlier ENOC conferences. Mini-Symposium MS-21 was devoted to a new topic: Nonlinear Dynamics in Acoustics. The program was organized through 9 parallel lecture sessions. The available time slot per oral presentation was 20 min., including discussion.
A special session (MS-22) has been dedicated to L.I. Manevich.

The congress was opened on Monday morning at 09:30. D. Bigoni chaired the session, F. Ubertini addressed a brief welcome to the participants, M. Geers (the current President of EUROMECH) gave a 10 minutes talk about the EUROMECH society, A. Corigliano (chairman of the Congress Committee) showed data on the participation in the congress and finally D. Bigoni gave some practical information. The opening session terminated at 10:00 with the general lecture given by K. Bertoldi.

Publications

482 abstracts accepted (Oral or Poster presentation) Conference Proceedings containing full texts of the papers were published in digital form on the Conference website:
https://enoc2020.sciencesconf.org/page/book_of_abstracts

384 registered participants

More than 40 countries: Algeria, Austria, Belgium, Brazil, Canada, (China), Czech Re-public, Denmark, France, Germany, Hungary, India, Iran, Italy, Israel, Japan, Latvia, New-Ze-aland, Netherlands, Norway, Oman, Pakistan, Poland, Portugal, Russia, Serbia, UK, Ukraine, USA, Saoudi-Arabia, Spain, Switzerland, Trinidad and Tobago, Turkey, etc.

ENOC Prizes

Two kinds of Prizes were attributed at the end of ENOC 2022 by the EUROMECH Nonlinear Oscillations Conference Committee.

ENOC 2022 Young Scientist Prizes

Two prizes, involving EUR 300 (Audrey Couineaux, Laboratoire d'Acoustique de l'Université du Mans, CNRS UMR 6613, Le Mans, France (LAUM) and Dennis Heyser Institute of Applied Dynamics (AD), Technische Universität Darmstadt L1|01 Otto-Berndt-Straße 2 D-64287 Darmstadt, Germany) rewarded the best oral presentations given during ENOC 2022 by young scientists (less than 35 years old).

ENOC Best Poster Award

Two Best Poster Award were given for the best poster presentation: Rima Saadaoui, (ICube, engineering science, computer science and imaging laboratory, Strasbourg, University of Strasbourg, 4 Rue Blaise Pascal, 67081 Strasbourg, France) and Pauline Kolb (Universidade de São Paulo (USP), Cidade Universitaria - 05508-090 São Paulo - Brazil and Department Civil Engineering, Technische Universitat D-64277 Darmstadt - Germany).

Best organization of a Mini-Symposium

The chair of ENOC 2022, in agreement with ENOC Committee has decided to award a prize for the best organization of a Mini-Symposium to the co-ordinator of MS-09 Nonlinear Dynamics in Engineering Systems, Prof. Yuri Mikhlin. Prof. Mikhlin made a great job in 2019, 2020, 2021 and 2022 despite the very difficult conditions in Ukrain this past year. His co-organizers (Prof. Konstantin Vitalievich Avramov, Prof. Francesco Pellicano, Prof. Matthew Cartmell) have been also warmly thanked for their efforts.

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ESMC11: European Solid Mechanics Conference

Galway, Ireland, 4-8 July 2022
Chairperson: Peter E. McHugh

The 11th European Solid Mechanics Conference (ESMC2022) was held at the National University of Ireland Galway (now University of Galway, as of September 1st, 2022), Ireland, July 4th to 8th, 2022. The conference website is www.esmc2022.org.
The conference was chaired by Professor Peter McHugh, Professor of Biomedical Engineering, University of Galway. The Local Organising Committee (LOC) consisted of 27 members.
Following normal practice and following approved protocols, University of Galway engaged the services of the PCO company Abbey Conference & Events as the Conference Secretariat. The conference was specifically organised in a fully in-person format and no hybrid presentation delivery facilities were provided for the general sessions or mini-symposia sessions. The conference had 8 themes, with a General Session (GS) for each theme, and 54 Mini-Symposia (MS) (involving 163 MS Organisers). To incentivise attendance at the conference, in the post-Covid context, all papers presented at the conference were presented orally and there were no poster presentations. The conference preparation and delivery was also strongly supported by the European Solid Mechanics Conference Committee (ESMC Committee), chaired by Professor Gerhard Holzapfel, and the EUROMECH Officers and Administration (EUROMECH President, Professor Marc Geers).
The conference was hosted in the main Arts/Science building and in the adjoining IT building at the centre of the University of Galway campus. The University made these two central building fully available to the conference for its duration and the organising committee is most grateful to the University management for this great cooperation and support for the conference. The University Student Centre (Áras na Mac Léinn) hosted the main registration area and the plenary lectures (in the Bailey Allen Hall). There was also an Exhibition & Catering Marquee erected close to the IT building in the very beautiful riverside setting, for the sponsor exhibition stands and the lunch catering.
The conference programme broadly followed that of previous recent ESMCs: 5 days (July 4th to 8th), with 1 lunchbreak and 2 coffee breaks per day. There were 7 plenary lectures delivered over the course of the week: 1 General Lecture, 5 Plenary Lectures and 1 EUROMECH Solid Mechanics Prize Lecture. 19 rooms were used for 19 parallel GS and MS sessions, with up to 13 2-hour sessions per room over the course of the week.
The conference was opened on the morning of Monday, July 4th, by the University of Galway President, Professor Ciarán Ó hÓgartaigh and by Minister Hildegarde Naughton, TD (Minister of State at the Department of Transport). Professor Peter McHugh gave an introduction to the conference and Professor Marc Geers gave an introduction to the EUROMECH society. A Welcome Reception was held on the Monday evening in the Marquee (sponsored by Perfuze).
There was a Speaker/Committee Dinner on the evening of Tuesday, July 5th, held in the beautiful and historical University of Galway Aula Maxima. The Conference Dinner was held in the Galmont Hotel in Galway city centre and 666 people attended. After-dinner entertainment included an exhibition of traditional Irish music and dance. The location of the next ESMC conference was announced after the dinner: Lyon, France, with ESMC2025 to be chaired by Professor Eric Maire. The conference was closed by Professor Peter McHugh at the Closing Ceremony on Friday, July 8th, where he thanked all lecturers and participants, and all those who helped make the conference a success.
In addition to the normal ESMC features, a number of innovations were introduced at ESMC2022: (1) The Women in STEM Conference support Awards; (2) the Postdoc and PhD student Networking and Mentorship Session; and (3) the Panel Discussion.

Facts and Figures

The final overall numbers for ESMC2022 are summarised in Table 1 below. It should be noted that the number of registrants immediately prior to the conference was higher than the 1114 shown in the table (a total of 1185 as of July 3rd, 2022). However in the run-up to the conference there was an increase in Covid cases internationally, and there were capacity problems at airports internationally in the days before the conference resulting in flight cancellations, both combining to result in some last-minute participant cancellations. However, in the end, these cancellations did not negatively impact the total participant numbers to any significant extent.

Plenary Lectures

The General Lecture was given by Professor Thomas J.R Hughes and the Plenary Lecturers were: Professor Vikram Deshpande, Processor Ellen Kuhl, Professor Gerard Ateshian, Professor Alan Needleman and Professor Javier Llorca. The Solid Mechanics Prize Lecture was given by Professor Jean-Jacques Marigo.

EUROMECH Fellows

The EUROMECH Fellows award ceremony took place on Thursday, July 7th.
The presentations were made by Professor Marc Geers and Professor Stefanie Reese (EUROMECH Treasurer).
The EUROMECH Fellow awards were presented to Professor Vikram Deshpande, Professor Laura De Lorenzis and Professor Umberto Perego. The EUROMECH Solid Mechanics Prize was presented to Professor Jean-Jacques Marigo.

Young Researcher Awards (YRA)

The Young Researcher Awards were sponsored by EUROMECH (2 awards) and Springer Nature (2 awards). A Young Researcher was defined as a PhD student or a PhD graduate with up to and including 3 years post-doc experience. Researchers applied for this award at the time of abstract submission. Of the >1200 abstracts submitted (by abstract submission deadline in December, 2021) there were 472 valid YRA applications from across all 8 themes. A panel of 16 reviewers was assembled (11 from the ESMC Committee and 5 from the LOC), and following a systematic abstract review process 12 finalists were identified. One of the finalists withdrew and the 11 finalists presented their work in two special YRA sessions at the conference on Monday, July 4th. A panel of 5 judges (2 from ESMC Committee, 2 from LOC, and the Conference Chair) scored the presentations and met on Tuesday, July 5th, to agree the result. The 4 prize-winners were presented with their awards at the EUROMECH Fellows session by Professor Peter McHugh and Professor Marc Geers.
The winners were:

- Tianlu Wang, Max Planck Institute for Intelligent Systems, Germany
- Sarah Gayot, UCLouvain, Belgium

Women in STEM Conference Support Awards

The Women in STEM Conference Support Awards generously sponsored by Cerenovus. Researchers applied for this award (conference fee waiver) at the time of abstract submission. Of the >1200 abstracts submitted there were 99 valid Young Female Researcher (YFR) applications. A panel of 10 reviewers (from the LOC and a representative from the sponsor, Cerenovus) was assembled to review the applications (abstract + 250 word justification) and, following a systematic process, 30 YFRs were identified for the awards, across 14 countries. The number of awards availed of as of July 3rd, 2022 was 27 across 12 countries, following some delegate withdrawals.

Postdoc and PhD student Networking and Mentorship Session

In advance of the conference, the Young Researchers (who had registered for the conference) were invited to sign up for this event. There was an immediate positive response, and between these and others who came to event and asked to participate, 230 Young Researchers met with a team of 30 Mentors (senior and experienced faculty members, from the across the nationalities and conference themes) to discuss career progression and success in research.
The event was held in the University of Galway College Bar (SULT, in the University Student Centre), on the evening of Wednesday, July 6th.

The Panel Discussion was held on Thursday, July 7th. Six distinguished scholars with backgrounds in different solid mechanics domains gave their views on the future of solid mechanics and the future development of the solid mechanics community. The panel members were: Professor Gerhard Holzapfel, Professor Laura De Lorenzis, Professor Marc Geers, Professor Laoise McNamara, Professor Vikram Deshpande and Professor Kerstin Weinberg. The discussion was chaired by Professor Peter McHugh.

Sponsorship

The conference received generous sponsorship/support from 15 organisations (in addition to EUROMECH): University of Galway Office of Vice-President for Research and Innovation, CÚRAM SFI Centre for Medical Devices, Fáilte Ireland, Cerenovus, Medtronic, I-Form Advanced Manufacturing Research Centre, Stryker, Perfuze, Alemnis, Medscan 3D, Aran Biomedical, 3DS Dassault Systemes, Instron, Zeiss and Springer Nature.

A team of 30 Student Helpers was organised to participate in the conference and to assist with the practical running the conference, including duties such as: technical assistance in the session rooms, helping with practical information and guidance for participants, crowd flow management throughout the venue, etc. The Student Helpers contributed significantly to the success of the event.

Conclusion

It was generally considered that the conference was a great success, and many messages of thanks and appreciation from participants were received during and after the event. A very nice collection of photographs from the event has been uploaded to the conference website.
The Conference Chair expresses sincere thanks to all who gave so generously of their time and effort to make the conference a success, in particular the Local Organising Committee, the MS Organisers, the ESMC Committee and the EUROMECH Officers and Administration.
The Conference Chair also expresses sincere thanks to the University of Galway Conference & Event Centre for excellent support given, and to Abbey Conference & Events for their excellent work as Conference Secretariat.

SUGGESTIONS FOR FUTURE

Suggestions for the future would include the continuation of some of the innovative features introduced at ESMC2022, including the mentorship session in particular and also the panel discussion. It would be good to continue the Women in STEM Conference Support Awards if possible, which in practice depends on securing sponsorship.

It is worthy of note that ESMC2022 attracted a very large number of young researchers: 36.2% of the participants were registered as students, and additionally there was a significant number of post-docs present. This was great to see, as young researchers represent the future of the field. As such, the activities that promote young researcher attendance and participation should be further developed. In particular, it is suggested that consideration be given to awarding more prizes at the conference, in addition to the Young Researcher Awards, as with 472 Young Researchers applying at the ESMC2022 abstract submission stage, only being able to make 4 awards (2 from EUROMECH, and 2 from Springer Nature sponsorship received for ESMC2022) left a large number of excellent applicants disappointed.

Perhaps additional prizes within each theme might be considered, sponsorship permitting.

EFMC14: European Fluid Mechanics Conference

Athens, Greece, 13-16 September 2022
Chairperson: John Tsamopoulos

Organisation

The conference was organised by the University of Patras (UPatras). The local organi-zing committee was chaired by John Tsamopoulos (UPatras), while scientific guidance was provided by the EUROMECH Fluid Mechanics Conference Committee (EFMCC), headed by Matthias Heil (University of Manchester).

Participation and Venue

Owing to the large number of more than 1020 submitted abstracts, the selection criteria applied by the EFMCC were quite strict and only 880 abstracts were accepted for oral presentations. Due to last minute administrative and pandemic difficulties the number of presentations were 814. EFMC14 was attended by 890 delegates from 39 countries with 29 accompanying persons.
The conference started on Monday afternoon with a guided tour of the Acropolis Museum, which is right below the historic hill with the Parthenon on top. This was followed by a recep-tion in the nearby Athens tennis club. On Tuesday morning the Opening Ceremony took place at the Banquet Hall of the Athens International Conference Center. Welcome addresses were delivered by the chairman of EFMC14, John Tsamopoulos; the secretary general of EUROMECH, Jacques Magnaudet and the vice Rector of the University of Patras, Dionysios Mantzavinos. The official opening of the conference was declared by the mayor of the city of Athens, Dr. Ko-stas Bakoyannis. The Conference Dinner took place on Thursday, September 15th, at the BLE AZURE, located by the sea in the Athens Riviera, with free transportation provided from the Meeting Venue and back. The dinner was accompanied by contemporary music and dancing by many conference participants until early the next morning.

Programme

The scientific programme covered all aspects of fluid mechanics with emphasis on its fundamentals and new areas of interest.
The contributed papers were presented in a total of 101 sessions, 11 in parallel, whereas the Prize lectures and the invited talks were given in a single session which was held in the Banquet Hall. All sessions took place at the single conference venue of Megaron Athens International Conference Center.

Prize Lectures and Invited Talks

The EFMC13 prize lecture was given by Uriel Frisch (since this meeting was not held due to the pandemic), the EFMC14 prize lecture was given by Patrick Huerre with the assistance of Lutz Lesshafft. A total of seven invited keynote lecturers were delivered by: Lydia Bourouiba, Maurizio Quadrio, Markus Uhlmann, Anne Juel, Juan Lopez, Stephane Popinet and Robert Moser.

Young Scientist Awards

During the Closing Session on 16 September, the winners of the Young Scientist Awards were announced.
They were:

- Bianca Viggiano (Dep. Mech. Engineering, Portland State University, USA) for the presentation entitled “Building up a turbulent jet from homogeneous turbulence”, and
- Jeremy Parker (Physical systems Laboratory, EPFL, Switzerland) for the presentation entitled “Variational methods for finding periodic orbits in turbulence”.

EUROMECH Colloquia Reports 2021

EUROMECH Colloquium 609
"Granular Patterns in Oscillatory Flows"
8 – 10 September 2021, VIRTUAL [Genova, Italy]
Chairperson: Marco Mazzuoli
Co-Chairperson: Markus Uhlmann

Introduction

Natural phenomena associated with flows that appear steady or in an equilibrium state at observational scales are often in fact the result of flow fluctuations occurring at much smaller or larger scales. Such fluctuations can be chaotic, like the velocity of small turbulent eddies, or exhibit some regularity, like the oscillatory flow induced by wind waves. The former are responsible for the random pick-up of sediment grains from the seabed, while the latter create the sedimentary pattern observable near coastlines. Besides the formation of bedforms under surface waves, some other conspicuous examples of phenomena that are strongly related to oscillatory flows are acoustic streaming, granular segregation and the assembly of motile bacteria due to their collective motion. Indeed, oscillatory flows can be considered as prototypes of accelerating flows, and insights obtained in such a basic field are fundamental.

Oscillatory fluctuations can be due to secondary flows generated by the interaction of steady flows with wavy solid boundaries, and vice versa, or primary flows generated by harmonic oscillations of boundaries, which can coincide with solid particles. In either case, solid-fluid interactions are clearly fundamental, as the dynamics of the boundaries are coupled with those of the flow. The nature of these interactions can be purely mechanical, e.g. sediment grains, or involve for instance electrostatic forces, such as those acting on cohesive parti-cles, or be driven by the biological collective behaviour. Granular patterns, which stem from solid-fluid interactions, reflect the microscopic properties of granular matter.

Interest in granular and oscillatory flows is growing in different scientific communities, as witnessed by the increasing number of articles and projects devoted to the subject, both for scientific enquiry and in environmental and industrial applications. The Colloquium provided an opportunity to discuss themes related to the mechanics of granular flows and suspensions and to the development of patterns of particles subjected to the action of oscillatory flows, highlighting the advancements and emphasising the improvements that the recent numerical and experimental techniques, such as DNS, LES, PTV and tomographic PIV, have led to in our understanding of the interaction between particles and vortex structures. The objective of the Colloquium was to promote the dissemination of recent developments and identify innovative approaches to the investigation of granular patterns through cross-fertilization between different scientific communities.

Programme and discussion topics

The Colloquium was carried out in hybrid modality in accordance with the constraints imposed by the COVID-19 pandemic. Nonetheless, 30 presentations were given, 13 in person and 17 online. Moreover, three key lectures were given by the invited speakers Jason Butler (University of Florida, USA), Enrico Foti (University of Catania, Italy) and Daniel Ahmed (ETH, Switzerland), introducing three of the significant themes of the Colloquium, namely the mechanical behaviour of granular suspensions subject to oscillatory flow, the effect of sea-waves on marine sediment and the exploitation of oscillatory flow properties for biomedical and industrial applications, respectively. In the spirit of the Colloquium, the participants made multidisciplinary contributions of high quality. The scientific issues and the main achievements presented during the Colloquium are reported in the following.

Pattern formation in wall-bounded conditions

Basic mechanisms of particle attraction and repulsion associated with the secondary flows arising in a wall-bounded oscillatory flow were presented. It was found that such mechanisms are responsible for the formation of particle patterns that might give rise to the bedforms on a granular bed subject to flow oscillations in the viscous regime. In the oscillatory channel flow configuration, flow oscillations were found to generate a cross-flow which promoted the formation of particle concentration patterns. The phenomena underlying the formation of bedforms beneath a vertically oscillating flexible plate was another fruitful area of discussion. Particle dynamics in turbulent steady wall-bounded flow were also described and useful suggestions provided for modelling complex suspensions. The effect of the Reynolds number on the segregation of non-axisymmetric fibres, as derived from experimental observations, was discussed. The effect of thermally-stratified turbulent channel flow on the dynamics of semi-buoyant particles was also described. Finally, preliminary results were given from a numerical investigation of the dynamics of turbulent slurry pipe flow.

Suspension mechanics

In the absence of bottom confinement, the effect of flow oscillations on viscous dense suspensions was the subject of three contributions. The granular stresses developing in a bed of cohesionless spherical particles subject to flow oscillations were described and compared with those that can be predicted using two-phase rheological models. Oscillatory flows could be used to unblock shear-jammed configurations. In particular, it was shown that ellipsoidal particles changed their orientation during the oscillation period, thereby reducing the overall viscosity of the mixture compared with spherical particles. On the other hand, the orientation of grains can induce shear thickening and eventually cause jamming, depending on the grain geometrical properties. The hydrodynamics of coarse-grained granular material

was advanced in the context of fluidised-bed modelling. In microgravity conditions, the aggregation rate of cohesive particles has been experimentally observed to be proportional to the square root of time, more rapid than expected if only Brownian motions were present. Therefore, the effects of the high frequency oscillations associated with space flight on the aggregation mechanism could be the missing ingredient to explain the measurements.

Sediment transport and origin of bedforms

A large number of contributions were devoted to sediment transport mechanics. The sediment transport associated with a turbulent oscillatory flow over a bed of cohesionless sediment was described in detail using particle-resolved direct numerical simulations (DNS). For the values of the parameters characterising wind-waves, the effects of the flow unsteadiness on the sediment flow rate were found to be quite small. Similar DNSs were also used for turbulent open-channel flows to compute the distribution of the bottom shear stress along flow-transversal bedforms and to explain the origin of sediment ridges. How reliable in practice are wall-resolved and wall-modelled large eddy simulations in predicting sediment transport? Such a question was also discussed in the Colloquium with the objective of extending the small computational domains that characterise the computationally challenging DNS to spatial scales that are relevant for engineering applications. In the context of sediment transport mechanics, remarkable advances have been made in understanding the fundamental processes underlying the formation and evolution of bedforms. The dynamics of the vortices stemming from flow separation at the crest of small-scale sea bedforms were described using the RANS approach and their effect on the bedform evolution highlighted. It was impressive to see that PIV measurements could also be made directly from the field. At a larger scale, the vortical structures induced close to the bottom and at the sea surface by breaking waves were analysed experimentally, using the PTV technique to identify the cores of the vortices, and numerically by means of 2D RANS simulations. Strong vertical pressure gradients associated with the interaction of a granular bed with turbulent vortices developing close to the bottom were found to cause the displacement and transport of sediment particles. The action of fluid jets, like those generated by helicopter rotors, impinging into the sediment, and the interaction between the surface vortices associated with breakers and near-bed turbulent structures, were described based on both experimental and numerical results.

Bedform dynamics and modelling

Bedforms adapting to transient flow configurations exhibit some unusual dynamics. Three contributions were devoted to interpret the behaviour of merging, repulsing and splitting dunes, with the purpose of developing relatively simple models that predict the bedform evolution. Indeed, significant efforts were devoted to the modelling of bedforms. Beyond DNS, which can be considered the numerical counterpart of physical experiments, Eulerian two-phase models were employed to investigate the evolution of ripples in an oscillatory flow. The results resembled the dynamics of actual ripples generated by wind-waves. The ROMS model was used to simulate the flow over tidal sand-waves, leading to an explanation of the relative enhancement of turbulence on the lee side of bedforms with respect to previous analytical predictions. Finally, the stability analysis of an oscillatory boundary layer at the bottom of finite amplitude surface waves was performed, and the mechanism of transition to turbulence described.

Comments about the new 'hybrid modality' experience

Colloquium 609 was the second EUROMECH Colloquium organised in hybrid modality (after Colloquium 614). This allowed a number of participants to join who would otherwise have been unable to do so because of COVID-19 travel restrictions. Our comments, given below, may provide useful input to future Colloquia run in hybrid modality.

Available recordings: all the presentations were recorded, and the videos are available on the website https://609.euromech.org/video/ (log in with username '609' and password 'oscillatory').
The recordings ensure remote participants in different time zones can access all contributions.

Online participation in the sessions: remote and in-person participants were able to interact easily during the Q&A sessions following each talk. The scientific discussions took place smoothly.

Online discussions during the breaks: during the breaks (coffee/tea breaks, lunch time) online participants had available a 'virtual coffee room' where the scientific discussion could actively continue. However, it should be mentioned that there was less exchange between in-person and remote participants during those virtual coffee breaks. For this purpose, communication terminals would need to be installed around the spaces used in the coffee breaks.

Social events: there were no online counterparts of social events. This fact still represents the main difference between virtual and in-person Colloquia.

Conclusions

Colloquium 609 succeeded in gathering leading experts on the motion of grains in oscillatory flows, who delivered high quality presentations. Many participants left excellent comments. Both on-site and remote particpants engaged in fruitful scientific discussions that will hopefully have a noticeable impact on the future development of the field.

EUROMECH Colloquium 611
"Jet Noise Modelling and Control"
30 August – 1 September 2021, VIRTUAL [Poitiers, France]
Chairperson: Peter Jordan
Co-Chairpersons: Anurag Agarwal, Lutz Lesshafft

Introduction
Jet noise modelling and control efforts are largely based, now more than ever, on hydrodynamic instability theory, informed by the analysis of experimental and numerical data. In particular, the strong predictive capacity of so-called linear resolvent analysis, and its link to spectral proper orthogonal decomposition of flow data, has been much investigated over the last five years, and these developments were showcased in many presentations at our Colloquium. It is noteworthy that these tools and concepts are recent for the academic community, yet are already employed in industrial research and development. Participating colleagues from industry played an active role in the presentations and discussions, and provided valuable guidance in the formulation of future development objectives.

Participants
Most leading academic research groups from the field were represented in the 54 participants at the Colloquium, which included 23 PhD students and postdocs and 3 industrial R&D engineers. Participants came from institutions in France, Germany, Spain, Italy, UK, Russia, China, USA, Brazil and Australia. 25 participants joined the Colloquium by video conference, due to travel or personal restrictions. For nearly all participants that were physically present, the Colloquium was the first in-person scientific event since the start of the pandemic, and the occasion was enthusiastically appreciated.

Programme and discussion topics
38 oral presentations of 20 minutes each were given over the three days of the Colloquium, 16 of these by remote participants. Two round-table discussions of about one hour each were held on the topics 'How have streaks changed the jet-noise modelling paradigm?' and 'Towards nonlinear dynamic modelling of jets and their sound'. These two featured subjects were indeed at the center of many contributions; other recurring topics included the estimation of unknown flow data, the modelling of long-range flow resonance dynamics and the understanding of aerodynamic sound sources.

EUROMECH Colloquium 618
"Uncertainty quantification in computational mechanics"
13 – 14 December 2021, VIRTUAL [Luxembourg]
Chairperson: Lars Beex
Co-Chairperson: Eleni Chatzi

Introduction
Uncertainty quantification in predictive modelling is the discipline of both characterising uncertain features and discrepancies of a model and propagating these uncertainties, in order to assess their effect on quantities of interest. Probability theory forms a crucial cornerstone of uncertainty propagation, as it provides the mathematical foundation to quantify uncertainties. Surrogate modelling, which generally only emulates model's relevant input-output relations, and reduced-order-models, which incorporate the physics of the full model at reduced computation, are other major ingredients. This is necessary due to the complex, often nonlinear and time-varying (and hence, time-consuming) nature of models that describe actual engineered systems.

Uncertainty quantification forms the foundation of numerous engineering fields, including reliability analysis and structural health monitoring, and is well-formulated, understood, studied and exploited by researchers working in such domains. In the field of computational mechanics, however, uncertainty quantification is relatively new. The Colloquium aimed at exchanging knowledge on uncertainty quantification a cross d ifferent r esearch fields, with the physics of interest therefore being highly diverse. The talks encompassed both static and dynamic analyses, as well as the mechanics of solids and fluids. Depending on the target use case, certain presentations relied heavily on the analysis of experimental data, whereas others focused on the development of novel numerical methods and their mathematical foundations. This element of diversity was well appreciated by the participants.

Discussion topics
The presentations in this Colloquium all focused on one or more of the aforementioned foundations of uncertainty quantification: probabilistic modelling and identification; and surrogate/reduced order modelling. Although not all presentations employed these concepts for uncertainty quantification, the diversity in themes and use cases gave the Colloquium a liveliness in spite of its virtual nature that was much appreciated by the participants.
Since each abstract can still be accessed online, the remainder of this section groups the presentations under the above main headings, although some belong to more than one category.

Probabilistic models

A fair proportion of presented works dealt with probability theory. This group may be subdivided into two sub-clusters: those that dealt with the efficient probabilistic modelling and propagation of uncertainties; and those that focused on identifying model features and their uncertainties probabilistically.

Prof. Guilleminot's presentation fell under probabilistic modelling, focusing on fractional finite elements (FE) to sample parameter inputs from random fields effectively and efficiently. Compared to the common practice of sampling from a high-dimensional probability density function, fractional FE models carry the twin advantages of (a) superior speed and (b) ease of exploitation for complex geometries. Other presenters who focused on probabilistic modelling were Prof. Girolami and Prof. Worden, who constructed finite element frameworks to incorporate efficiently and accurately uncertain model features such as model parameters. Such frameworks were demonstrated to work well in the context of nonlinear problems. Prof. Worden presented a framework that evaluates the accuracy of a stochastic FE framework and, when this is deemed insufficient, the approach blends the framework with a data-driven ML model. The last presenter incorporated probability theory in mechanical simulations: Dr. Hale used the Malliavin derivative to quantify the sensitivity of stochastic mechanical problems, by analogy with its use in econometrics. Prof. Cicirello presented a non-intrusive framework for propagation of uncertainties through expensive-to-evaluate models. Bayesian optimization was employed to reduce the number of simulations to be evaluated and simultaneously quantify the uncertainty in the resulting response bound estimates.

Five other presentations considered Bayesian inference for identifying probabilistically model aspects such as model parameters and cracks. Bayesian inference unifies measurement data with a priori knowledge of the physical system of interest and can even be used when the data has a high degree of sparsity. Dr. Alkam employed Bayesian theory for the probabilistic identification of cracks in caternary columns, and validated his results with measurements from columns still in service. Prof. Noels on the other hand used the framework in combination with a neural network to identify orthotropic elastoplastic parameters of short-fibre-reinforced polymers to emulate rapidly the model's forward runs. Dr. Zhang exploited Bayes' theorem to identify the parameters of elastoviscoplasticity using force-displacement curves and plastic surface deformation of nano-indentation. Dr. Rappel first presented an inter-correlated, bounded random fields model and then used Bayesian inference to identify the random fields' parameters for a sparse data set. Finally, Prof. Papadimitriou presented a design-of-experiments framework based on Bayes' theorem in the context of structural health monitoring, where the aim is not to identify damage but to identify which sensor locations have the highest probability of identifying damage if it occurs.

Surrogate and reduced-order models

In this class of methods, we are concerned with models that substitute physics-based simulators. One approach to this end is to rely on Full Order simulations from expensive numerical models. In this regard, Dr. Agathos presented a reduced-order modelling (ROM) approach, where low-dimensional spaces are constructed from appropriately selected columns of the flexibility matrix of the system. In a similar spirit, Dr. Geelen presented a localized reduction approach that can be applied non-intrusively for nonlinear systems. The proposed reduced model is constructed entirely from snapshot data and does not require access to high-fidelity discretized operators. Prof. Kerfriden presented a Bayesian approach for reducing computation in multiscale simulations, in which the local microscale solution is replaced by an Encoder-Decoder Convolutional Neural Network that generates fine-scale stress correctors to coarse predictors. Dr. Pickering presented a Neural Network surrogate approach for nonlinear systems experiencing extreme events. The framework was demonstrated on the prediction of extreme events related to deep-water waves.

Surrogate models may also be developed by means of data-driven inference.
Prof. Kumar suggested such an approach, the EUCLID framework for data-driven discovery of hyperelastic material constitutive laws, via either (i) a hierarchical-Bayesian sparse regression framework drawing from a large catalogue of candidate functions, or (ii) an ensemble of physics-consistent neural networks with higher generalization capabilities.

Finally, the possibility exists to combine physics-based models with data (grey-box modelling), as presented by Prof. Cross, who demonstrated a grey-box approach to physics-informed machine learning in which ML algorithms are adapted to account for physical engineering insights to improve predictive capabilities in Structural Health Monitoring.
Prof. Koutsourelakis further presented an integrated methodological framework, relying on both black- and grey-box approaches, for inverting the Process-Structure-Property chain in order to identify those variables that result in designs satisfying property-related objectives.

EUROMECH Colloquium 620
"Extreme dissipation and intermittency in turbulence"
17 – 19 May 2021, VIRTUAL [Delft, The Netherlands]
Chairperson: Gerrit E. Elsinga
Co-Chairperson: Julian C. R. Hunt

Introduction

Extreme viscous dissipation rates and the associated extreme strain rates are critical in many industrial, environmental and astrophysical processes dominated by small-scale turbulence. For example, dissipation extremes can lead to local flame extinction and pollutant formation, can affect the chemistry of molecular clouds, are sites for droplet collision and growth in clouds and enhance the intermittency of the scalar dissipation rate. Extreme dissi-pation also sets the smallest scale in a turbulent flow, thereby posing resolution requirements for experiments and numerical simulations, which is especially relevant in the study of the aforementioned small-scale processes.

Despite its importance, there is no suitable theory to explain the Reynolds number scaling of the dissipation extremes. Any successful new theory will need to account properly for the intermittency and the development of turbulent flow structures at high Reynolds numbers. However, connecting the recent understanding of turbulent flow structure with the prediction of dissipation extrema in real industrial, environmental and astrophysical applications remains a significant challenge and opportunity.

This Colloquium brought together scientists from different disciplines (fluid mechanics, turbulence, applied mathematics, atmospheric sciences and astrophysics) to discuss the key questions confronting the field.

Participants

Keynote lectures were presented by:

- Luca Biferale (Tor Vergata, Rome), who reported on the insights gained from turbulence simulations where a feedback on the local vorticity is implemented
- Bérengère Dubrulle (U Paris-Saclay, CNRS), who presented results from experimental and numerical investigations of potential blow-up events in turbulent flow
- Takashi Ishihara (Okayama University), who discussed large-scale shear layer structures in high-Reynolds number turbulence
- Eliezer Kit (Tel Aviv University), who presented atmospheric measurements of intermittency and bursts of extremely high dissipation
- Alain Pumir (ENS de Lyon, CNRS), who described extreme enstrophy and dissipation event observed in direct numerical simulations and their Reynolds number dependence
- Pui-K uenYeung (Georgia Tech), who discussed recent advances in high-resolution high-Reynolds number simulations and their relevance to the investigation of extreme events

A further 29 contributed talks were presented.

Discussion topics

The themes emerging from the talks and discussions are summarized below.

Observations of extreme events

Results were presented from direct numerical simulations as well as laboratory experiments. They revealed that the Reynolds number scaling of extreme events cannot be predicted from classical arguments, i.e. Kolmogorov theory. A theory to explain the observations is currently lacking. The multi-fractal model may provide (upper) bounds, but not yet the actual scaling. Furthermore, the present observations cover a limited Reynolds number range, and it would be of major interest to extend them to higher Reynolds numbers, especially in the light of reported large-scale influences (see below). The dynamics of extreme events were also discussed, which is relevant to their stability and the development of potential singularities. Several talks therefore considered extreme events and intermittency from the perspective of singularities and the irreversibility of turbulence, where Lagrangian and Eulerian viewpoints have been combined.

The flow scenarios considered in the various talks included homogenous isotropic turbulence, MHD turbulence, wall-bounded turbulence, superfluids and buoyancy-driven flows. In MHD, extreme dissipation originates from multiple sources, and their relative importance was examined. The implications of extreme events for particle motions, clustering and collisions were also discussed.

Large-scale influences

The fact that extreme events do not follow classical scaling suggests they may be influenced by large scales. Several talks discussed the mechanisms of collective vortex organisation, the importance of non-local triads and the clustering of intense dissipation into large-scale structures, such as for example large-scale shear layers. Examples of large-scale (or larger-scale) clustering of intense dissipation events were given from direct numerical simulations, atmospheric observations (so-called bursting phenomena) and cosmic observations of molecular clouds. Such spatial clustering of very intense small-scale motions is

considered to have important implications for dissipation scaling as well as particle dispersion. A model based on the organisation of intense dissipation in large-scale shear layers was proposed, which could capture the observed anomalous scaling of extreme dissipation. Furthermore, the analysis of weak solutions of the Navier-Stokes equations provided further insight into the origins of the low-dimensional accumulation of dissipation (clustering).

Numerical experiments and control

Computer simulations allow modification, or removal, of the different terms in the governing equations. Results from these numerical experiments provide guidance to the design of turbulence control strategies and give insight into the significance of these terms in the cascade process and in the development of intermittency. Similarly, the methods developed to explore causality in turbulent flows make local changes to the flow and examine their effect. This is a relatively new and promising development.

Conclusions

Overall, the Colloquium was successful in bringing the communities together and provided fruitful discussions on progress in the field as well as on the open issues.

Acknowledgement

The organisers would like to thank EUROMECH for its support.

EUROMECH Colloquium 621
"Transport and fluxes in dispersed turbulent flows"
30 June – 2 July 2021, VIRTUAL [Reykjavik, Iceland]
Chairperson: Luca Brandt
Co-Chairpersons: Pedro Costa, Francesco Picano

Introduction

The aim of the Colloquium was to present the latest advances in the understanding of turbulent dispersed multiphase flow in the presence of moving interfaces (i.e. particles, bubbles or droplets), and to address the current progress and future challenges in the understanding of these flows through advanced numerical and experimental techniques.

The rapid development of high-fidelity numerical algorithms, together with improved computational power, has enabled very detailed interface-resolved simulations. These have been used not only to improve our fundamental understanding of multiphase flows, but as a starting point for the development or improvement of low-dimensional upscaled models, within so-called Euler-Euler and Euler-Lagrange frameworks. On the experimental front, there are interesting advances based on index-matched techniques, non-optical approaches to measuring multiphase flows, and other impressive multiphase turbulence optical measurement setups, some of which we were fortunate to hear presented in the Colloquium. The exchange of knowledge and ideas around these aspects was the main goal of the Colloquium, which, in our opinion, it achieved with great success.

Programme and parcicipants

There were around 90 participants, and some 30 talks, with three keynote lectures, by Mikaël Bourgoin, Maike Baltussen, and Gretar Tryggvason. In addition, a final collective discussion on the perspectives in the field was organised for the last day, coordinated by Alfredo Soldati and Arezoo Ardekani. The full program and list of participants, together with the list of abstracts, has been archived in [1].

Given the online nature of the Colloquium, it was decided to schedule it over two half days (Days 1 and 3), and one full day (Day 2). The talks were grouped broadly by topic, with some exceptions to allow for different time zones.

Day 1

Day 1 focused on particle-laden turbulent flows. In line with the Colloquium goals, the largely numerical contributions were balanced by a keynote lecture on advanced experiments. Different types of carrier flows laden with a dispersed phase were addressed, ranging from

the experiments of Lagrangian particle diffusion in turbulent jets in the keynote by Mikaël Bourgoin to wall-bounded turbulence studied with both particle-resolved and particle-modelled simulations. Two subsequent contributions considered the simulation and modelling of a dense wake flow, and turbulence-driven particle capture in the surface of droplets. The last talks of the day considered advanced modelling approaches for gas-particle and gas-liquid flows, with heat transfer, and ended with a contribution on turbulent spray combustion in a rocket combustor.

Day 2

Day 2 focused on turbulent two-fluid flows, such as droplet- and bubble-laden flows, with all but one talk numerical in nature. Despite this common theme, a rich variety of problems was addressed, in a clear demonstration of the growth of the field. Another common theme of these contributions was the prominent use of interface-resolved simulations to describe such flows with high fidelity, clearly showing the advance of numerical methods and computing time availability. Topics such as phase change, effects of surfactants, non-Newtonian suspending fluids, heat, and mass transfer (with a comprehensive contribution in the keynote by Maike Baltussen) were addressed here. However, their outstanding detail and depth sparked interesting discussions on both the limitations of simulations and their ability to reveal certain quantities that are difficult to measure.

Day 3

Day 3, with some exceptions, focused on non-spherical particles and fibres, with two experimental talks. In addition, the keynote lecture of Gretar Tryggvason posed important questions about the nature of direct numerical simulations of multiphase turbulence and the fact that they are typically not independent of the numerical method, contrary to the definition of DNS. Other outstanding issues, such as three-phase flow modelling, machine learning and interface-coarsening for large-eddy simulations of multiphase flows, were also discussed.

Finally, at the end of Day 3, a plenary discussion was held. Here, outstanding issues such as the portfolio of numerical approaches to tackle the same problem, the reproducibili-ty and accessibility of resources, and the challenges in experiments were discussed. Finally, contributions of experimental nature were deemed to be crucial here, and the small number of contributions of this type - only four out of 28 - posed some concerns. Quoting a comment raised in the discussion, ‘While we can ensure that we are solving our equations right, we need experiments to make sure we are solving the right equations!’ The small number of experimental contributions was deemed to reflect the prevalence of numerical studies due to their easier accessibility and lower cost, and the major challenges that still revolve around measuring multiphase turbulence.

Conclusions

In our view, the Colloquium was a great success. The quality of the contributions was excellent, and while the online nature of the Colloquium did not allow for the close interactions that are typical and expected in normal times, we were able to reach a much wider audience by holding it online. An important, outstanding conclusion is that the field needs more resources focused on devising high-quality experimental campaigns, in an epoch where numerical studies seem to be dominating the field.

[1] P. Costa, F. Picano, & L. Brandt. (2021). EUROMECH Colloquium 621 ‘Transport and Fluxes in Dispersed Turbulent Flows’, Reykjavik, Iceland (Online Congress). https://doi.org/10.5281/zenodo.5076018

EUROMECH Colloquium 626
"Mechanics of high-contrast elastic composites"
6 – 8 September 2021, VIRTUAL [Keele, UK]
Chairperson: Danila Prikazchikov
Co-Chairperson: Andrea Nobili

Introduction

Analysis of strongly inhomogeneous elastic structures, including multi-component elements, composites, as well as periodic media, is an important area of modern interdisciplinary research, having numerous engineering applications, such as bio-inspired composites, soft robotics, modelling of photovoltaic panels and laminated glass, insulation panels, etc. The presence of large contrasts in physical and geometrical properties leads to drastic changes in mechanical behaviour compared to homogeneous materials or those with moderate or mild contrasts, and this motivates theoretical and experimental analysis of the related problems. Recent advances in this area allow more accurate modelling of high-contrast composite solids and structures.

Participants

The Colloquium attracted 56 participants from 19 countries, including valuable con-tributions from the well-known international centres of excellence, such as: Aalborg Uni-versity (Denmark); University of California Berkeley & Texas A&M (USA); Rheinisch-Westfälische Technische Hochschule Aachen & Weierstraß-Institut für Angewandte Analysis und Stochastik (Germany); NUI Galway (Ireland); École Nationale des Travaux Publics de l'État (ENTPE) & University Jean Monnet (France); Zhejiang University & Tianjin Uni-versity (China); Technion – Israel Institute of Technology (Israel); Politecnico di Milano, University of Perugia & University of Trento (Italy); Krakow Technical University (Poland); Saint-Petersburg State University (Russia); and University of Bath, University of Cambridge, Imperial College London, University of Liverpool, University of Southampton & University College London (UK).

Discussion topics

Thin laminates

High-contrast thin laminates have a number of important engineering applications, e.g. laminated glass.
The related problems were addressed in a number of talks, in particular developing engineering and asymptotic theories for high-contrast layered structures, and studying the effect of strong inhomogeneity on the dynamic behaviour, which is a delicate issue of formulating boundary conditions, etc. [Altenbach, Askari, Boutin, Fu, Ghulghazaryan, Kaplunov]. The occurrence of extra-low-frequency spectra, when the hard components perform almost rigid body motion, was noted as an important feature associated with the dynamics of strongly inhomogeneous structures.

Multispan waveguides

Problems for layered structures are closely related to those for multi-component waveguides. The results of exact and asymptotic treatments of some of these problems were presented at the Colloquium, including in particular considerations of strongly inhomogeneous bars, as well as the problem of flutter of a multispan structure in a supersonic flow [Amato, Kuznetsov, Şahin].

Engineered micro-structured materials

Another important focus of the Colloquium was on the mechanical behaviour of engineered materials with micro-structure, including fibre-reinforced composites. Results were presented for problems on structures with inclusions [Chen, Dal Corso, Mityushev, Nieves], as well as asymptotic formulations for micro-structured plates [Nobili], and also studies of meta-concrete [Pandolfi] and meta-materials designed for applications at extreme deformations [Bigoni]. Inspiring talks by Steigmann and Rajagopal studied cutting-edge problems of stress concentrations near a hole in a fibre-reinforced elastic solid, and the development of the Cosserat model in a solid containing curved and twisted fibres.

Periodic structures

High contrast also plays an important role in the analysis of periodic media. A number of rigorous mathematical treatments were presented, including sharp operator-norm asymptotics for thin elastic plates with rapidly oscillating periodic properties [Cherednichenko], stochastic homogenisation of high-contrast media [Cherdantsev], uniform asymptotics for a family of degenerate variational problems with applications to error estimates in high-contrast homogenisation problems [Kamotski], as well as analysis of norm-resolvent convergence to zero-range models with internal structure in models with strong inhomogeneities [Kiselev], and a technique of high-contrast dynamic homogenisation of periodic micro-resonances with random properties [Smyshlyaev]. In addition, the analytical solution for a cell problem in the case of the homogenization of transport properties of densely packed, high-contrast fibre composites was presented [Andrianov].

Industrial applications

A useful number of modern engineering applications of high-contrast media were discussed, including laminated glass [Boutin], lightweight structures [Altenbach], biomechanical applications, nonlinear bio-composites and soft materials [Destrade, Rudykh, Saccomandi, Volokh], understanding the role of inhomogeneities during hydraulic fracture [Mishuris], and investigations of engineered materials with enhanced dynamic performance [Pandolfi].

An interesting idea of employing strongly inhomogeneous seismic barriers was also proposed [Bratov].

In addition, several talks dealt with the analysis of strong inhomogeneous problems of fluid-solid interaction, including the development of high-contrast asymptotic techniques [Panasenko] and a study of wave propagation in fluid-filled periodic shells composed of high-contrast cells [Sorokin].

Conclusions

The Colloquium highlighted a number of important effects of strong inhomogeneity in various fields of mechanics. The subject is clearly interdisciplinary, and it was an excellent opportunity to bring together (albeit in online format) experts from various branches of modern engineering, including mechanical, civil, and material engineering, along with applied mathematicians to discuss the theoretical and experimental challenges associated with high contrast in a number of technical problems. Recent advanced methodologies were discussed, including rigorous and formal asymptotic techniques, robust computational schemes and new experimental results.

The organisers were very pleased with the contributions of the participants, and both during and after the Colloquium we had very positive feedback for the scientific content.

Acknowledgement

We would like to thank EUROMECH for its support in organising the Colloquium.