NEWSLETTER41
April 2012
EUROPEAN MECHANICS SOCIETY

President's Address

2012 is an election year for the EUROMECH Council, which is the governing body of our society. Four new members will be elected during this coming autumn to replace the following four colleagues: H. H. Fernholz (Fluids, Germany), O. E. Jensen (Fluids, United Kingdom), H. Petryk (Solids, Poland) and M. Raous (Solids, France) The Advisory Board (a list of current members is available on the web at www.euromech.org). will prepare a list of candidates for whom members of EUROMECH may vote in November-December 2012. Suggestions for candidates may be made to any member of the Advisory Board. If you wish to suggest a candidate, please make sure that he/she is willing to serve on the Council for a six-year term. Please also supply a one-page curriculum vitae and a complete address. The final choice of candidates will reflect both the need for some continuity with the remaining Council members and for a suitable distribution over the different countries in Europe. A sufficient representation of the different research areas within fluid and solid mechanics should also be ensured.

Members of the society should be thanked for their efforts in nominating colleagues to the EUROMECH prizes and for election to EUROMECH Fellow status. We rely on the wisdom and expertise of the EUROMECH Prize and Fellow committees to select the awardees. The winners will receive their awards officially on the occasion of the Solid Mechanics Conference in Graz in July 2012 and of the Fluid Mechanics Conference in Rome in September 2012.

Many thanks for your involvement in the activities of the European Mechanics Society.

Patrick Huerre
President, EUROMECH

EUROPEAN MECHANICS SOCIETY

Contents

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EUROMECH Solid Mechanics Fellow 2009 paper

“The Fabric of Plasticity”

Erik Van der Giessen was named Fellow of EUROMECH at the EUROMECH Solid Mechanics Conference held in Lisbon (Portugal), September 7–11, 2009

Erik Van der Giessen[1]

Abstract

During the twentieth century, plasticity, as an example of inelastic deformation of materials, has grown to become a distinct field in solid mechanics. As a research topic it combines material science with mathematical modelling at a hierarchy of length scales, and encompasses dislocations as well as tensorial constitutive equations. Because of its predictive powers in engineering, plasticity models have become a standard ingredient of an engineer’s toolbox, but do we really understand what it is? This essay looks back at plasticity from a more philosophical point of view with the aim of unravelling the fabric of plasticity. Does the current hierarchy of theories provide a reductionist explanation? Or rather, does it have a multiscale structure that expresses the emergent phenomena that are contained within plasticity? The conclusion of these considerations turns out to be that the challenge is still ahead of us.

1. Introduction

A Google search on the term “plasticity” in August 2009 gave close to 3,900,000 hits. Roughly half of these refer to brain, or neuro, plasticity – a phenomenon that, for instance, has taken place inside your brain after having learned something from this essay or have been challenged by it –; the other half to materials plasticity – the ability for a solid to be shaped permanently.

I have dedicated part of my scientific life to plasticity, standing on the shoulders of two giants: Besseling (my thesis advisor and co-author of [1]) and Burgers (who introduced the vector b[2] that uniquely characterizes a dislocation). Figure 1 is a cartoon of my career. During my PhD, I tried to develop constitutive equations for large plastic deformations of metals that develop texture. The kinematic basis of this large-strain theory was laid down by Besseling in 1968, but the challenge was to account for the fact that materials become anisotropic as a consequence of plastic deformation. The theory became very complex because texture is the collective property of the orientation of the crystallites in the underlying polycrystalline materials. In an attempt to understand more about texture, I started to study the plastic deformation of aggregates of crystallites (one step in counter-clockwise direction in Fig. 1. Soon, I came to realise that progress was limited by the lack of my understanding of what is happening inside each grain (next step). This introduced me into the world of crystal plasticity, where plasticity is not described simply by a plastic strain tensor but by slips (or shears) on individual glide systems. Looking at smaller scales from there, textbooks told me that this slip is made possible by the motion of dislocations – those intriguing defects in crystals that Burgers managed to characterize by his renowned vector. The link between Besseling and Burgers was closed for me halfway the 1990s when I had the fortune of being able to start working on the behaviour of dislocations together with Alan Needleman at Brown University.

1 University of Groningen, The Netherlands; E.van.der.Giessen@rug.nl

2 It may be interesting for EUROMECH readers to know that while material science professor at Delft University of Technology W.G. Burgers was studying dislocations, it was his brother, J.M. Burgers, professor in fluid mechanics at the same university, who introduced the Burgers vector. In his farewell speech, W.G. Burgers said that “he was proud to be the uncle of the vector.”

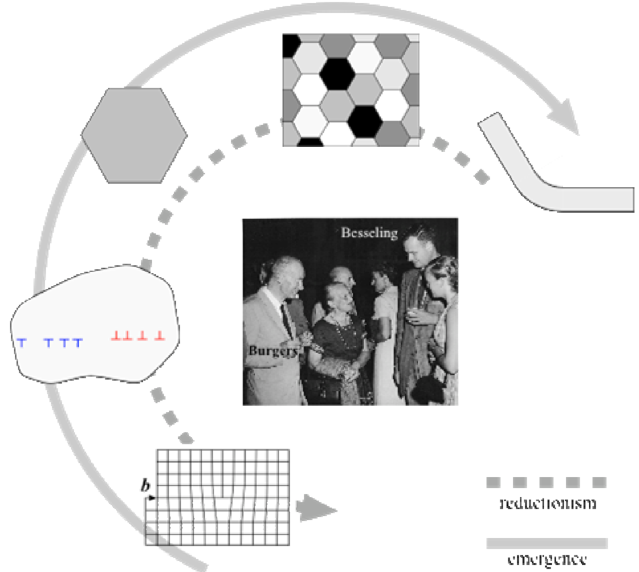

Fig. 1: The various length scales in plasticity, swirling around two giants of its theory, J.M. Burgers and J.F. Besseling (picture taken at Stanford University around 1960). One of the two big arrows connecting the scales represents the reductionist’s view on plasticity, the other symbolizes emergence.

With Figure 1 in mind, it will come as no surprise that plasticity is a popular topic in multiscale modelling. The multiscale paradigm comes in two flavours: a rather idealized and seldom practiced approach where the behaviour of smaller scales is embedded in that of the next size scale, and the more common one where understanding from smaller scales is used to inform higher-scale models. In either form, multiscale plasticity is sometimes viewed as the ‘complete theory of plasticity’. But, is it? Or, if not, is this just a matter of time and continued research efforts? In this essay I will put multiscale plasticity in a more philosophical framework based on the notions of ‘reductionism’ and ‘emergence’.

2. Reductionism

Many people hold the view that science and engineering is about dissecting a complex problem into smaller components that can be analysed. If that component is still complex, you break it up into even smaller pieces, and so on. A true reductionist would keep going down, hoping that, eventually, he will find a component that is simple enough for him to understand. Thus, the reductionist point of view on plasticity is that, in the end, it boils down to the behaviour of dislocations in the atomic lattice of a material.

But what is meant by "understanding" in the above? That we can explain what it is that causes plastic deformation? Or that we can predict how the plasticity of a macroscopic component depends on the material? The latter question is imprecise, however, since plasticity is history dependent: contrary to elasticity, in plasticity it matters how much deformation the component has been subjected to previously. The reader can experience this himself by means of the paperclip he is playing with while reading this: every time you bend it back-and-forth it is slightly harder to do so (until surface cracks appear and it becomes easier, but this is a different story). The way in which plasticity depends on the material under consideration is incorporated in classical macroscopic theories of plasticity through material parameters such as yield strength and hardening rate, quantities that, in general, are different for every material.

Let us leave 'prediction' for a subsequent section and return to the seemingly simpler question: what is the cause of plastic deformation? Well, we know the answer to that question: the motion of dislocations. And, moreover, we know a lot about the atomistic structure of the core of these 'fundamental particles' of plasticity. Yet, this does not mean we really understand the plastic deformation of a paperclip, let alone the plastic deformation that turned a flat sheet of metal into the body of your car. In between these macroscopic, complex phenomena and the atoms in the material there are eight, ten or more orders of magnitude in size scales and the intermediate microstructures, as sketched in Fig. 1. I do not think anybody will expect that we can explain the bending of your paperclip by knowing the positions of all atoms – note that there are of the order of 10^{22} of them in your paperclip[3] – as a function of time!

Even if we had unbelievably faster computers than we have now, the description of plastic bending on a macroscopic scale by tracking the motion of all constituent atoms would fail for two reasons: initial conditions and output. A simulatio nof the motion of atoms using Newton's laws requires knowledge of the initial positions and velocities of all of them – providing these initial conditions is as awkward as it is impossible. On the output side, imagine the humungous amount of information you would need to process in order to find out what all these atoms, in the end, have done to re-shape your paperclip. There is too much information, it is too complex.

Fortunately, we are saved by ....

3 A typical Dutch paperclip has a volume of around $40 mm^3$.

3. Emergence

Emergence[4] is sometimes put forward "when the behaviour of a system appears to transcend anything that can be found in its components" [3], or when "high-level simplicity 'emerges' from low-level complexity"[2]. This does sound a lot like multiscale plasticity! At each of the size scales in Fig. 1 between atomistics (lower left-hand corner) to the macroscopic scale of a specimen (top right-hand corner) there is emergent behaviour:

- at the discrete-dislocation length scale, the collective misplacement of atoms in the lattice emerges as a dislocation in an otherwise fully elastic background continuum;
- the motion of these dislocations leads to the emergence of crystallographic slip inside single crystals;
- collective or competitive slip in a polycrystalline aggregate leads to internal stress contributing to the Bauschinger effect, and to texture development by cooperative lattice rotation;
- or to more or less isotropic behaviour at the macro-scale.

Each of the above steps in emergence has two correlated characteristics: reduction of the number of degrees of freedom and introduction of new coarse-grained degrees of freedom with associated constitutive equations:

- At the discrete-dislocation length scale, dislocations are described only by their Burgers vector, slip plane normal and slip direction. Their evolution is governed by a configurational force (rather than a Newtonian force) and the interaction with the background continuum through long-range elastic fields and constitutive rules for the short-range interactions.
- The slip produced by moving dislocations is described by shears on separate slip systems, which add up to the continuum notions of plastic strain and rotation in individual grains. These shears (or rather shear rates, in order to incorporate history dependence) are governed by local resolved shear stresses (another continuum notion). The interaction between dislocations, is what is observed as hardening at the single crystal level.
- Plastic deformation of polycrystalline aggregates is described by plastic strain rates being the weighted averages over orientation space, usually with a discretized orientation distribution.
- At the final macroscopic scale, plasticity is described by a flow rule for the plastic strain rate, as a direct function of stress. In its simplest form, such a constitutive equation can be a critical value for the Von Mises stress, but there is a host of more complex expressions available in the literature that attempt to incorporate (hardening) effects caused by smaller-scale events.

It is noteworthy that the higher levels in the plasticity hierarchy adopt more and more abstract degrees of freedom, usually in the form of hidden (or internal) tensorial state variables.

4. The Ultimate Theory of Plasticity

So, if the multiscale image of plasticity is not a reductionist's view, is it purely based on emergence then?

4 The most well-known example is 'life' — a phenomenon emerging out of a large bag of interacting molecules in the right environment.

I don't think so, ... yet. Rather than 'multiscale plasticity' it even seems fairer to speak of 'plasticity at multiple scales'. The multiple scales shown in Fig. 1 give some structure to the different faces of plasticity in the sense of ordering, it is not a structure in the sense of layers built on top of other layers of knowledge. In principle, a polycrystal theory of plasticity could be 'derived' from a single crystal theory, and a single crystal continuum theory could be 'constructed' on the basis of discrete dislocation plasticity, etc. .... but, apart from certain aspects, these formal scale transitions have not been performed. Also historically, the 'from-small-to-large' image of plasticity does not hold: the smallest (discovery of the dislocation) and the largest (e.g. Von Mises' yield stress) ends of multiscale plasticity started early in the first half of the twentieth century, the rest was filled in during the remainder of the century. The intermediate-scale descriptions have been developed as autonomous theories, driven by the needs of engineering science and tested by dedicated experiments. They were not quantitatively informed from smaller scales, but at best 'inspired'.

An example of this kind of 'small-scale inspired' modelling is Besseling's fraction model. While the technical details can be found in [1], the idea (originating from the late 1950s) was to recognize that a macroscopic material element is not uniform and that different regions (called 'fractions') behave in a different way. By adopting a very simple macroscopic plasticity model for each of these fractions, but with different properties, Besseling found that rather complex hardening could be described with a small number of fractions (typically less than 10). Quite interestingly, the concept has proved very useful at a different length scale, namely in summarizing the predictions of the Bauschinger effect in thin films by means of discrete dislocation simulations [4].

5. Conclusions

Let me return to the "... yet" in my answer at the beginning of the previous section. In an ideal world, an emergence-based theory of plasticity would be a true multiscale description starting from the atomic level, with subsequent higher-length scale model emerging by appropriate coarse-graining. Such an approach has been explored in the last decade for the scale transition of discrete dislocation plasticity to continuum crystal plasticity. It has taught the mechanics community that there is more to scale transitions than 'volume averaging' (as the ruling paradigm in micromechanics). The key is not only to eliminate the irrelevant degrees of freedom, but also, as is well known in statistical mechanics, to transfer this 'loss of information' to the next scale in some form of entropy. I do not know how this entropy should propagate up the size scale ladder and how to generalize the approach to higher length scales, but people are working on it.

I am quite convinced that it is this kind of statistical mechanics thinking that will be crucial in disclosing the true fabric of plasticity.

6. Aknowledgements

Many of the ideas expressed here are inspired by two fascinating books: [2] and [3]. The similarity to the title of Deutsch's book [2] is intentional and meant as a tribute to his philosophy of science.

I have deliberately refrained from citing technical papers on plasticity. There are too many important contributions from too many influential authors: any selection would be unfair within the very limited amount of space. I realize that this is paradoxical and unusual in any scientific text, but hope that the reader can forgive me for it in this non-scientific essay.

7. References

[1] J.F. BESSELING & E. VAN DER GIESSEN, 1994, Mathematical Modelling of InelasticDeformation, Chapman & Hall (now CRC Press).

[2] D. DEUTSCH, 1997, The Fabric of Reality, Allen Lane, The Penguin Press.

[3] I. STEWART & J. COHEN, 1997, Figments of Reality: the evolution of the curious mind,Cambridge University Press.

[4] S.S. SHISHVAN, L. NICOLA & E. VAN DER GIESSEN, 2010, Bauschinger effect inunpassivated freestanding thin films, Journal of Applied Physics 107, 093529.

EUROPEAN MECHANICS SOCIETY

EUROMECH Fellows: Nomination Procedure

The EUROMECH Council was pleased to announce the introduction of the category of **EUROMECH Fellow**, starting in 2005. The status of Fellow is awarded to members who have contributed significantly to the advancement of mechanics and related fields. This may be through their original research and publications, or their innovative contributions in the application of mechanics and technological developments, or through distinguished contribution to the discipline in other ways.

Election to the status of Fellow of EUROMECH will take place in the year of the appropriate EUROMECH Conference, EFMC or ESMC respectively. The number of fellows is limited in total (fluids and solids together) to no more than one-half of one percent of the then current membership of the Society.

Nomination conditions:

- The nomination is made by **two sponsors** who must be members of the Society;
- Successful nominees must be members of the Society;
- Each nomination packet must contain a completed Nomination Form, signed by the two sponsors, and no more than four supporting letters (including the two from the sponsors).

Nomination Process:

- The nomination packet (nomination form and supporting letters) must be submitted **before 15 January** in the year of election to Fellow (the year of the respective EFMC or ESMC);
- Nominations will be reviewed before the end of February by the EUROMECH Fellow Committee;
- Final approval will be given by the EUROMECH Council during its meeting in the year of election to Fellow;
- Notification of newly elected Fellows will be made in May following the Council meeting;
- The Fellow award ceremony will take place during the EFMC or ESMC as appropriate.

Required documents and how to submit nominations:

Nomination packets need to be sent before the deadline of 15 January in the year of the respective EFMC or ESMC to the President of the Society. Information can be obtained from the EUROMECH web page www.euromech.org and the Newsletter. Nomination Forms can also be obtained from the web page or can be requested from the Secretary-General.

EUROMECH - European Mechanics Society

NOMINATION FORM FOR FELLOW

NAME OF NOMINEE: ....

OFFICE ADDRESS: ....

....

EMAIL ADDRESS: ....

FIELD OF RESEARCH: ....

Fluids: ☐ Solids: ☐

NAME OF SPONSOR 1: ....

OFFICE ADDRESS: ....

....

....

EMAIL ADDRESS: ....

SIGNATURE & DATE: ....

NAME OF SPONSOR 1: ....

OFFICE ADDRESS: ....

....

....

EMAIL ADDRESS: ....

SIGNATURE & DATE: ....

EUROMECH- European Mechanics Society: Fellow Application

EUROPEAN MECHANICS SOCIETY

SUPPORTING DATA

- Suggested Citation to appear on the Fellowship Certificate (30 words maximum);
- Supporting Paragraph enlarging on the Citation, indicating the Originality and Significance of the Contributions cited (limit 250 words);
- Nominee's most Significant Principal Publications (list at most 8);
- NOMINEE'S OTHER CONTRIBUTIONS (invited talks, patents, professional service, teaching etc. List at most 10);
- NOMINEE'S ACADEMIC BACKGROUND (University Degrees, year awarded, major field);
- NOMINEE'S EMPLOYMENT BACKGROUND (position held, employed by, duties, dates).

SPONSORS' DATA

Each sponsor (there are two sponsors) should sign the nomination form, attach a letter of recommendation and provide the following information:

- Sponsor's name;
- Professional address;
- Email address;
- Sponsor's signature/date.

ADDITIONAL INFORMATION

Supporting letters (no more than four including the two of the sponsors).

TRANSMISSION

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EUROPEAN MECHANICS SOCIETY

EUROMECH Prizes: Nomination Procedure

Fluid Mechanics Prize
Solid Mechanics Prize

Regulations and Call for Nominations

The Fluid Mechanics Prize and the Solid Mechanics Prize of EUROMECH, the European Mechanics Society, shall be awarded on the occasions of Fluid and Solid conferences for outstanding and fundamental research accomplishments in Mechanics.
Each prize consists of 5000 Euros. The recipient is invited to give a Prize Lecture at one of the European Fluid or Solid Mechanics Conferences.

Nomination Guidelines

A nomination may be submitted by any member of the Mechanics community. Eligible candidates should have undertaken a significant proportion of their scientific career in Europe. Self-nominations cannot be accepted.
The nomination documents should include the following items:

- A presentation letter summarizing the contributions and achievements of the nominee in support of his/her nomination for the Prize;
- A curriculum vitae of the nominee;
- A list of the nominee's publications;
- At least two letters of recommendation.

Five copies of the complete nomination package should be sent to the Chair of the appropriate Prize Committee, as announced in the EUROMECH Newsletter and on the Society's Web site www.euromech.org Nominations will remain active for two selection campaigns.

Prize committees

For each prize, a Prize Committee, with a Chair and four additional members shall be appointed by the EUROMECH Council for a period of three years. The Chair and the four additional members may be re-appointed once. The committee shall select a recipient from the nominations. The final decision is made by the EUROMECH Council.

Fluid Mechanics Prize

The nomination deadline for the Fluid Mechanics prize is **15 January in the year of the Fluid Mechanics Conference**. The members of the *Fluid Mechanics Prize and Fellowship Committee* are:

- A. Kluwick (Chair)
- O. E. Jensen
- D. Lohse
- P. Monkewitz
- W. Schröder

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Solid Mechanics Prize

The nomination deadline for the Solid Mechanics prize is **15 January in the year of the Solid Mechanics Conference**. The members of the *Solid Mechanics Prize and Fellowship Committee* are:

- W. Schiehlen (Chair)
- H. Myhre Jensen
- N.F. Morozov
- M. Raous
- B. A. Schrefler

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EUROMECH Conferences in 2012

The general purpose of EUROMECH conferences is to provide opportunities for scientists and engineers from all over Europe to meet and to discuss current research.
Europe is a very compact region, well provided with conference facilities, and this makes it feasible to hold inexpensive meetings.
The fact that the EUROMECH Conferences are organized by Europeans primarily for the benefit of Europeans should be kept in mind. Qualified scientists from any country are of course welcome as participants, but the need to improve communications within Europe is relevant to the scientific programme and to the choice of leading speakers.
A EUROMECH Conference on a broad subject, such as the ESMC or the EFMC, is not a gathering of specialists all having the same research interests. Much of the communication which takes place is necessarily more in the nature of imparting information than exchange of the latest ideas. A participant should leave a Conference knowing more and understanding more than on arrival, and much of that gain may not be directly related to the scientist's current research. It is very important therefore that the speakers at a Conference should have the ability to explain ideas in a clear and interesting manner, and should select and prepare their material with this expository purpose in mind.

ESCM8
8th European Solid Mechanics Conference
DATE: 9-13 July 2012
LOCATION: Graz, Austria
CONTACT: Prof. G.A. Holzapfel
E-MAIL: holzapfel@tugraz.at

EFMC9
9th European Fluid Mechanics Conference
DATE: 9-13 September 2012
LOCATION: Rome, Italy
CONTACT: Prof. Roberto Verzicco
E-MAIL: verzicco@uniroma2.it

EUROMECH Colloquia in 2012

EUROMECH Colloquia are informal meetings on specialized research topics. Participation is restricted to a small number of research workers actively engaged in the field of each Colloquium. The organization of each Colloquium, including the selection of participants for invitation, is entrusted to a Chairman. Proceedings are not normally published. Those who are interested in taking part in a Colloquium should write to the appropriate Chairman. Number, Title, Chairperson or Co-chairperson, Dates and Location for each Colloquium in 2010, and preliminary information for some Colloquia in 2011 and 2012, are given below.

514. New trends in Contact Mechanics
Chairperson: Dr. Michel Raous
Directeur de Recherche CNRS
Laboratoire de Mécanique et d'Acoustique
31, Chemin Joseph Aiguier
13402 Marseille Cedex 20, France
Email: raous@lma.cnrs-mrs.fr
Co-chairpersons: Prof. Peter Wriggers
Dates and location: 27-31 March 2012, Cargese, Corsica, France
http://euromech514.cnrs-mrs.fr/

524. Multibody system modelling, control and simulation for engineering design
Chairperson: Prof. Ben Jonker
University of Twente, Faculty CTW
Mechanical Automation
P.O. Box 217 – Building Horst
7500 AE Enschede, The Netherlands
Email: J.B.Jonker@utwente.nl
Co-chairpersons: Prof. Werner Schiehlen
Dates and location: 27 February-1 March 2012, Enschede, The Netherlands
http://www.utwente.nl/ctw/euromech524/

528. Wind Energy and the impact of turbulence on the conversion process
Chairperson: Dr. Joachim Peinke
Institute of Physics & ForWind
University of Oldenburg
D 26111 Oldenburg, Germany
Email: peinke@uni-oldenburg.de
Co-chairpersons: -
Dates and location: 22-24 February 2012, Oldenburg, Germany

532. Time-periodic structures:current trends in theory and application
Chairperson: Dr. Fadi Dohnal
Institute for Structural Dynamics
Department of Mechanical Engineering
Technische Universität Darmstadt
Petersenstr. 30, 64287 Darmstadt, Germany
Email: dohnal@sdy.tu-darmstadt.de
Co-Chairperson: Prof. Dr. J. J. Thomsen
Dates and location: 27-30 August 2012, TU Darmstadt, Germany
http://www.sdy.tu-darmstadt.de/euromech532

533. Biomechanics of the Eye
Chairperson: Dr Rodolfo Repetto
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Via Montallegro 1, 16145, Genoa, Italy
Email: rodolfo.repetto@unige.it
Co-Chairpersons: Jennifer Siggers, Alessandro Stocchino, Michael Girard
Dates and location: July 2012, University of Genoa, Italy

534. Advanced experimental approaches and inverse problems in tissue biomechanics
Chairperson: Prof. Stéphane Avril
Ecole Nationale Supérieure des Mines
158 cours Fauriel, 42023 SAINT-ETIENNE cedex 2
Email: avril@emse.fr
Co-Chairperson: Prof. Sam Evans
Dates and location: 29-31 August 2012, Saint-Etienne, France
http://euromech534.emse.fr/

535. Similarity and Symmetry Methods in Solid Mechanics
Chairperson: Prof. Jean-François Ganghoffer
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Email: jean-francois.Ganghoffer@ensem.inpl-nancy.fr
Co-Chairperson: Dr. Ivailo Mladenov
Dates and location: 6 - 9 June 2012, Varna, Bulgaria

536. Nanobubbles and micropancakes
Chairperson: Dr. James Seddon
University of Twente
Faculty of Science and Technology
Physics of Fluids, P.O. Box 217
7500 AE Enschede, The Netherlands
Email: j.r.t.seddon@utwente.nl
Co-Chairpersons: Dr. Detlef Lohse , Dr. Elisabeth Charlaix
Dates and location: 13 - 17 February 2012, Les Houches, France

537. Multi-scale Computational Homogenization of heterogeneous structures and materials
Chairperson: Prof. Julien Yvonnet
Université Paris-Est, Laboratoire Modélisation et Simulation Multi Echelle (UMR CNRS 8208)
5 Bd Descartes, 77454 Marne-la-Vallée cedex 2, France
Email: julien.yvonnet@univ-paris-est.fr
Co-Chairpersons: Dr. Marc Geers, Dr. Frederic Feyel
Dates and location: 26-28 February 2012, Université Paris-Est, France
http://msme.univ-mlv.fr/euromech-colloquim-537/

538. Physics of Sports
Chairperson: Prof. Christophe Clanet
Laboratoire d'Hydrodynamique (LadHyX)
Ecole Polytechnique
91128 Palaiseau cedex, France
Email: christophe.clanet@ladhyx.polytechnique.fr
Co-Chairperson: Prof. Metin Tolan
Dates and location: 3-6 April 2012, Ecole Polytechnique, Paris, France
http://events.polytechnique.fr/home/physics-of-sports/#KLINK

539. Mechanics of Unsaturated Porous Media:Effective stress principle from micromechanics to thermodynamics

Chairperson: S. Majid Hassanizadeh
Department of Earth Sciences
Faculty of Geosciences
Utrecht University
P.O. Box 80021
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Email: hassanizadeh@geo.uu.nl
Co-Chairperson: Ehasan Nikooee

Dates and location: 27-30 August 2012, Utrecht University, The Netherlands
http://www.geo.uu.nl/hydrogeology/Colloquium2012/Euromech_main.html

540. Advanced Modelling of Wave Propagation in Solids

Chairperson: Dr. Radek Kolman and Prof. Miloslav Okrouhlík
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Email: kolman@it.cas.cz
Co-Chairperson: Arkadi Berezovski

Dates and location: 1-3 October 2012, Prague, Czech Republic
http://ec540.it.cas.cz./

EUROMECH Colloquia Reports

EUROMECH Colloquium 513
"Dynamics of non-spherical particles in fluid turbulence"
6-8 April, 2011, Udine, Italy
Chairperson: Helge I. Andersson
Co-Chairperson: Alfredo Soldati and Jari Hämäläinen

Dynamics of non-spherical particles in fluid flow are encountered both in nature and in industrial applications, e.g. airborne solid particles or aerosols, carbon nanotubes, micro-organisms like phytoplankton, sediment-laden flows and wood-fibre suspensions.

The scope of EUROMECH Colloquium 513 included both studies and modelling of the dynamical behaviour of non-spherical particles as well as the modulation of the turbulence field brought about by the particles. The focus was on generic aspects and physics of particulate turbulent flows, computer simulations, laboratory or field measurements, and theoretical studies. The topics discussed included :

- Fibre-suspensions;
- Particle dynamics in free and wall-bounded turbulence;
- Fluid-particle interactions;
- Collision modelling;
- Agglomeration;
- Advances in measurement and simulation techniques;
- Rheological modelling.

EUROMECH Colloquium 513 was arranged by Prof. H.I. Andersson (Norwegian University of Science and Technology, Norway) and Prof. A. Soldati (University of Udine, Italy) at CISM (International Centre for Mechanical Sciences), University of Udine, Udine, Italy on 6-8 April, 2011. It was organized in association with the ERCOFTAC Special Interest Group on fibre suspension flows (SIG43) chaired by Prof. J. Hämälainen (Lappeenranta University of Technology, Finland), being the 3rd SIG43 workshop following workshops in Finland in 2009 and in Sweden in 2010.

Altogether, 42 people took part in the Colloquium. 38 papers were presented during the three
Altogether, 42 people took part in the Colloquium. 38 papers were presented during the three days dealing with numerical simulations, theoretical modelling and experimental studies of non-spherical particles in fluid turbulence. The vast majority of the participants came from European institutions, but talks were also given by scientists from Israel, Canada and

the United States. An introductory keynote lecture was delivered by Professor Cyrus K. Aidun (Georgia Institute of Technology, USA) on “Fibre suspension flow inside straight and converging channels”. In accordance with the traditions of EUROMECH Colloquia, no proceedings were published. However, electronic versions of the most of the presentations and the Book-of-Abstracts are made available at: http://158.110.32.35/Euromech/presentations.html

EUROMECH Colloquium 512
“Small scale Turbulence and related gradient statistics”
26-29 October, 2009, Turin
Chairpersons: Prof. Daniela Tordella and Prof. Katepalli R. Sreenivasan

Following the Colloquium a Special Issue of Physica D Nonlinear Phenomena entitled Small Scale Turbulence has been issued on February 1st, 2012, (Vol 241, Iss 3, Pgs 135-314) and is now available online at http://www.sciencedirect.com/science/journal/01672789/241/3.

EUROMECH Colloquium 521
“Biomedical Flows at Low Reynolds Numbers”
29-31 August 2011, ETH Zurich
Chairperson: Prof. Leonhard Kleiser
Co-Chairperson: Prof. Timothy J. Pedley

The study of biological flows enjoys a rapidly increasing interest. Research on biomedical flow systems and animal locomotion has reached a high level of maturity and has become a well established topic within the larger field of fluid mechanics. While there are many research groups studying flow problems at moderate to large Reynolds numbers (e.g. cardiovascular fluid mechanics - see also Colloquium No. 529, June 2011), academic research on biomedical flows at low Reynolds numbers is less commonly found. This fact is unfortunate since low-Reynolds-number flows are highly relevant to medicine and biology in general, and to physiology in particular. In collaboration with medical scientists and biologists, the fluid dynamics community is able to make substantial contributions to these fields.

Typical low-Reynolds-number biomedical and biological flow systems may include:

- Microcirculation and red blood cell transport;
- Flow in the lower airways;
- Cerebrospinal fluid flow;
- Lymphatic flow;
- Flows in organs such as the eye and the inner ear (balance sense, hearing);
- Biomedical microdevices (e.g. filters, pumps, drainages, microrobots);
- Propulsion and collective behaviour of microorganisms.

EUROMECH Colloquium 521 brought together researchers from groups throughout Europe working on low-Reynolds-number biomedical and biological flows. Theoretical, computational as well as experimental contributions were accepted for oral presentation. Due to the above-mentioned restriction of the scope, all presentations could be well accommodated within three days (no posters).

There were 48 participants from 11 countries and a total of 35 oral presentations. This includes 30 contributed presentations (20+5 minutes) and the following five invited keynote lectures (45+5 minutes) by leading researchers in their fields of specialization:

- Timothy Secomb (University of Arizona, USA): Mechanics of blood flow in the microcirculation

- Annie Viallat (INSERM, Marseille, F): Full dynamics of red blood cells in a shear flow: rolling, tumbling tanktreading
- Eric Lauga (UC San Diego, USA): Optimality in cellular hydrodynamics
- Bradley Nelson (ETH Zurich, CH): Microrobots: (Artificial) Life at low Reynolds numbers
- Melody Swartz (EPF Lausanne, CH): Interstitial and lymphatic flow: More than just a drainage system.

The contributed talks addressed a large variety of topics including the following:

- **Microcirculation and the dynamics of biological capsules.** The complex dynamics of biological capsules (e.g. red blood cells) as well as the blood flow in the microcirculation was the topic of nine contributed presentations (plus two invited talks). Irrespective of the linear nature of the governing equations of low-Reynolds-number flows, these talks illustrated the wide range of nonlinear phenomena that are present in this field. The surprising complexity of the dynamics is due mainly to the multiphase character of these flow systems which includes a fluid phase (e.g. blood plasma) and a particulate phase (often split again into a solid phase surrounding the capsule and a second fluid phase within the capsule).
- **Propulsion of microorganisms and microrobots.** Seven presentations on microorganisms and microrobots (plus two invited talks on that subject) addressed different aspects of propulsion mechanisms in the low-Reynolds-number regime. The combination of talks on biological organisms and man-made micro-swimmers provided a good example how research on the biomechanics of microorganisms can support the development of new surgical methods (e.g. micro-surgery in the eye).
- **Physiological flow systems.** A larger number of talks focussed on specific flow systems in the human body: e.g. flow in the brain, the lymphatic system, the placenta, the liver, the balance sense, the cochlea, the eye, the intestines and the lung. These presentations illustrated how fundamental results for low-Reynolds-number flows can applied and used to help understanding the (patho-)physiology of large and complex organs. The proposed models often span a large range of length scales and include multiple physical phenomena,

The extended two-page abstracts were collected in a printed Book of Abstracts which was handed out to the participants upon arrival. This Book is also permanently available online through the ETH Publications Repository (www.e-collection.library.ethz.ch).
The format of the Programme (including long coffee and lunch breaks) allowed for lively discussions among the participants. All sessions were well attended. The social events: Welcome Reception on Monday; Conference Dinner on Tuesday; Farewell Apéro on Wednesday were also well attended and contributed to the relaxed and open atmosphere of this meeting. Nearly all of the participants stayed to the very end of the Colloquium.

The Colloquium finished with a discussion (chaired by Prof. T.J. Pedley) on future directions in low-Reynolds-number bio-fluiddynamics. Some participants suggested that Colloquia on specific organs and/or biological systems (e.g. plants) would be desirable. Others emphasised that the integration of biologists, medical scientists etc. at such meetings is important to maintain the focus of the present research on biologically relevant questions. Commonalities in computational techniques employed in a number of contributions were also noted.
It would be worthwhile to intensify the exchange and possibly to undertake steps towards establishing well-tested community codes. There was general agreement that meetings on the specific topic of low-Reynolds-number biological flows in widespread applications are valuable and that more should follow.

After intense preparations for the event over a period of 1.5 years, it was rewarding to see everything running smoothly and to meet fellow scientists. Participants were notably enthusiastic about the quality of the scientific programme and organization of the Colloquium. Perhaps most important of all, new collaborations were initiated at the meeting.

EUROMECH Colloquium 522
"Recent Trends in Optimisation for Computational Solid Mechanics"
10-12 October 2011, Erlangen, Germany
Chairperson: Prof. Paul Steinmann

The aim of EUROMECH Colloquium 522 was to identify recent trends in optimisation as applied to problems in Computational Solid Mechanics. The focus was primarily on novel methods and computational developments rather than on practical and industrial applications of well-established approaches.

Since the advent of the finite element method in the middle of the last century, Computational Solid Mechanics is an ever developing scientific field steadily exceeding its current borders. The "multi" problems like multi-physics and/or multi-scale problems are routinely and successfully addressed. Likewise, optimisation, as intensively investigated in the Applied Mathematics and Mechanics communities, has become a powerful tool in various scientific fields.

Paradigmatic applications in Computational Solid Mechanics are the optimisation of the shape and topology of solid bodies, and other inverse problems like the identification of material parameters. Since solving the direct problem is naturally a prerequisite for tackling an inverse problem as embodied in an optimisation task, challenges and corresponding solution methods in Computational Solid Mechanics are developing at a notably faster pace. Moreover, inverse problems are seldom well-posed and thus often demand sophisticated regularisation and solution techniques. The degree of attention dedicated to solution methods for direct problems as opposed to inverse problems is also clearly documented by the comparatively large number of conferences on Computational Solid Mechanics.

The intention of the Colloquium was to foster the mutual exchange of ideas and recent methods and developments related to hot topics in optimisation for Computational Solid Mechanics between the Applied Mathematics and Computational Solid Mechanics communities.

Presentations at the Colloquium were divided between six topics:

- Topology Optimisation;
- Shape Optimisation;
- Materials Optimisation;
- Methods (e.g. Level-Set Methods), Algorithms, Regularisation;
- Sensitivity Analysis;
- Models and Materials.

In total, 41 participants from 10 different countries contributed to the Colloquium. Invited speakers of high international standing provided excellent reviews and insights into their recent research results. There were 33 presentations of 30 minutes each. Time was allowed for discussion after each presentation.

A guided tour through the history of the baroque city of Erlangen followed by a reception at the old university library was organised. The Colloquium dinner took place in the casual atmosphere of one of the traditional and famous beer cellars of Erlangen. The unconstrained time available in a relaxed atmosphere allowed much discussion about future research directions in computational optimisation and led to promise of new collaboration.

The organising committee for EUROMECH Colloquium 522 was: Kai-Uwe Bletzinger, Technical University Munich (TUM), Munich, Germany; Günter Leugering, University Erlangen-Nuremberg (FAU), Erlangen, Germany; Ole Sigmund, Technical University of Denmark (DTU), Lyngby, Denmark; Paul Steinmann, University Erlangen-Nuremberg (FAU), Erlangen, Germany.

EUROMECH Colloquium 523
"Ecohydraulics: linkages between hydraulics, morphodynamics and ecological processes in rivers"
15-17 June, 2011, Clermont-Ferrand, France,
Chairperson: Prof. Wim S.J. Uijttewaal

Channels of natural streams almost always feature bends and meanders. Projects for renaturalization of previously canalized rivers now consider recreation of sinuous channels as a primary measure. Effective implementation requires a good knowledge of the hydrodynamic, morphodynamic, and ecological processes that occur in meandering channels. Specifically, the mutual interactions between the physical and biological components of the ecosystem represent a principal challenge for projects aiming to increase stream biodiversity.

Recent research projects concerning both physics and biology in river bends have demonstrated the importance of cross-disciplinary research. EUROMECH Colloquium 532 brought together scientists and engineers with a strong interest in environmental flows, river morphodynamics and aquatic ecology. The sessions were organized around the following topics:

- Invertebrates; drift, distribution and biodiversity in relation to hydraulic stress;
- Morphodynamics; sediment transport and dispersion;
- Fish; behavior in relation to flow and morphology;
- Vegetation; development and flow interactions;
- Eco-engineering and stream restoration.

In total, 51 participants from 15 different countries contributed to Colloquium 532. Five keynote speakers reviewed recent research findings in areas that were central to the theme of the Colloquium. These keynote lectures constituted the framework according to the above mentioned topics.

There were 40 contributed presentations of 15 minutes each. After the presentations within each topic, a plenary discussion was held to summarize and discuss the more generic aspects of that theme. In addition, 11 posters were presented in a special poster session and during the breaks. An excursion was organized to different sites along the Alier river and its tributaries, where the effects of natural processes of this dynamic river could be observed. The good atmosphere and time available for interaction resulted in lively discussions focusing on the relevance of the research for practical applications and on powerful modelling techniques which might be used in the future for the physical and biological processes.

A book of extended abstracts was composed and made available during the Colloquium. After the Colloquium a number of selected authors were invited to write full papers for a special issue of the Ecohydrology Journal. Between 15 and 20 full papers are expected to be published in 2012.

EUROMECH Colloquium 525
"Instabilities and transition in three-dimensional flows with rotation"
21-23 June 2011, Écully, France
Chairperson: Prof. Benoît PIER

Shear flows are known to display a variety of spatio-temporal instabilities and complex transition scenarios. The route from a laminar flow to a fully turbulent régime cannot be understood without taking into account three-dimensional effects. Particularly interesting effects are observed in the presence of rotation --- either external, through rotating bodies, or internal, through large-scale vorticity. Recently, our understanding of such flows has been improved by technical advances in analysis and experiment and a vast increase in computing resources. This allows consideration of increasingly complex mean flow distortions. The complexity brought by three-dimensional coupling is approached with different techniques in the communities of hydrodynamic stability and turbulence. These can, however, be compared and, whenever possible, linked.

By bringing together experts in experimental, numerical and analytical approaches, EUROMECH Colloquium 525 attempted to clarify the global picture concerning transition and to narrow the gap between stability and turbulence analyses. It is expected that the development of modern analytical tools will suggest new experiments, and that novel experimental observations will in turn inspire more theoretical work.

Contributions covered the following, and other, topics:

- Three-dimensional boundary layers;
- Flows around or inside rotating bodies;
- Vortex breakdown;
- Spatio-temporal development of perturbations;
- Transition scenarios;
- Control;
- Transient phenomena;
- Inhomogenous and anisotropic turbulence.

EUROMECH Colloquium 525 took place at École Centrale de Lyon. The number and quality of submitted abstracts was such that the organizing committee decided early on to have the Colloquium over three full days. The final programme featured six keynote lectures, 38 oral presentations and seven poster presentations, organized in six half-day sessions. In total, there were 79 participants coming from 12 different countries, including four non-European participants. A hard copy of the book of abstracts was handed out during the Colloquium. All abstracts are available online in the open-access repository http://hal.archives-ouvertes.fr/EC525/. The complete programme can be viewed on the Colloquium's website http://lmfa.ec-lyon.fr/EC525/.

Contributions spanned a wide range of themes related to three-dimensionality and the effect of rotation, giration, swirl, etc., in fluids. Various approaches were presented, from theoretical hydrodynamic stability analyses looking at the evolution of small perturbations in different base flows and the global or local nature of the possible instability to fully turbulent flows in various settings. Some talks were devoted to the passage from laminar flows to turbulent states, regarding complex transition scenarios. In addition to analytical methods, numerical and experimental approaches were also presented. Several contexts were considered: homogeneous or shear flows in academic settings were used as simplified models permitting refined dynamical analyses, more "natural" contexts were of course studied, since rotation plays a role in environmental and geophysical ows. Applied or industry-related flows also lead to a number of interesting studies.

Colloquium 525 was supported financially by EUROMECH. Further support from École Centrale de Lyon, Association Française de Mécanique and ERCOFTAC is also gratefully acknowledged.

Objectives of EUROMECH, the European Mechanics Society

The Society is an international, non-governmental, non-profit, scientific organisation, founded in 1993. The objective of the Society is to engage in all activities intended to promote in Europe the development of mechanics as a branch of science and engineering. Mechanics deals with motion, flow and deformation of matter, be it fluid or solid, under the action of applied forces, and with any associated phenomena. The Society is governed by a Council composed of elected and co-opted members.

Activities within the field of mechanics range from fundamental research on the behaviour of fluids and solids to applied research in engineering. The approaches used comprise theoretical, analytical, computational and experimental methods.
The Society shall be guided by the tradition of free international scientific cooperation developed in EUROMECH Colloquia.
In particular, the Society will pursue this objective through:

- The organisation of European meetings on subjects within the entire field of mechanics;
- The establishment of links between persons and organisations including industry engaged in scientific work in mechanics and in related sciences;
- The gathering and dissemination of information on all matters related to mechanics;
- The development of standards for education in mechanics and in related sciences throughout Europe.

These activities, which transcend national boundaries, are to complement national activities.

The Society welcomes to membership all those who are interested in the advancement and diffusion of mechanics. It also bestows honorary membership, prizes and awards to recognise scientists who have made exceptionally important and distinguished contributions. Members may take advantage of benefits such as reduced registration fees to our meetings, reduced subscription to the European Journal of Mechanics, information on meetings, job vacancies and other matters in mechanics. Less tangibly but perhaps even more importantly, membership provides an opportunity for professional identification; it also helps to shape the future of our science in Europe and to make mechanics attractive to young people.

European Journal of Mechanics - A/Solids

ISSN: 0997-7538

The *European Journal of Mechanics A/Solids* continues to publish articles in English in all areas of Solid Mechanics from the physical and mathematical basis to materials engineering, technological applications and methods of modern computational mechanics, both pure and applied research.
The following topics are covered: Mechanics of materials; thermodynamics; elasticity; plasticity; creep damage; fracture; composites and multiphase materials; micromechanics; structural mechanics; stability vibrations; wave propagation; robotics; contact; friction and wear; optimization, identification; the mechanics of rigid bodies; biomechanics.

European Journal of Mechanics - B/Fluids

ISSN: 0997-7546

The *European Journal of Mechanics B/Fluids* publishes papers in all fields of fluid mechanics. Although investigations in well established areas are within the scope of the journal, recent developments and innovative ideas are particularly welcome. Theoretical, computational and experimental papers are equally welcome. Mathematical methods, be they deterministic or stochastic, analytical or numerical, will be accepted provided they serve to clarify some identifiable problems in fluid mechanics, and provided the significance of results is explained. Similarly, experimental papers must add physical insight in to the understanding of fluid mechanics. Published every two months, EJM B/Fluids contains:

- Original papers from countries world-wide
- Book reviews
- A calendar of scientific meetings