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EUROPEAN MECHANICS SOCIETY

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EUROPEAN MECHANICS SOCIETY

EUROMECH Conference Reports

ETC16 – 16th European Turbulence Conference

21 - 24 August 2017, Stockholm, Sweden
Chairperson: Prof. Dan Henningson

Brief summary

It was a great pleasure for us to host the 16th European Turbulence Conference again at KTH Royal Institute of Technology in Stockholm. KTH is one of Europe's leading technical and engineering universities and is also a leader in technical research in Sweden. The 3rd European Turbulence Conference was organized at the same location in 1990.

Briefly:

Altogether 17 symposia were organized, with up to 7 parallel sessions. The EMMC scientific committee appointed the symposia organizers. The symposia titles, organisers and numbers of contributions are listed below:

- 685 abstracts were submitted to the conference;
- 502 papers were selected for oral presentation at the conference. Each abstract was reviewed by three members of the scientific and local organizing committees;
- 523 registered participants from 27 countries, 90% from outside of Sweden and 25% from outside Europe;
- 50% of the participants were younger than 35 years (and thus eligible for the Euromech Young Scientist prize).

Invited speakers:

Altogether 17 symposia were organized, with up to 7 parallel sessions. The EMMC scientific committee appointed the symposia organizers. The symposia titles, organisers and numbers of contributions are listed below:

- Enrico Calzavarini, Université de Lille, France: "Lagrangian studies in turbulent flows, from inertial particles dynamics to modelling of active matter."
- Peter Davidson, Cambridge University, UK: "Turbulence in the core of the Earth"
- Berengere Dubrulle, Institut Rayonnement-Matière de Saclay (Iramis), France: "Intermittency, dissipation and singularities in turbulent flows."
- Christian Poelma, Delft University, Netherlands: "Measuring in opaque flows"
- Philipp Schlatter, KTH Mechanics, Sweden: "Progress on high-order simulations of turbulence around wings"
- Michael Shats, Australian National University, Canberra: "Turbulence at the liquid-air interface driven by surface waves"
- Greg Voth, Wesleyan University, USA: "A new view of the dynamics of turbulence from measurements of rotations of particles with complex shapes"

Young Scientist prize

We had 238 participants who signed up for the award. We ranked them according to the rating that they received on their submitted abstract. 57 out of 238 had a marking with 4 or above (on a scale between 3 and 5). We emailed the 57 candidates asking them to send us their CV no later than 11th of August. 29 out 57 responded and papers by those 29 candidates were reviewed by three members of the ETC16 scientific committee. The two winners were:

- Andrew Bragg from Duke University for his paper: "Analysis Of The Forward And Backward In Time Pair-Separation Pdfs For Inertial Particles In Isotropic Turbulence "
- Benjamin Favier from CNRS, IRPHE in Marseille for his paper: "Elliptical Instability Leading To Inertial Wave Turbulence"

ENOC9 - 9th European Nonlinear Oscillations Conference

25 - 30 June 2017, Budapest, Hungary
Chairperson: Prof. Gabor Stepan

Scope

Although the brand name ENOC (European Nonlinear Oscillations Conference) is still used as the historical abbreviation, the European Nonlinear Dynamics Conferences aim to cover the complete field of Nonlinear Dynamics, from Multibody and Stochastic Dynamics and Coupling to Stability, Identification, Control and (Structural) Optimization.

During recent decades, the area of nonlinear dynamics has been evolving in a revolutionary way, with applications to a wide variety of engineering systems. This has been made possible by the use of sophisticated computational techniques employing powerful concepts and tools of dynamical systems, bifurcation and chaos theory.

Themes

Two main general issues characterize the present research framework:

- the need to overcome the limitations inherent in the archetypal single- or few-degree-of-freedom models mostly considered in the past, and to deal with real systems;
- the increased interest in exploiting nonlinear dynamics modelling and analysis for designing physical and engineering systems and controlling their nonlinear and complex behaviour.

Aims

The aims are to:

- develop more reliable reduced-order models for the analysis of the higher-order systems and processes encountered in most technical applications;
- improve model validation from calibrated experimental investigations;
- generalize concepts and techniques for the analysis of new complex behaviours;
- explore the implications of nonlinearity and chaos in design and operation of advanced systems, as well as requirements for their control.

ENOC9 in 2017 aimed at bringing together a wide variety of specialists in order to show the latest developments, to foster future directions for development, to exchange experience, and to stimulate further interaction by in-depth exploration of both theory and recent applications of nonlinear dynamics.

EUROMECH Colloquia Reports 2017

EUROMECH Colloquium 578
"Rolling Contact Mechanics for Multibody System Dynamics"
10 – 13 April, 2017, Funchal, Madeira, Portugal
Chairperson: Jorge Ambrosio
Co-Chairperson: Werner Schiehlen

Rolling elements play a pivotal role in almost all modern engineering systems characterized by large relative motion between their mechanical components. Multibody Dynamics, being the best-suited discipline to deal with the computational dynamic aspects of the analysis and modelling of systems with very large motion, requires computationally efficient approaches and algorithms to evaluate rolling contact mechanics. These rolling contact mechanics are fundamental to characterization of the interaction between elements in rail-wheel contact, tyre-road contact, roller bearing contact dynamics and biomechanics of natural joints, among others. The fundamentals of the elastic, or plastic, rolling contact mechanics are also an inherent part of the tribology of rolling elements and wear, being naturally involved in the development of models for Finite Element Analysis or Multibody Dynamics.

EUROMECH Colloquium 578 covered the scientific topics that are needed to address the mechanical and computational challenges in handling rolling contact mechanics in the context of multibody dynamics. The following list shows some key aspects that were reviewed during Colloquium 578, through both their theoretical foundations and practical applications.

- Classic theories in elastic and plastic contact;
- Efficient computational algorithms for use in multibody dynamics applications;
- Tribology characteristics of the mechanical systems of interest;
- Consequences of wear in system response;
- Use of background contact theories.

Numerical problems arising from the computational implementation of the rolling contact formulations, being mostly transversal to the different areas of application, were of particular interest during the colloquium. Not only the performance of numerical methods associated with the integration of ordinary differential equations and solution of nonlinear equations, but also the modelling of systems to take advantage of improved understanding of the contact problem were discussed thoroughly.

A small scientific committee, including the organizers and 10 other leading scientists took care of the scientific program: E. Vollebregt VORtech, The Netherlands; G. Rill, University of Regensburg, Germany; J. Dominguez, University of Seville, Spain; J. Awrejcewicz, The Lodz University of Technology, Poland; J. Seabra, FEUP, University of Porto, Portugal; M. Rosenberger, Virtual Vehicle Research Center, Austria; P. Flores, University of Minho, Portugal; R. Lewis, University of Sheffield, United Kingdom; S. Bruni, Politecnico Milano, Italy; U. Nackenhorst, Leibniz University, Hanover, Germany. The presentations were selected from about 70 submissions. They were organized in a thematic form not only to ensure the consistent flow of the different topics but also to foster discussion and exchange of ideas.

Colloquium 578 took place over 2½ working days, with 53 participants from 18 countries and 47 presentations. All presentations were supported by abstracts. Many full-length papers were contributed on a voluntary basis. The colloquium was run without parallel sessions, so that the time for discussion could be managed flexibly to maximise the effective exchange of ideas.

The formal scientific programme was complemented by a social programme. Lunch periods of 1½ hours and tables of 10-14 encouraged continuation of scientific discussion and development of collaboration. The Tour and Banquet for all the participants and accompanying persons on the third day of the event helped to strengthen relationships.

Resulting from the excellent scientific quality of the Colloquium, the authors of selected presentations have been offered the opportunity to produce full-length papers for publication in a Thematic Issue of "Multibody System Dynamics" (ISI Impact factor 1.4), guest edited by J. Pombo, W. Schiehlen and J. Ambrósio. The papers will be peer-reviewed and, if accepted, published in 2018.

EUROMECH Colloquium 579
"Generalized and microstructured continua: new ideas in modelling and/or applications to structures with (nearly-) inextensible fibres"
3 – 8 April, 2017, Arpino, Italy
Chairperson: Francesco dell'Isola
Co-Chairpersons: Philippe Boisse

The main purpose of Colloquium 579 was to provide a forum for experts in generalized and microstructured continua with inextensible fibres, to exchange ideas and get informed about the latest research trends in the domain. Generalized continua with inextensible fibres (GCIF) are today employed in a very wide class of applications, ranging from the design of special fabrics to biological tissue engineering. The scientific problems posed by the growing needs of these kinds of application involve a very large number of areas, as the theoretical coverage, the design of suitable experimental procedures and the development of specific numerical tools are all crucial aspects of the general picture. The proposed topic lies in the framework of generalized continua. Although classical continuum models can be used to model almost all natural materials, they have poor predictive power when advanced architecture materials are considered. Recently, new manufacturing possibilities have created a need for improved understanding of generalized continua.

EUROMECH Colloquium 579 was a great success in terms of participation and quality of featured presentation and discussions. There were altogether about 63 participants from 15 countries, including 3 keynote lecturers: Philippe Boisse, INSA Lyon, France; Jean-François Ganghoffer, Université de Lorraine, France; Francesco dell'sola, Università degli Studi di Roma, La Sapienza, Italy.

The infrastructure of a small town like Arpino encouraged discussions and exchanges during the week of the colloquium, even outside the official schedule, and most of all during lunch breaks and social events.

The main key points discussed were the following:

- Phenomenology of materials reinforced with nearly inextensible fibres;
- General concept for microstructured continuum modelling;
- Micro-macro homogenization techniques and constitutive law identification;
- Strain and stress localization phenomena;
- Dynamic behavior of continua with inextensible fibres;
- Effects on acoustic properties of nearly inextensible reinforcements;
- Applications to mechanics of living tissue, engineering fabrics and composite reinforcements.

The key challenge today is not only to be able to predict the behaviour of already existing advanced materials, but also to succeed in prescribing constitutive characteristics at the micro-scale that will lead to desired behaviour at the macro-scale.
Several of the topics addressed are still very open, and the discussions provided a good push in what the organizers believe is the right direction for their solution and complete understanding. Numerous papers and preprints stemmed from the discussions and debates at Colloquium 579, demonstrating that the meeting has been successful in terms of scientific exchange and production. The community plans to regularize this event to a yearly basis.

EUROMECH Colloquium 582
"Short fibre reinforced cementitious composites and ceramics"
20 – 22 March, 2017, Tallin, Estonia
Chairperson: Heiko Herrmann
Co-Chairperson: Jürgen Schnell

Composites containing short fibres are important in many technological fields, the used composites range from fibre plastics to fibre concretes. Fiber composites are gaining importance, especially in the building industry, as they may increase the building speed and improve material properties. Fibres already in use include steel, basalt, carbon and polymer fibres, of many different shapes and aspect ratios. The aim of including fibres also varies, including improving tensile strength, post-cracking behaviour (ductility) and temperature resistance. In all cases, the microstructure and spatial and orientational distribution of the fibres is important. At this colloquium different methods and results for the analysis of microstructure and fibre orientation in cementitious building materials containing fibres, among them concretes and refractory composites, have been presented.

The goal of EUROMECH Colloquium 582 was to present a platform for the exchange of ideas between different fields with similar problems. While having different chemical compositions and length scales, cementitious composites and ceramics reinforced with short fibres share similar mechanical properties and theoretical problems. The addition of short fibres leads to a composite that has stochastically anisotropic and inhomogeneous properties, since several macro- and meso-scale properties depend on the spatial and orientational distribution of fibres. An important aspect is the micro-structure around the fibres and the adhesion of the matrix to the fibres, which has large influence on mechanical properties.

There were altogether 19 participants and 14 presentations at Colloquium 582, among these 3 keynote talks, given by: Daniele Casucci, Kaiserslautern; Johan L. Silfwerbrand, Stockholm; and Akke Suiker Eindhoven. Most importantly, the length of the presentation slots was larger than at typical conferences and offered more time for discussions and presentation of the topic in detail. Furthermore, informal discussions took part during coffee and lunch breaks as well as during the social programme.
Topics that recurred throughout were:

Fiber orientation analysis

As mentioned before, the orientation distribution of the short-fibres causes anisotropic material behaviour. As a consequence, the fibre orientation needs to be assessed and monitored during and after the production of parts made of short fibre reinforced materials. Different methods to extract information about the positions and especially orientations by means of X-ray computed tomography were discussed. Important aspects were the possibility to minimize user interaction and user mistakes, as well as the reliable separation of touching fibres to obtain information about individual fibres.

Interface between fibre and matrix

Another important topic was the interface between the fibres and the matrix material, notably the interfacial transition zone (ITZ). The structure of the transition zone has great influence on the bond between fibres and matrix (stiction), and on failure mechanisms, such as delamination of fibres and matrix, pull-out of fibres, friction during pull-out or rupture of the fibre in case of very strong bond/anchorage, influence of fibre orientations on cracking behaviour. The orientations of fibres have a strong influence on the cracking and post-cracking behaviour of the composite material. After an initial micro-crack has formed, it could be bridged by fibres and these fibres could arrest the crack growth if fibre orientations are favourable. It is also possible that fibres can be well aligned with each other, but have a "bad" orientation with respect to the acting forces.

Formation of shear bands

The influence of short fibres on the tensile and compressive strength of concrete has been investigated for some time already, but the interest in high temperature properties and fire safety is a more recent development. The addition of short polymer or carbon fibres has an influence on the fire resistance at temperatures much higher than the melting temperature of the polymer fibres or even after the carbon fibres have been burned away in refractory composites. The polymer fibres help to avoid explosive spalling caused by high vapour pressure in the material as they influence the migration of the vapour.
In refractory composites, the addition of fibres can have a beneficial influence of the compressive strength even after the material has been heated to temperatures at which the fibres themselves have been burned out.

Many participants have expressed their wish to obtain the slides of other presentations and also to have full papers. This demonstrates both the topical interest and the quality of the presentations. Also the wish to have future colloquia on this and related subjects has been expressed. The organisers and participants thank Euromech for making the meeting possible and for the financial support.

EUROMECH Colloquium 585
"Advanced experimental methods in tissue biomechanics"
12 – 16 February, 2017, Burg Warberg, Germany
Chairperson: Markus Böl
Co-Chairpersons: Alexander E. Ehret

Accurate mechanical characterisation of soft biological tissues and the identification of suitable material models is of high interest, not only for fundamental research, but also in many fields of life sciences and medicine. One major problem concerns the measurement of these properties without damaging the surrounding tissue or applying highly invasive techniques. Inverse numerical methods, where classical forward finite element analyses are iteratively tuned so that they fit the experimental outcome, are one possibility to address this problem and provided a focus for the previous Colloquium 534, held five years ago. However, a large number of remaining and new open questions are still to be answered, when identifying mechanical characteristics or material parameters from experiments on biological tissues.

The aim of EUROMECH Colloquium 585 was therefore to capture the advances in this field, with a particularly focus on new types of experiments and measurement set-ups, and their combination with computational methods. This goal was clearly achieved: A variety of novel and promising experimental techniques were presented that combine classical mechanical characterisation with advanced microscopy techniques, bioreactor set-ups, dedicated loading protocols that provide different physical, chemical or biological cues, and computational tools to control the systems and analyse the results. Advanced modelling and simulation approaches to interpret the experimental outcome were proposed, bridging the different scales from the nano- though micro- to the macro-level.

Colloquium 585 brought together experts from experimental, theoretical, biomedical, and clinical research focusing on experimental soft tissue biomechanics, and young scientists from all related areas. To support the participation of early stage researchers, three grants were awarded, including the regular conference fee, hotel costs, and all meals. Both questions related to fundamental research, as well as aspects related to medical applications were addressed during the colloquium.

The scientific programme for Colloquium 585 included 46 oral presentations. These highlighted various experimental methods in biomechanics ranging from experiments on cells and single fibres through passive soft tissue and active muscle mechanics to methods used to identify mechanical characteristics of whole organs. All contributions were followed by an intensive and constructive discussion. Further, five of the presentations were provided as keynote lectures given by international experts which provided overviews on recent advances in five focused areas.

During the colloquium, a mutual understanding of current problems and possible solutions was developed, despite the different areas of expertise of the participants. This was facilitated by the relatively small number of participants and by the colloquium venue, the medieval castle Burg Warberg, which hosted all participants. This allowed an intensive scientific exchange during the talks but also during coffee, lunch, and dinner breaks.

The scientific results presented at the colloquium were consistently of very high quality and will partly be published in a peer-reviewed special issue of the Journal of the Mechanical Behaviour of Biomedical Materials. The feedback received from the participants was throughout very positive. The organisers and participants are very thankful to EUROMECH for their support, which made this outstanding scientific meeting possible.

EUROMECH Colloquium 586
"Turbulent superstructures in closed and open flows"
12 – 14 July 2017, Erfurt, Germany
Chairperson: Jörg Schumacher
Co-Chairperson: Bruno Eckhardt

The classical picture of turbulence which has prevailed since the pioneering works by Kolmogorov, Prandtl and others from the first half of the last century is that turbulent fluid motion is characterized by a cascade of vortices and swirls of different sizes that give rise to a featureless and stochastic fluid motion. Our daily experience shows, however, that open and closed turbulent flows in nature and technology are often organized in prominent large-scale and long-living structures, which are called turbulent superstructures. These large-scale structures dominate the global transport of mass, heat and momentum; they act as barriers to transport and they increase the variability and fluctuations in the flow.

The analysis of turbulent superstructures is now possible due to significant advances in measurement techniques, numerical simulation, and mathematical characterization. Tomographic laser-based measurement techniques can track the dynamics of turbulent structures with unprecedented resolution in space and time. Direct numerical simulations on massively parallel supercomputers have advanced to a level where turbulent flows in extended domains can be simulated at sufficiently high Reynolds numbers and in parameter ranges where superstructures emerge. Efficient Eulerian and Lagrangian methods to characterize dominant vortices and flow structures, as well as determining the transport across their boundaries, have been developed in applied mathematics. Computer science provides efficient algorithms for the visualization of structures in very large data sets.

The goal of EUROMECH Colloquium 586 was to exchange new results on the structure and physics of turbulent superstructures and to discuss future directions in this field of turbulence research among scientists from applied mathematics, physics, engineering and computer science. The colloquium programme thus included recent experimental and numerical results on the processes that generate and sustain turbulent superstructures, on their dynamics, the transport across their (relatively sharp) interface and their impact on turbulent flow properties in simple open (e.g. boundary layers) and closed flows (e.g. pipe flows, Taylor-Couette flows or Rayleigh-Bénard convection). The focus of the presentations was on simple flow geometries.

For each of these specific topics, a keynote presentation was scheduled (45 minutes presentation time plus 15 minutes discussion time). The five invited keynote speakers are well-known experts in their research fields and beyond:

- Kathrin Padberg-Gehle, Lüneburg reported on the Lagragian analysis of transport by coherent sets and/or turbulent superstructures;
- Ivan Marusic, Melbourne and Javier Jimenez, Madrid on new statistical detection methods of turbulent superstructures and the connection of superstructures to smaller vortices and packages of vortices near the walls;
- Themistoklis Sapsis, Cambridge, USA discussed the role of large-scale extreme events for the global statistics in turbulent flows and presented new strategies to predict their appearance, which are based on the solution of an optimization problem.
- Jerry Westerweel, Delft gave a keynote presentation on the dynamics in the vicinity of turbulent/non-turbulent interfaces. Recent experiments and simulations determined the so-called viscous small-scale nibbling as the main mechanism of transport across sharp interfaces. These interfaces are considered as transport barriers that surround turbulent superstructures.

In addition to the 5 keynote talks, 13 contributed talks lasting 30 minutes and 11 short talks lasting 20 minutes were scheduled. There were also 10 poster presentations in a session during the first evening of the meeting. The schedule of the colloquium was set up so that there was sufficient time for mutual and group discussions during the breaks between the sessions and over meals. The outcome of these discussions was summarized at the end of the meeting.

Specific open topics and resulting future tasks were identified during the course of the colloquium, which can be grouped and summarized as follows:

Detection of turbulent superstructures

Which Eulerian and Lagrangian methods are suited best to detect turbulent superstructures and which new experimental and numerical techniques are necessary to monitor the structures in space and time? How important are spatial and statistical symmetries for the detection of superstructures? Are there new tools to compress the information of vector and tensor fields which are derived from the flow modeling effectively? The Related talks were by: Marusic, Melbourne; Encinar, Madrid; Weiss, Göttingen; Scheel, Los Angeles; Bross, München; Oberlack, Darmstadt; von Larcher, Berlin.

Origin and mechanics of turbulent superstructures

What is the dynamical origin of turbulent superstructures? Can they be traced back to exact coherent states and/or primary flow instabilities? How sensitively do turbulent superstructures depend on specific boundary conditions in the flow system? Are superstructures com-

posed of a whole hierarchy of smaller-scale structures? How are superstructures connected to extreme events? Related talks: Jimenez, Madrid; Hwang, London; Wesfreid, Paris; Blass, Twente, Sapsis, Cambridge, USA; Pausch, Marburg.

Transport by turbulent superstructures

How much do turbulent super-structures contribute to the global turbulent transport? How important is the superstructure interface as a transport barrier? How precisely can the interface of a turbulent superstructure be resolved by Lagrangian methods? Related talks: Padberg-Gehle, Lüneburg; Karrasch, München; Öttinger, Zürich; Westerweel, Delft.

Reduced modelling and control

What are efficient ways to reduce the number of degrees of freedom to describe superstructures? Which strategies can be applied to control turbulent superstructures, i.e. to stabilize such structures in a turbulent shear flow? Related talks: Schlatter, Stockholm; Feldmann, Bremen; Gerlach, Paderborn.

From this list of open points, it becomes clear that many questions which are related to turbulent superstructures are far from being completely answered. They will require further joint interdisciplinary efforts. There is now a priority programme on this subject, funded by the Deutsche Forschungsgemeinschaft.

Colloquium 586 was successful and fruitful. It provided a format which allowed us to summarize the current progress in the field and to generate new momentum and ideas for future research. The three organizers of the colloquium would therefore like to thank EUROMECH for making this colloquium possible.grateful for financial support from the Russian Foundation for Basic Research.

EUROMECH Colloquium 588
"Coupling Mechanisms and Multi-Scaling in Granular-Fluid Flows"
2 – 5 October 2017, Toulouse, France
Chairperson: Laurent Lacaze
Co-Chairpersons: Diego Berzi, François Charru Jacques Magnaudet, Thomas Bonometti

Granular flows are encountered in many geophysical and industrial applications. The transport of sand in rivers, oceans, deserts and oil pipes, debris flows and snow avalanches are some examples where the dynamics of the flow are controlled by the physical processes induced at the grain scale. Contrary to classical fluids, the size of the elementary constituents of granular materials is not infinitesimal with respect to the mesoscopic deformation scale, such as the length of ripples and dunes in sediment transport or run-out in avalanches, which makes their continuous description questionable. Yet, in the case of dry granular flows for which the effect of the surrounding fluid can be neglected, phenomenological rheological models and more fundamental approaches based on kinetic theory have been developed during recent decades and have been shown to be relevant in many situations. When interactions with the fluid are significant, the problem becomes more complex as the fluid can flow in the granular medium, leading to strongly coupled dynamics between the two phases. Extending continuous models towards such configurations and thus modelling granular fluid flows at the different scales remain a challenging task. The description of granular-fluid dynamics has been an increasingly attractive field of research for the last ten years, leading to a substantial stream of publications, including field measurements as well as laboratory experiments, numerical modelling at various scales and theoretical developments.
The aim of EUROMECH Colloquium 588 was to gather the European scientific community to exchange on recent developments regarding the coupling mechanisms in granular fluid flow at all scales, from that of the grain to that of the whole system.
The main topics were:

- Macro-phenomena: bedload and saltation; collisional suspensions; turbulent suspensions; debris flows and granular-fluid avalanches.
- Micro-processes: turbulence modulation; relaxation processes; rheology; boundary conditions.

Colloquium 588 was held from the 2 to 5 October 2017 at the Institut de Mécanique des Fluides de Toulouse. There were more than 50 participants and 41 presentations including 4 keynote lectures given by Olivier Pouliquen, Marseille; Jim McElwaine, Durham; Jim Jenkins, Cornell; and Eric Lajeunesse, Paris. Each day was dedicated to a specific scientific topic, introduced by one of the keynote lectures. Scientific issues addressed and discussed during these days were:

Fluid-particle interaction and rheology

The modelling of fluid-particle flows encountered in applications remains a key issue. Continuum models need constitutive equations to describe the coupled system. These rheological models should work for situations as complex as the ones observed in nature, involving irregular particle shapes and unsteady, inhomogeneous flow configurations. On the other hand, discrete numerical simulations, such as DNS for the fluid coupled with DEM for the particles, which could be used to test the continuum, rheological models, need to account for the local interaction/contact between particles. As the scale of this interaction is small compared to the size of the system, this short-range modelling remains challenging, in particular when particle shape is complex, while being a key ingredient for continuum models in dense configurations. The presentations proposed during the first day of the colloquium highlighted the new results obtained on these issues. In particular, they showed results on models for the rheology of suspensions of solid particles as complex as fibres, the role of turbulence on the rheology, the influence of surface roughness and shape on the local particle-particle interaction, the integration of lubrication models into DNS simulations at the micro-scale. An important data set obtained from idealized experimental configurations has been shown to be available to support rheological models, which can now be included in numerical models resolved at the scale of the particles. This will allow major progress in the parametrization of large scale models to predict more complex flows.

Granular avalanches

Most avalanches and landslides observed at the surface of the Earth can be modelled as granular flows interacting with a surrounding ambient fluid. The community is seeking a closer collaboration between field measurements and idealised laboratory experiments/simulations. The keynote of this session was focussed on field observations and key questions associated with these observations. Laboratory experiments and numerical modelling showed in the different presentations focussed on some of these questions such as friction models, topographic effect, dilatancy and pore pressure. From a modelling point of view, it was shown that upscaling from micro-scale to depth-integrated models is now possible for these fluid-particle flows. All the tools (numerical, experimental, field measurement) are available for a conscientious confrontation on avalanche flows. This should reinforce collaborations between the different communities involved on the topic.

Sediment transport

Sediment transport modelling remains difficult, as the range of scales encountered covers several orders of magnitude. The upscaling from the dynamics of the single grain to sheet flow

is, for instance, not obvious. Numerical modelling developed in recent years allows access to these different scales.
Together with theoretical models and experiments, the aim is to be able to model the motion of sediment from the onset up to intense transport. The methods that have been presented during this session were dedicated to the description of this configuration at local scale. The key contributions addressed the modelling of the turbulent flow over the rough bed, the development of dedicated experimental techniques to track each individual grain in the coupled fluid-grain system, and DEM simulations from the onset to intense transport with links to the local rheology of the granular material. Different approaches have been proposed to tackle these key questions, and new collaborations are expected to emerge from Colloquium 588.

Morphodynamics

There is still a great interest in the community in understanding how the motion at the grain scale affects macroscopic quantities such as the morphological characteristics of rivers and/or the development of instabilities at the surface of a granular bed, evolving into ripples and dunes. During the colloquium it has been shown how experiments in wind tunnels and water flumes, and numerical simulations (DNS for the fluid coupled with DEM for the particles) can provide deep insights into the physics that drives the evolution of the interface between the fluid and the granular medium. Key questions such as the definition of ripples and dunes observed in experiments and the physical processes at their origin are still unclear. Recent numerical modelling will allow to improved understanding of these processes.

In conclusion, the colloquium was divided into four main topics, involving different scientific communities. It appeared that the interactions between the different topics allow new approaches to several unsolved problems. We hope that these interactions will lead to several new collaborations to address the questions revealed during Colloquium 588. Encouragingly, 27 participants applied for a one year membership and one participant for a five year membership to EUROMECH.

EUROMECH Colloquium 590
"Turbulent/nonturbulent interfaces: from laboratory to geophysical scales"
3 – 5 July 2017, London, UK
Chairperson: Maarten van Reeuwijk
Co-Chairperson: Markus Holzner, Carlos da Silva, Javier Jimenez

EUROMECH Colloquium 590 followed a workshop on a similar topic in 2012. It was clear that significant progress in understanding of turbulent/non-turbulent interfaces (TNTI) had been made during the last five years. The range of physical problems and scales covered was impressive. These include the understanding of the structure of the turbulent-nonturbulent interface, new decomposition techniques to understand how turbulent entrainment is brought about, progress on the understanding of internal interfaces, and research into physically important complex applications, such as reacting mixing layers (combustion), non-Boussinesq plumes and applications involving particles (clouds, volcanic plumes). A full programme (including abstracts) can be found on http://590.euromech.org/program/programme-abstracts/.

The keynote lectures at Colloquium 590 were given by:

- Prof. Marc Avila, Bremen on "Laminar-Turbulent Interfaces in Pipe Flow";
- Prof. Takashi Ishihara, Nagoya on "Internal Interfaces in Turbulence";
- Prof. Andrew Woods, Cambridge, UK on "Entrainment and Mixing in Geophysical Flows".

The discussions were fruitful and highlighted several topics that remain to be resolved. One of the most pertinent questions regards the scaling of the thickness of the TNTI. The currently accepted view is that there is a turbulent interface layer which scales on the Taylor length scale, bounded on the nonturbulent side by a viscous superlayer which is of the order of the Kolmogorov length scale. Several authors presented findings which supported this view for various flows, but recent simulations indicate that at higher Re_λ the turbulent interface layer starts scaling on the Kolmogorov length scale (https://doi.org/10.1017/jfm.2018.143). However, this is not the case for turbulent boundary layers at similar Re_λ (https://doi.org/10.1017/jfm.2016.430). This important issue requires further analysis and research.

Another question that emerged is whether there is one universal TNTI. Part of the question stems from the differences between jets and ZPG boundary layers concerning shear in the outer layer. Are the large-scale structures affected by the wall or is it flapping or precessions in the centreline of the jet that explain the difference?

The question of a single universal TNTI is exacerbated when considering further body forces, such as buoyancy. Here, recent work points to the fact that the viscous super-layer seems unaffected but there is an effect on the turbulent sub-layer. More complex problems, such as reacting flows in combustion, particle-laden flows or cloud edges have multiple interfaces and it remains an open question whether the TNTI is influenced by these processes and how the behaviour of the interfaces differs.

Overall the workshop was highly successful in bringing together the TNTI community, exchanging information and aligning future research. It was discussed that a follow-up meeting should take place in a few years.

EUROMECH Colloquium 591
" Three-dimensional instability mechanisms in transitional and turbulent flows"
18 – 20 September 2017, Bari, Italy
Chairperson: Jean-Christophe Robinet
Co-Chairperson: Stefania Cherubini

It is still considered a remarkable fact that three-dimensional coherent motion develops in fluid flows at Reynolds numbers much smaller than the critical value for the rise of two-dimensional instabilities. This behaviour is recovered in simple parallel flows, such as pipes, boundary layers and channels, which are prone to subcritical transition, as well as in wall-bounded or open flows around solid objects of complex geometry, such as the flow over a roughness element or a wall cavity. It also occurs in fully turbulent flows, in which three-dimensional coherent structures such as streaks and hairpin vortices are repeatedly observed.

For the case of parallel flows, the presence of three-dimensional coherent structures and the consequent transition to turbulence has been interpreted recently on the basis of a simplified self-sustained cycle relying on simple modal and non-modal energy growth mechanisms, coupled through non-linearity. This self-sustained cycle has proved to be able to explain recurrent exact coherent structures of different types (equilibria, periodic orbit, and chaotic motions) which appear to form the backbone of transition. However, it is still unclear if and how this simplified theory can be extended to the case of fully turbulent flows, where coherent structures develop on top of random, chaotic fluctuations at different (outer and inner) scales, or even to the case of more complex flows in which the laminar solution is far from being parallel, such as three-dimensional flows around solid objects.
In these cases, three-dimensional modal or non-modal instability might develop and interact with each other, potentially sharing some features with the self-sustained coherent structures found for the simpler parallel flows.

The purpose of EUROMECH Colloquium 591 has been to bring together researchers studying the rise and development of instability mechanisms leading to three-dimensional flow structures in different shear flows, with the aim of trying to find some common features between the structures triggering or sustaining turbulence in such different cases. Deep knowledge of exact coherent structures in parallel flows, as well as the recent possibility of performing instability analysis on complex three-dimensional or fully turbulent flows, now make it possible to achieve such an ambitious goal.

These topics were discussed in depth during the 3-day long Colloquium 591, which brought together about 57 participants, 54 of them presenting their recent works in 20-minute talks. Three key note lectures were given by:

- Denis Sipp, France;
- Dwight Barkley, UK;
- Matthew Juniper, UK.

During the conference, the discussions were grouped in different themes, listed and explained as follows.

Mean Flow and Resolvent
In recent years, the question of performing stability analyses in turbulent flows linearizing the Navier-Stokes operator around the mean flow has become an important issue. Many presentations addressed this point by showing the latest developments in this topic and more particularly the use of the resolvent to evaluate the optimal response of a turbulent flow. This theme has shown considerable potential, especially for applications around the dynamics of jet flows and their control.

Subcritical Transition & Transitional and Turbulent Flows
One of the objectives of Colloquium 591 was to bring together the "turbulence/sub-critical transition" community with the "linear instability" community. Many works have been presented on the computation of exact coherent solutions (ECS) of Navier-Stokes equations and the different connections between them, in particular concerning turbulent spot dynamics or the development of turbulent stripes in shear flows such as Couette, channel or Couette-Poiseuille flows. The first results have been shown on the role of optimal trajectories, in the sense of the energy of the system, in the dynamics around the ECS.

Modal and non-Modal Instabilities
The set of presentations in the "modal and non-modal instability" sessions have shown that the related numerical methods are now sufficiently mature to be applied to highly three-dimensional flow configurations.

Wake Instabilities
This session demonstrated the possible evolution of instability computation methods, especially around periodic solutions. The methods presented in the previously discussed session can now allow the computation of secondary instabilities, especially around forced or pulsed flows for complex geometries, which is the new point of current developments.

Rotating and Centrifugal Instabilities
This session was a special application of the more general "Modal and non-Modal Instabilities" sessions. It mainly focused on the analysis of Goertler's instabilities for curvilinear geometries and more particularly their non-linear evolution until transition to turbulence.

Control and Reduced Models

This last session showed a possible extension of stability and transition analyses to turbulence. In particular, the important transfer of knowledge and methods on modal decomposition, developed for several years to study instabilities, towards the construction of a reduced-order model for flow control was demonstrated. A very impressive and promising example was shown by T. Colonius' team at Caltech on jet flows where DMD, POD and resolvent methods are used to develop efficient models for turbulent jet control.

The success of Colloquium 591 encourages us to continue with the aim of bringing together the "instability'', "subcritical transition" and "turbulence" research communities. It would be interesting to repeat this conference in two or three years to evaluate the scientific evolution of these communities, and their upcoming interactions. We thank EUROMECH for making this meeting possible, and for all the financial and organizational support. More specifically, we thank Dr Sara Guttilla for her efficiency and availability.

EUROMECH Colloquium 592
"Deformation and damage mechanisms of wood-fibre network-based materials and structures"
7 – 9 June 2017, Stockholm, Sweden
Chairperson: Sören Östlund
Co-Chairperson: Umberto Perego

Wood-fibre network-based materials and structures, such as paper and paperboard, have a long tradition in society as carriers of information and as packaging material. However, recent concerns regarding the environment and sustainability, as well as industrial requirements for increased efficiency, have created a demand for a deeper understanding of the mechanics of such materials, reaching a level considerably beyond current industrial practice. This also includes the use of wood fibre network-based materials in non-traditional applications.

The objective of EUROMECH Colloquium 592 was to share and discuss recent advances in experimental characterisation and modelling of the deformation and damage mechanisms of wood fibre network-based materials and structures in manufacturing, converting and end use at all relevant length scales. There were altogether 61 participants and about 37 presentations including a key note lecture given by Daniel Söderberg, KTH, Stockholm. Extended abstracts of all presentations were included in the Book of Abstracts. The relatively large number of participants from research institutes and industry should be acknowledged. There was extensive interaction between the participants during breaks and session chairmen had to work hard to reassemble participants in the lecture hall.

The presentations covered a wide range of topics related to the major challenges in the field, such as paper-moisture interaction during conversion and end-use, paper-fluid interaction during papermaking and printing, and the multiscale and stochastic nature of paper damage. Recurring issues addressed in the talks and discussion were:

The true bonded contact area in fibre-fibre joints

The mechanical properties of the fibre-fibre joint play an important role in the strength and stiffness properties of fibre network materials. Detailed understanding of the physics, chemistry and mechanics of the fibre-fibre joint is far from complete. A key concept here is to understand the area in real contact between two fibres and the chemical bonds acting between the surfaces. At the colloquium, contributions addressing these issues were presented in the form of X-ray microtomography analyses of the joint and analysis of the dominating bonding mechanisms at different length scales.

Modelling of the fibre-fibre joint

The mechanical properties of fibre-fibre joints, both from physical and modelling points of view, were also heavily discussed. Here, issues related to combined loading of the fibre-fibre joint and to how to capture the physics of the fibre-fibre joint in modelling at different scales were addressed. The mechanics of fibre-fibre joints under combined modes of loading and aspects related to network modelling were addressed by several groups, and issues related to the important problem of dimensional stability, such as hygroexpansion, were also heavily discussed. An important issue in this context is not only to capture the continuum behaviour, but also local variations in properties and to include parameters that make it possible for material producers and end-users to benefit from the results.

Statistical effects

The mechanisms that control stiffness and strength of fibre-based materials originate from the structure at the microscale, where the fibre mechanical properties, fibre morphology and orientation, the number of inter-fibre contacts, bonding properties and disordered nature of the fibre network play crucial roles. Therefore, statistical effects play a significant role in understanding the mechanical properties of these materials. Important issues addressed at the colloquium are the applicability of weakest links concepts and Weibull theory. This was discussed by several groups. Statistical effects constitute a relatively novel research area for the community, where major advancements are needed and expected in the near future. This is also related to the homogenization of materials at different length scales in multiscale modelling.

Moisture effects

Understanding and modelling the influence of moisture on the mechanical properties of paper materials is one of the grand challenges in the mechanics of paperboard. This topic was addressed by several speakers at different structural levels, including continuum-based mixture theory, build-up of stiffness and strength during drying and modelling of hygroexpansion. The inclusion of moisture and temperature effects in 3D continuum models is a relatively unexplored research area, although some recent advances were presented at the colloquium.

Capturing micro- and meso-mechanical phenomena in continuum models

The mechanisms that control stiffness and strength of fibre-based materials originate from the structure at the microscale, where the fibre mechanical properties, fibre morphology and orientation, the number of inter-fibre contacts, bonding properties and disordered nature of the fibre network play crucial roles. Therefore, it is natural to tackle the questions related to the mechanics of the fibre network structures at the length scale where the essential components can be taken into consideration. At the same time, bringing the information from the microscale upwards to the product scale at the appropriate climate conditions is the only way to make the scientific findings both relevant and applicable. Failure is often initiated at

the scale of a few fibres, whereas quality parameters, in general, are defined in a continuum mechanics setting that results in essentially size-independent properties.
Issues related to these aspects were addressed frequently in many of the talks. It can be concluded that both continuum and network models have made major advances in recent years, but there are still many important issues to be resolved, particularly regarding the coupling between different length scales. In continuum models, issues arising at the colloquium included, for example, damage in the form of delamination and deformation and damage in load cases characterized by significant contributions from in-plane compression. In network modelling, issues related to both characterization of the network structure and modelling of fibre-fibre joints were addressed. In network modelling, the important issues of multi-axial loading, particularly in the case of substantial compression and shear, are still in the very early stages.

Parameter identification in multi-scale models
While being touched upon in many talks, this is still an unresolved area. It is particularly important to define reliable and robust parameters that capture the underlying deformation and damage mechanisms, while still allowing their measurement in an industrial setting where statistical effects also play a significant role.

It is clear that many critical questions are far from being answered and the community has agreed to plan for a new meeting in about 5 years. Many participants have expressed their strong appreciation for the colloquium; we would like to quote one of the participants "Frankly, this EUROMECH conference was one of the most enjoyable meetings I experienced. Engaged, dynamic, and interesting!" This is what we wanted to achieve. The colloquium has also strengthened the ties between the paper mechanics and material mechanics communities and this was also one of the objectives. Finally, we would like to thank EUROMECH for the financial and especially organisational support.

EUROMECH Colloquium 595
"Biomechanics and computer assisted surgery meets medical reality"
29 – 31 August 2017, Lille, France
Chairperson: Mathias Brieu
Co-Chairperson: Stéphane P.A. Bordas

There have been recent major developments in biomechanics and computer assisted surgery. Many researchers are working on approaches to improve and optimize medical treatments. Personalized medical treatment is the objective of such research. However, the key issue of patient-specific treatment is the final validation in relation to the medical reality. In order to improve treatments, scientists want to develop patient-specific in-silico simulations that mimic the medical reality with the highest possible accuracy. The key issues scientists have to address is how to represent the medical reality in simplified form, model the anatomy and the geometries of the considered structures in interaction, and thereby develop the numerical and physical models and behaviour laws. Comparison with medical reality requires researchers to understand the limitations of clinical measurements and clinical trials, having reduced sensitivity and accuracy with increased uncertainties.

The aim of EUROMECH Colloquium 595 was to allow the exchange of ideas, approaches and methodologies in recent developments, dealing with fluid and solids. There were 38 participants and 36 presentations, including four key-note lectures by:

- Karol Miller, University of Western Australia;
- Irène Vignon-Clementel, INRIA Paris & Sorbonne Université UPMC;
- Abdul Barakat, Ecole Polytechnique;
- Hervé Delingette, INRIA Sophia Antipolis.

The presentations and the discussions addressed four key issues:

From experimental tests to constitutive models

Presentations highlighted the differences between constitutive models which seek to represent every contribution of every scale of soft tissue, and the experimental ability to measure an effective sensitivity to every parameter. Despite the considerable progress of destructive and non-destructive mechanical characterization it seems, to the participants understanding, more pragmatic to differentiate the first order parameters, whose influence can be identified, from second order parameters, whose influence might not be identified, and to simplify as much as possible the constitutive models to be applied in a high-dispersion medical context.

From medical images to numerical simulations

The key to patient-specific simulation, and patient-specific treatment, lies in the ability to obtain a numerical model directly from medical imaging. The medical images, obtain in a clinical environment and not in a research environment, are of low resolution. The main difficulty stems is in the ability to obtain an accurate geometric and mechanical model from such low resolution medical images. Participants presented several methods to identify the geometry of the anatomical feature under investigation. In each case resolution was the key problem. Several papers introduced manufactured physical models and particularly silico models, observed using medical imaging equipment. Silico models seem to offer the best numerical accuracy for patient-specific simulation.

From model to numerical simulations

Constitutive models and numerical simulations must be gathered and used to simulate patient-specific cases. This leads to simulation with a very large number of parameters, coming from both constitutive and geometric models. The resolution of the numerical models, the number of degrees of freedom of finite element meshes and numerical algorithms to solve nonlinear problems are important factors. The sensitivity to that large number of parameters and the accuracy of the final results have also been questioned.

Real-time & planning surgery simulations

In a surgery-planning context, numerical simulations should be real-rime to fulfil the expectation of surgeons. In such a context, the huge number of parameters, or degrees of freedom, of a problem is an issue. Real-time simulation requires minimisation of the number of parameters. However, the requirements of accurate simulation, being compared to medical reality, require high fidelity. The balance between reducing the resolution of models to reach real-time simulations and increasing the accuracy of models to reach bio-fidelity has been addressed during the colloquium. Physical models manufactured in silico which mimic physiological or physio-pathological cases, seem to be a direction of development to estimate the balance between speed-up and resolution in real-time simulation.

EUROMECH Colloquium 595 provided a very good opportunity for the community of researchers in biomechanics to link with those working in applications and medical reality, share experience and discuss applications and problems. Several participants in the colloquium said how much they enjoyed the exchange and wished to meet again in 2 years. Colloquium 595 is also leading to a book series "Biomechanics and Computer – Assisted Surgery Meets Medical Reality", being published by Springer in 2017 with selected contributions.