EUROPEAN MECHANICS SOCIETY

Newsletter 35

July 2009

President's Address

2009 is an election year for the EUROMECH Council, which is the governing body of our Society. Five new members will be elected during the autumn. 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 2009. 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 six years. 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 disciplines within fluid and solid mechanics should also be ensured.

The new members of the Council will take office on 1 January 2010. Candidates will prepare biographical notes which will be available online and which will also be included in the Newsletter before the elections.

As announced in the previous newsletter, EUROMECH is a partner in the "**E**uropean **C**ollaboration Dissemination of **Aero**nautical research and applications" (E-CAero) grant supported by the European Commission. In this context, several events have been scheduled in collaboration with other European societies involved in aeronautical research. A joint "EUROMECH-EUCASS Mini-Symposium on Flow Stability" will take place within the "3rd European Conference for Aero-Space Sciences" in Versailles on July 6-9, 2009. Colloquium 507 on "Immersed boundary methods: current status and future research directions" to be held on June 15-17, 2009 in Amsterdam is co-sponsored with ERCOFTAC. A Mini-Symposium on "Turbulence Control" is also planned with ERCOFTAC within the 12th European Turbulence Conference, September 7-10, 2009, in Marburg. Finally a joint EUROMECH-ECCOMAS Mini-symposium is being organized within the 7th European Solid Mechanics Conference, September 7-11, 2009, in Lisbon. We expect that these joint projects will further enhance synergies between members of our societies.

EUROMECH is also pleased to announce that the 3rd *EUROMECH Solid Mechanics Prize* has been awarded to Viggo Tvergaard (Technical University of Denmark) *"for his outstanding contributions to a broad spectrum of Solid Mechanics in particular for his fundamental* *research on stability of structures, plastic flow localization and shear banding, ductile fracture, and creep rupture, and for taking physically based analyses of ductile fracture from an academic discipline to an engineering design tool supported by computational methods"*. Three Fellows have been elected for their seminal contributions to Solid Mechanics: Davide Bigoni (University of Trento), Felix Chernousko (Russian Academy of Sciences) and Erik van der Giessen (University of Groningen). These awards will be conferred officially on the occasion of the 7th European Solid Mechanics Conference this coming September 2009 in Lisbon.

We are very grateful to colleagues who prepared the nomination files and we encourage our members to become actively involved in this process in future years. This is an important aspect of the life of our society.

Patrick Huerre

President, EUROMECH

Contents

Addresses for EUROMECH Officers

President: Professor Patrick Huerre
Laboratoire d'Hydrodynamique, Ecole Polytechnique
F - 91128 Palaiseau cedex, France
E-mail: huerre@ladhyx.polytechnique.fr
Tel.: +33(0)1 6933 5252
Fax: +33(0)1 6933 3030

Vice President: Professor Hans-H. Fernholz
Hermann-Föttinger-Institut, Technische Universität Berlin
Müller-Breslau Strasse 8
D-10623 Berlin, Germany
E-mail: fernholz@pi.tu-berlin.de
Tel.: +49 30 314 23359
Fax: +49 30 314 21101

Secretary-General: Professor Bernhard Schrefler
Dipartimento di Costruzioni e Trasporti
Università di Padova, Via Marzolo 9
I-35131 Padova, Italy
E-mail: bas@dic.unipd.it
Tel.: +39(0)49 827 5611
Fax: +39(0)49 827 5604

Treasurer: Professor Wolfgang Schröder
Chair of Fluid Mechanics and Institute of Aerodynamics
RWTH Aachen, Wüllnerstr. 5a
D-52062 Aachen, Germany
E-mail: office@aia.rwth-aachen.de
Tel.: +49(0)241 809 5410
Fax: +49(0)241 809 2257

Newsletter editors:
Dr Roger Kinns (*E-mail: RogerKinns@aol.com*)
Professor Bernhard Schrefler (*E-mail: bas@dic.unipd.it*)

Newsletter Assistant:
Dr Sara Guttilla (*E-mail: S.Guttilla@cism.it*)

Web page: **http://www.euromech.org**

EUROMECH Council Members

PATRICK HUERRE, Laboratoire d'Hydrodynamique, Ecole Polytechnique, 91128 Palaiseau cedex, France — *E-mail*: *huerre@ladhyx.polytechnique.fr*

HANS H. FERNHOLZ, Herman – Föttinger - Institut für Strömungsmechanik, Technische Universität Berlin, Müller-Breslau Strasse 8, 10623 Berlin, Germany — *E-mail: fernholz@pi.tu-berlin.de*

BERNHARD A. SCHREFLER, Dipartimento di Costruzioni e Trasporti, Università di Padova, Via Marzolo 9, I-35131 Padova, Italy — *E-mail: bas@dic.unipd.it*

WOLFGANG SCHRÖDER, Chair of Fluid Mechanics and Institute of Aerodynamics RWTH Aachen, Wüllnerstr. 5a, 52062 Aachen, Germany — *E-mail: office@aia.rwth-aachen.de*

JORGE A.C. AMBRÓSIO, IDMEC, Instituto Superior Técnico, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal — *E-mail: jorge@dem.ist.utl.pt*

OLIVER E. JENSEN, School of Mathematical Sciences, University of Nottingham, NG72RD, United Kingdom — *E-mail: Oliver.Jensen@nottingham.ac.uk*

DETLEF LOHSE, University of Twente, Department of Applied Physics, P.O. Box 217, 7500 AE Enschede, The Netherlands — *E-mail: d.lohse@utwente.nl*

HENRIK MYHRE JENSEN, Department of Building Technology and Structural Engineering, Aalborg University, Sohngaardsholmsvej 57, DK-9000 Aalborg, Denmark — *E-mail: hmj@civil.auc.dk*

HENRIK PETRYK, Institute of Fundamental Technological Research, Polish Academy of Sciences, Swietokrzyska 21, 00-049 Warsaw, Poland — *E-mail:hpetryk@ippt.gov.pl*

MICHEL RAOUS, Laboratory of Mechanics and Acoustics –CNRS, 31 Chemin Joseph Aiguier, 13402 Marseille Cedex 20, France — *E-mail: raous@lma.cnrs-mrs.fr*

Chairpersons of Conference Committees

GERTJAN F. VAN HEIJST (*Fluid Mechanics*), Eindhoven University of Technology, Physics Dept., Fluid Dynamics Lab., W&S Building, P.O. Box 513, NL-5600 MB Eindhoven, The Netherlands — *E-mail: G.J.F.v.Heijst@fdl.phys.tue.nl*

DOMINIQUE LEGUILLON (*Mechanics of Materials*), Laboratoire de Modélisation en Mécanique, Université Pierre et Marie Curie, Couloir 55-65, case courrier 162, 4 place Jussieu, 75252 Paris Cedex 05, France — *E-mail: leguillo@lmm.jussieu.fr*

DICK H. VAN CAMPEN (*Non-linear Oscillations*), Eindhoven University of Technology, Mechanical Engineering Department, Den Dolech 2, P.O. Box 513, 5600 MB Eindhoven, The Netherlands — *E-mail: d.h.v.campen@tue.nl*

RAY W. OGDEN (*Solid Mechanics*), Department of Mathematics, University of Glasgow, University Gardens, Glasgow G12 8QW, Scotland, UK — *E-mail: rwo@maths.gla.ac.uk*

ARNE V. JOHANSSON (*Turbulence*), Royal Institute of Technology, Department of Mechanics, 10044 Stockholm, Sweden — *E-mail: viktor@mech.kth.se*

Paul GERMAIN

28 August 1920 – 26 February 2009

Paul Germain, a highly respected and influential French and European scientist, passed away in Paris in February 2009, aged 89. He was an honorary member of the EUROMECH Society.

Monsieur Germain, as he was known universally among our community of fluid and solid mechanicians, was a member of the EUROMECH Committee from January 1975 to December 1979. Those were the days when EUROMECH was under the enlightened, firm and rigorous leadership of George Batchelor, at a time when the activities of the society revolved mainly around the organization and selection of specialized workshops known as colloquia. This has proved to be a highly successful formula; more than 500 such scientific gatherings have taken place throughout Europe.

Paul Germain, a graduate of the élite *Ecole Normale Supérieure de la rue d'Uhm*, received his doctorate in Mathematical Sciences in 1948. After holding several appointments at the *Centre National de la Recherche Scientifique* (CNRS), *ONERA*, the Universities of Poitiers and Lille, he spent most of his career as a Professor of Mechanics in Paris, at *Université Pierre et Marie Curie* (1958-1977, 1985-1987) and at *Ecole Polytechnique* (1977-1985). He made several extended visits to the United States at the California Institute of Technology, Brown University, Stanford and Berkeley. Fluid Mechanics and Continuum Mechanics were Paul Germain's primary areas of interest. He made seminal contributions to supersonic aerodynamics, transonic flows, the structure and dynamics of shock waves and magnetohydrodynamics. By applying the method of virtual works in the context of continuum thermodynamics, he developed an elegant unified framework which has had a lasting impact on the entire field of Mechanics. Several books by Paul Germain bear testimony to the depth of his approach. His courses at *Université Pierre et Marie Curie* and at *Ecole Polytechnique* have greatly influenced several generations of students.

Paul Germain was General Director of ONERA from 1962 to 1967. He became a member of the *Académie des Sciences* in 1970 and its *Secrétaire Perpétuel* from 1975 to 1995. In this capacity, he played a key role in the development of the academy and in promoting the Mechanical Sciences in France and internationally. His important contributions to Mechanics were recognized when he became President of our worldwide society, the *International Union of Theoretical and Applied Mechanics* between 1988 and 1992.

Paul Germain was a foreign member of numerous international academies: *American Academy of Arts and Sciences*; *US National Academy of Engineering*; *National Academy dei Lincei*; *Polish Academy of Sciences*; *Académie Royale des Sciences, des Lettres et des Beaux-Arts of Belgium*; *USSR Academy of Sciences*; *Pontifical Academy of Sciences*.

On a more personal level, Paul Germain was profoundly Christian and his faith led him to uphold the highest moral standards. In all respects, he was a striking person and a gentleman who will be greatly missed.

Patrick Huerre

EUROMECH Young Scientist Prize paper
"Edge of chaos and the turbulence transition in linearly stable shear flows"

Tobias M. Schneider*

T. M. Schneider won the EUROMECH Young Scientist Prize, awarded at the 7th EUROMECH Fluid Mechanics Conference held in Manchester, September 2008.

Abstract

The transition to turbulence in pipe and plane Couette flow differs from the better understood situation of Taylor-Couette or Rayleigh-Bénard flow in that the laminar profile is stable against infinitesimal perturbations for all Reynolds numbers. Moreover, even when turbulent flow is established, it can spontaneously return to laminar flow. These observations are compatible with the formation of a strange chaotic saddle known from dynamical system theory. Here we focus on the dynamics near the boundary between laminar and turbulent dynamics. Applying the iterated edge tracking algorithm we compute the relevant hyperbolic structures intermediate between laminar and turbulent dynamics and relate our findings to the classical saddle-node bifurcation scenario.

1 Introduction

Pipe flow and plane Couette flow belong to the class of shear flows where turbulence occurs despite the persistent linear stability of the laminar profile [1, 2, 3]. As already described by Osborne Reynolds 125 years ago [4], triggering turbulence in these flows requires not only a sufficiently high Reynolds number (Re) but also a perturbation of sufficient amplitude. Thus, laminar and turbulent dynamics coexist for the same Re which naturally raises the question of a surface in the state space of the system such that trajectories on one side return to the laminar profile and those on the other side become turbulent.

Guidance on the nature of the dividing surface is offered by the appearance of exact coherent states, which together with their entangled stable and unstable manifolds provide the necessary state space elements for turbulent dynamics: These exact solutions appear in bifurcations of saddle-node type so that it is natural to associate the 'upper branch' (characterized by higher kinetic energy) with turbulent dynamics and the lower branch with the threshold in critical perturbation amplitude. In plane Couette flow this scenario seems to be borne out [5, 6]: at the point of bifurcation the upper branch state (the node) is stable and the lower branch one (the saddle) has only one unstable direction. On increasing Re, the upper branch undergoes secondary bifurcations

*School of Engineering and Applied Sciences, Harvard University, 29 Oxford Street, Cambridge, MA 02139, USA and Fachbereich Physik, Philipps-Universität Marburg, Renthof 6, D-35032 Marburg, Germany

which presumably leads to the complex state space structure usually associated with turbulent dynamics. If the lower branch state does not undergo secondary bifurcations but continues to have a single unstable direction only, its stable manifold can divide state space such that initial conditions from one side decay more or less directly to the laminar profile, whereas those from the other side show some turbulent dynamics.

2 The iterated edge tracking algorithm

Empirically, one may study the boundary between laminar and turbulent dynamics by following the time evolution of flow fields and thereby assigning a lifetime, i.e. the time it takes for a particular initial condition to decay towards the laminar profile [7, 8]. Increasing the amplitude of the perturbation one notes changes between regions with smooth variations in lifetimes (where trajectories decay rather directly) and regions with huge fluctuations showing a sensitive dependence on initial conditions, since neighboring initial states can have vastly different lifetimes. A point on the border between laminar and chaotic regions is said to lie on the *edge of chaos* [7]. From a point of dynamical systems theory, the edge of chaos generalizes the usual basin boundaries between attractors to situations in which the chaotic motion is transient only [9].

We study the dynamics of velocity fields that are intermediate between laminar and turbulent flows and evolve inside the edge by using the algorithms described in [8, 10, 11] to confine the velocity fields to this intermediate situation. Thereby, the evolution follows the dynamics within the edge and approaches embedded invariant dynamic objects. The edge of chaos then coincides with the stable set of this invariant dynamic object, which we call the edge state.

The connection between this concept and the saddle-node approach described before is straightforward: if the boundary between laminar and turbulent regions is formed by the stable manifold of a saddle state, then the manifold coincides with the edge of chaos, and the edge state is the saddle state itself. However, this is possible only if the saddle state has a single unstable direction. If further directions are unstable, the edge state will not be a fixed point but a periodic orbit or a chaotic attractor.

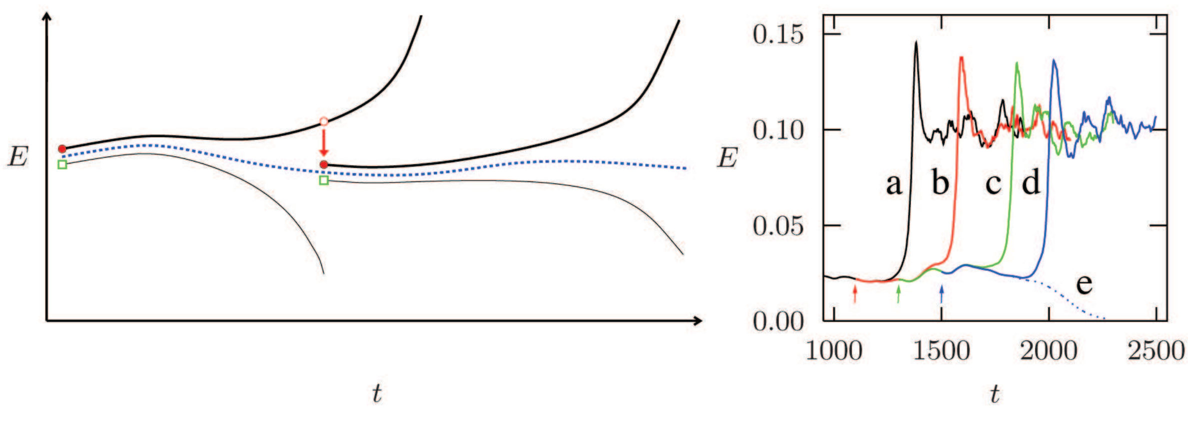


Figure 1: *(Color online) Left panel: Schematic visualization of the operational approximation method. Right panel: Energy E of the deviation from the laminar profile for trajectories bounding the edge of chaos. The continuous lines (a-d) show trajectories that swing up to the turbulent flow. For the last control step, starting at* $t = 1500$*, the corresponding decaying trajectory (e) is presented as an additional dotted line. The accuracy of the approximation is better than* $\frac{\Delta E}{E} \approx 2 \times 10^{-6}$.

The procedure for tracking the dynamics on the dividing surface is shown schematically in Figure 1, where we plot the energy of a perturbation field as it evolves in time. One chooses a pair of initial conditions from the family $\mathbf{u}_\lambda = \mathbf{u}_L + \lambda\mathbf{v}$, with $\mathbf{u}_L$ the laminar profile and $\mathbf{v} = \mathbf{u} - \mathbf{u}_L$ where $\mathbf{v}$ prescribes the (arbitrary) spatial structure of the flow field. The amplitude λ is chosen such that one initial condition (red filled circle) is located on the turbulent side of the edge and one (green open box) on the opposite laminar side. Bisecting in λ we can focus on trajectories which live for a substantial time close to the boundary before turning turbulent (thick black line) or decaying (thin black line). These two trajectories approximate an intermediate one that neither decays nor turns turbulent but remains in the edge (blue dotted line). Since the 'edge trajectory' is unstable and the approximating trajectories separate exponentially, they are followed for a finite time only before a new pair of initial conditions is constructed by taking the state of the previous trajectory that finally turns turbulent (red open circle) and rescaling its amplitude. The right panel of Figure 1 illustrates the edge tracking for pipe flow at Re=2875. Note that the edge dynamics is energetically clearly separated both from turbulence and from laminar flow ($E \equiv 0$ in the plot).

The tracking of the dynamics in the edge offers several exciting possibilities as it can be applied to basically any dynamical system that shows two distinct types of dynamics such as laminar flow and turbulence for the same control parameters. The convergence of the algorithm only requires the edge state to be an attracting set, so that the relevant hyperbolic structure can be computed without further assumptions about its nature (fixed point, periodic orbit or chaotic attractor). We here apply the edge tracking first to plane Couette flow which allows to connect it to the ideas about lower branch solutions advocated in [6]. Then we turn to pipe flow calculations before we close this note with some concluding remarks and suggestions for future studies.

3 Plane Couette flow

In plane Couette geometry the flow is driven by two parallel plates moving in opposite directions. The numerically considered flow domain is set to be 2 units high, 2π units wide and 4π units long, and periodically continued in spanwise and downstream direction.

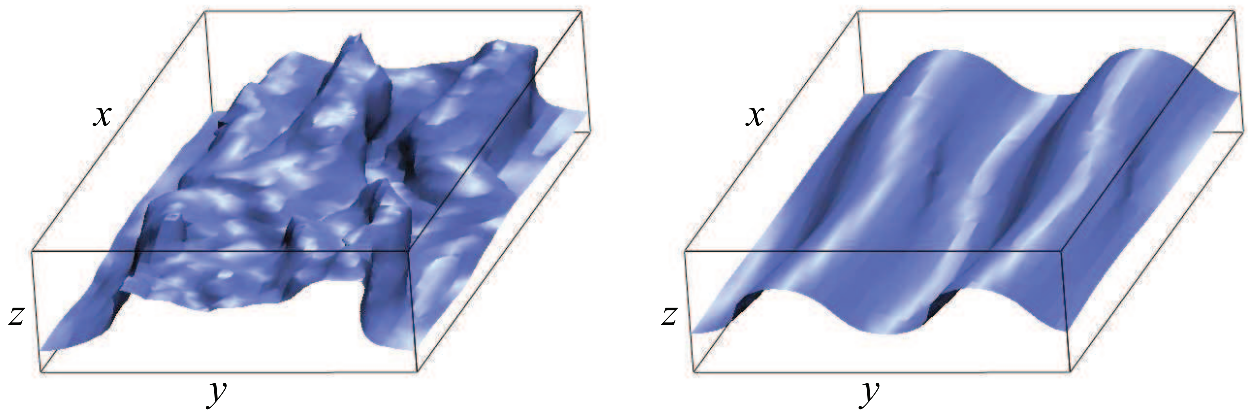


Figure 2: *(Color online) Approach to the edge state in plane Couette flow for* Re = 400*: Isosurfaces of vanishing downstream velocity ($v_x = 0$) both for an arbitrary initial state (left) and the final edge state (right).*

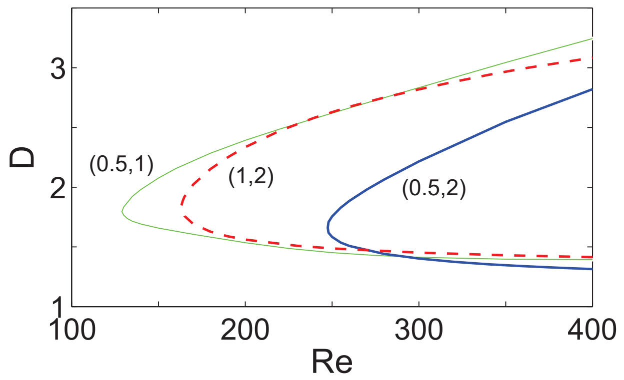


Figure 3: *(Color online) Bifurcation diagram for three pairs of lower/upper-branch equilibrium solutions, with* $(\alpha, \gamma) = (0.5, 1)$, $(0.5, 2)$ *and* $(1, 2)$. *The drag D is the wall drag normalized by the drag of laminar flow at the same Reynolds number.*

In Figure 2 we present both the initial and final state of a typical edge tracking calculation for $\mathrm{Re} = U_0 h/\nu = 400$ where h is half the channel height, U_0 half the velocity difference of the plates and ν the kinematic viscosity of the fluid. Despite different complex topologies of the initial flow field, the edge trajectories are attracted to the same stationary flow field. In view of the saddle-node bifurcation scenario discussed above, Wang et al [6] suggested that this state should coincide with a particular lower branch equilibrium solution. However, their state is similar to, but not identical to the state found here. Introducing the wavenumbers α and γ for the structures, so that the periods in the downstream and spanwise direction are $2\pi/\alpha$ and $2\pi/\gamma$, the found edge state is $(\alpha, \gamma) = (0.5, 2)$, whereas [6] suggested a state with $(\alpha, \gamma) = (0.5, 1)$. In Figure 3 we show the bifurcation diagram for three states that fit into the periodic domain. The suggested $(0.5, 1)$-state is the lower branch solution formed in the first saddle-node bifurcation at $\mathrm{Re} \approx 127.7$ and also shows the 'simplest' topology in terms of number of streamwise vortex pairs. At $\mathrm{Re} = 400$, however the $(0.5, 2)$-state shows a drag closest to laminar flow thus raising the question if it could be on the edge. The answer is given by a numerical eigenvalue analysis which gives 4, 1 and 5 unstable directions for the states $(\alpha, \gamma) = (0.5, 1)$, $(0.5, 2)$ and $(1, 2)$, respectively [10]. Thus, only the $(0.5, 2)$ state has a stable manifold that is of codimension 1 and can therefore locally divide state space in two domains. Consequently it acts as the relevant saddle state.

To summarize: the refined edge tracking algorithm applied here to plane Couette flow in a parameter range where the lower branch solutions has a stable manifold of codimension 1 confirms the expectations based on the saddle-node bifurcation scenario, but in addition it helps to identify which state among several possible ones is indeed the invariant object in the edge, i.e. the *edge state*.

4 Pipe Flow

We now turn to the probably most studied hydrodynamical system of pressure driven flow through a straight circular pipe. At intermediate Re one observes localized domains of turbulence called puffs [12] which travel down the pipe at a typical length of 30 pipe diameters. Instead of considering an extended system capturing the full spatio-temporal structure of the dynamics, we here focus on the internal turbulent dynamics of a puff [13]. Thus, as in previous studies of turbulent statistics [14] and of lifetime distributions [15] we numerically consider a periodically continued pipe segment of 5 pipe diameters length (see [16] for a discussion of finite size effects).

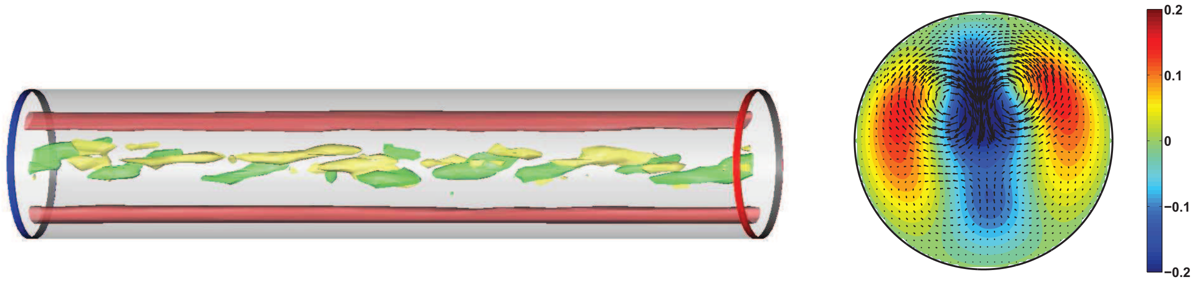


Figure 4: *(Color online) The chaotic edge state flow field in pipe flow. Left: Instantaneous snapshot showing the elongated low speed streaks and constantly active vortical structures in the center region. Right: time-averaged flow field characterized by a pair of counter-rotating vortices located off-center.*

Edge trajectories starting from various types of initial conditions were found to be attracted to the edge state flow field presented in Figure 4 [17, 8]. As the edge state found in plane Couette flow, the pipe edge state shows a simple global topology dominated by a pair of counter rotating vortices located off center. However, the locally attracting object is neither a time-independent fixed point as in plane Couette flow nor a traveling wave, as suggested by recent discoveries of exact coherent solutions to the full nonlinear Navier-Stokes equations [18, 19, 20]. Instead, the invariant object shows a chaotic dynamics as evidenced by the constantly active vortical structures in the center region of the pipe. We thus conclude that the edge of chaos is formed by the stable set of a chaotic saddle, which is the edge state of pipe flow. While the edge of chaos is extended throughout the state space of the system, the statistical weight on the local attractor embedded in the edge appears to be centered in a small region which results in the simple global structure of the observed flow field.

While the edge state presented in Figure 4 is computed for Re $= 2875$ no bifurcations or transitions between flow topologies have been observed on varying Re in the studied range between 1900 and 4000.

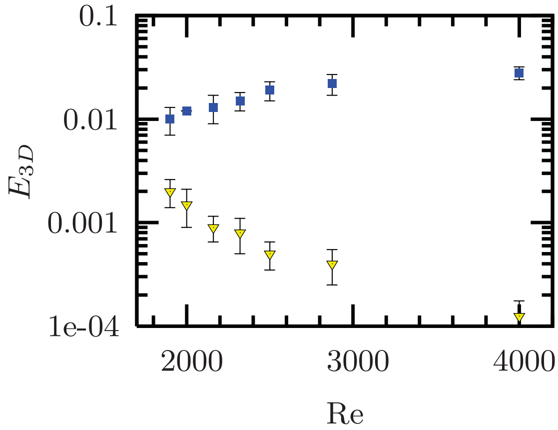


Figure 5: *Typical energy of the edge trajectory (yellow, down-facing triangles) and turbulence (blue boxes) as a function of Re. The data can be estimated from trajectories approximating edge dynamics (cf. Figure 1). Energetically, the edge state is always separated from the laminar state ($E \equiv 0$) and from turbulence. However, the separation of the edge and turbulence decreases with decreasing Re.*

In Figure 5 we show the variation of the energy[1] both of the edge state and turbulent dynamics with Re. As Re decreases, the energy of the turbulent state decreases

[1] Instead of the full energy, only the energy content of modes that are not translationary invariant is shown.

while the one of the edge state increases, and they seem to merge at some Re near 1800. Note, however, that numerical simulations for the chosen domain show that turbulence at Re=1900, where the edge state can still be identified is transient [15, 16], so that the coalescence between the turbulence and the edge state cannot be correlated to a possible crisis that would turn the transient turbulent saddle into a permanent attractor. Moreover, the ability to determine an edge state when the turbulence is transient and not permanent shows that the edge state tracking algorithm as presented here generalizes the concept of basin boundaries to situations of transient chaos [9].

5 Conclusions and outlook

Using concepts of dynamical system theory we have studied the stability boundary between laminar flow and turbulence that has to be crossed when the transition occurs or flow relaminarizes. Studying the dynamics intermediate between laminar flow and turbulence we computed locally attracting structures in the stability boundary termed edge states. For plane Couette flow we found a specific lower branch fixed point solution thus confirming expectations based on the saddle-node bifurcation scenario.

In pipe flow, the edge state is dynamically non-trivial and chaotic. Naturally this local chaotic attractor will contain simpler periodic or relative periodic structures [20] but they will have more than one unstable direction so that their stable manifold has codimension higher than one and cannot divide state space. This seems to be the case for all exact coherent structures observed thus far in pipe flow.

The edge state remains energetically separated from both the laminar state and turbulence over the whole studied range in Re including values, where turbulence is transient and decays spontaneously. Thus, there are not only two but three energetically separated types of dynamics and we conclude that the transition to turbulence in pipe flow is mediated by flow structures that are neither located in the neighborhood of the stable laminar profile nor are part of the statistically relevant 'core region' of the chaotic saddle supporting turbulence. Explaining the transition to turbulence in pipe flow and other related linearly stable flow situations thus requires understanding the role and the interaction of three dominant objects in the system's state space: the laminar state, the strange chaotic saddle *and* the edge state discussed here.

While applying nonlinear dynamics concepts allowed for much recent progress in understanding the transition mechanism in the canonical pipe flow problem, several important questions still remain to be answered [21]. One interesting task – in the author's opinion – is to understand the full spatio-temporal structure of extended systems and to explain, why transitional turbulence is typically observed in localized domains such as turbulent puffs only. In view of the simple flow structures found in edge states, edge tracking in extended systems might provide a useful test case for studying the mechanisms that give rise to localized turbulence and select their macroscopic length scales.

I would like to thank B. Eckhardt for his constant support and for introducing me to the fascinating field of nonlinear dynamics and fluid mechanics. Moreover, I thank J. Vollmer, B. Hof, J. Westerweel, F. De Lillo, J.F. Gibson, L. Kim, J. Moehlis, F. Mellibovsky and A. Meseguer for various valuable and enlightening discussions that helped to shape the concepts presented here. Financial support by the Deutsche Forschungsgemeinschaft is gratefully acknowledged.

References

[1] S. Grossmann, Rev. Mod. Phys. **72**, 603 (2000).

[2] R. R. Kerswell, Nonlinearity **18**, R17 (2005).

[3] B. Eckhardt, T. M. Schneider, B. Hof, and J. Westerweel, Annu. Rev. Fluid Mech. **39**, 447 (2007).

[4] O. Reynolds, Phil. Trans. R. Soc. **174**, 935 (1883).

[5] D. Viswanath, Journal of Fluid Mechanics **580**, 339 (2007).

[6] J. Wang, J. Gibson, and F. Waleffe, Phys. Rev. Lett. **98**, 204501 (2007).

[7] J. Skufca, J. Yorke, and B. Eckhardt, Phys. Rev. Lett. **96**, 174101 (2006).

[8] T. M. Schneider, B. Eckhardt, and J. A. Yorke, Phys. Rev. Lett. **99**, 034502 (2007).

[9] J. Vollmer, T. M. Schneider, and B. Eckhardt, New J. Phys. **11**, 013040 (2009).

[10] T. M. Schneider, J. F. Gibson, M. Lagha, F. D. Lillo, and B. Eckhardt, Phys. Rev. E **78**, 037301 (2008).

[11] T. M. Schneider and B. Eckhardt, Phil. Trans. R. Soc. **367**, 577 (2008).

[12] I. Wygnanski, M. Sokolov, and D. Friedman, J. Fluid Mech. **69**, 283 (1975).

[13] B. Eckhardt and T. M. Schneider, Eur. Phys. J. B **64**, 457 (2008).

[14] T. M. Schneider, B. Eckhardt, and J. Vollmer, Phys. Rev. E **75**, 066313 (2007).

[15] B. Hof, J. Westerweel, T. M. Schneider, and B. Eckhardt, Nature **443**, 59 (2006).

[16] T. M. Schneider and B. Eckhardt, Phys. Rev. E **78**, 046310 (2008).

[17] T. M. Schneider and B. Eckhardt, Chaos **16**, 041103 (2006).

[18] H. Faisst and B. Eckhardt, Phys. Rev. Lett. **91**, 224502 (2003).

[19] H. Wedin and R. Kerswell, J. Fluid Mech. **508**, 333 (2004).

[20] C. Pringle and R. R. Kerswell, Phys. Rev. Lett. **99**, 074502 (2007).

[21] B. Eckhardt, Nonlinearity **21**, T1 (2008).

EUROMECH Young Scientist Prize paper
"On the settling of clouds of particles in viscous fluids"

Bloen Metzger, Maxime Nicolas & Élisabeth Guazzelli*

B. Metzger won the EUROMECH Young Scientist Prize, awarded at the 7th EUROMECH Fluid Mechanics Conference held in Manchester, September 2008

Abstract

Torus formation, destabilisation into droplets, self-similar cascade : the sedimentation of a cloud of particles in a viscous fluid is spectacular. How can a system that is conceptually so simple develop such rich behaviours? The long range nature of the hydrodynamic interactions between the settling particles (akin to the *N-body problem*) is the essential component to understand these behaviors.

1 Introduction

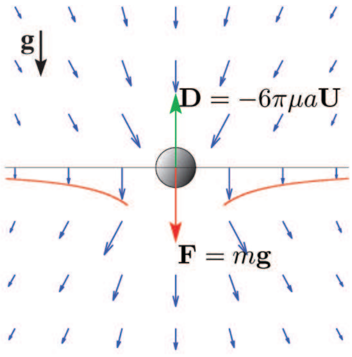
When small particles settle in a viscous fluid which is initially at rest, they generate flow perturbations which spatially decay very slowly. The particles influence themselves mutually through the fluid. These hydrodynamic interactions, specific to Stokes flows (cf. Figure 1), are at the origin of complex phenomena which are of great interest. They occur in a large number of natural phenomena like the behavior of red blood cells and mud sedimentation at river mouths. But above all, they provide a unique opportunity to study the N-body problem experimentally. Like the gravitational interactions which govern the motion of planets, hydrodynamic interactions are of the long-range type.

We will start by describing the sedimentation of one, two and three particles. When more than two particles come into play, we address the N-body problem; chaotic behaviors arise. The second part of this paper is dedicated to the sedimentation of a ”cloud of particles”. Movies are available on the following link [9].

2 1, 2, 3 particles

The problem of the fall of a spherical particle in a viscous fluid was completely solved by Stokes in 1851[2]. When the effects of viscosity dominate those of inertia, the induced fluid motion is a solution of the Stokes equation (cf. Figure 1). The amplitude of the generated flow field decays very slowly, as the inverse of the distance to the sphere. We will show that this property is crucial to understanding the dynamics of a large collection of particles.

*IUSTI - CNRS UMR 6595,Technopôle de Château-Gombert,13453 Marseille Cedex 13, France



$$\nabla.\mathbf{u} = 0 \qquad\qquad (1)$$
$$\nabla p - \mu\triangle\mathbf{u} = \rho\delta(r)$$

$$\mathbf{u}(\mathbf{r}) = \frac{\mathbf{F}}{8\pi\mu}\left(\frac{\mathbf{I}}{r} + \frac{\mathbf{r}\otimes\mathbf{r}}{r^3}\right) \qquad (2)$$

Figure 1: *When a small particle of radius a settles in a viscous fluid of viscosity* μ*, the drag force* $\mathbf{D} = -6\pi\mu a\mathbf{U}$ *exerted by the fluid on the particle exactly balances the gravity force* $\mathbf{F}$ *in such a way that the settling speed of the particle* $\mathbf{U} = \mathbf{F}/6\pi\mu a$ *is constant. The induced fluid flow* $\mathbf{u}$ *is solution of the Stokes equations (1) , where p stands for the pressure field and* δ*, the Dirac function describes the force field distribution inside the fluid assuming the particle is a point force. The analytical solution of these equations (2) is known as the Oseen tensor. The blue arrows represent the velocity field induced into the fluid by the motion of the particle and the red curve indicates its most remarkable property which is the slow decay (as* $1/r$*) of its amplitude.*

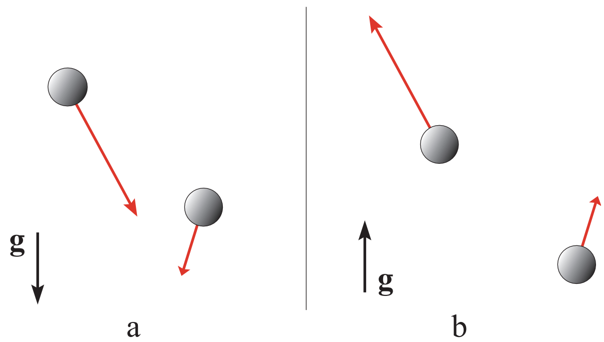


Figure 2: *Two identical spheres fall in a viscous fluid under their own weight. Owing to the linearity of the Stokes equations, one can show that the velocities of the two spheres are necessarily identical. a) Imagine that the sphere located at the back (relative to the overall motion) has the largest velocity ; it catches up the first sphere and the two spheres thus get closer to each other. b) Now inverse gravity g. Owing to the linearity of the equations, reversing the forces means reversing the velocities. The sphere located in front moves faster thus the two spheres move away from each other. However, the two situations mentioned above are formally identical; their evolution must be the same. The velocities of the two spheres are thus identical.*

When two identical spheres sediment in a viscous fluid, the fluid motion induced by the fall of each particle influences the trajectory of the other particle. The velocity of each sphere can be evaluated by adding its sedimentation velocity in isolation to the velocity induced in the fluid by the motion of the other particle. The velocity of a pair of particles is thus larger then the velocity of an isolated particle (cf. Figure 3.b). Owing to the linearity of the Stokes equations, one can show that the velocity of the two spheres are necessarily identical. (cf. Figure 2.b). The two particles settle together without observing any relative motion.

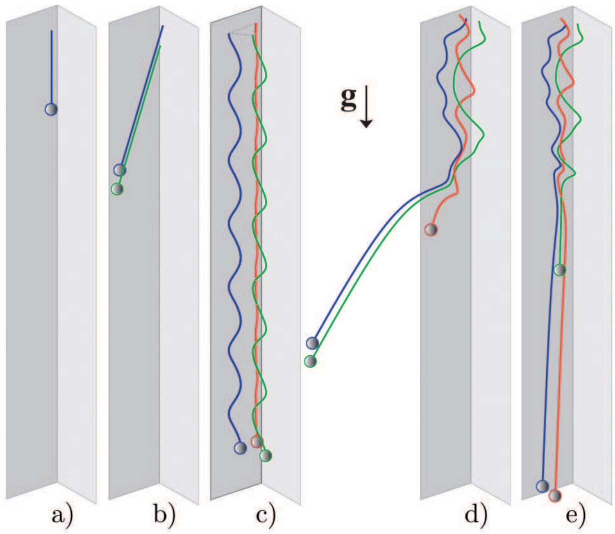


Figure 3: *Numerical simulations : sedimentation of a) one, b) two c,d,e) three particles in a viscous fluid. c) Initially displaced at the summits of a horizontal equilateral triangle, the particles follow a periodic motion. d) When randomly displaced, after some "mixing" phase during which the particles totally change their relative positions, a couple is formed (blue and green particles) and the third particle lags behind. e) When the simulation starts from a slightly different initial configuration, the evolution is essentially the same at short times but the long time evolution is completely different. This time the pair made of the blue and red particles escapes and the green particle is left behind. This extreme sensitivity to initial conditions is inherent to chaotic systems.*

The situation is different for three particles [4]. Peculiar initial configurations produce a periodic motion (cf. Figure 3.c) ; for instance when the three particles are displaced at the summits of a horizontal equilateral triangle. In other cases, the motion is chaotic (cf. Figure 3.d and 3.e). One distinguish a phase of interaction involving three particles during which the particles totally change their relative positions. Then a pair "escapes" leaving the third particle behind. The chaotic nature of the three particle configuration is well illustrated by the extreme sensitivity to initial conditions (cf. Figure 3.d and 3.e).

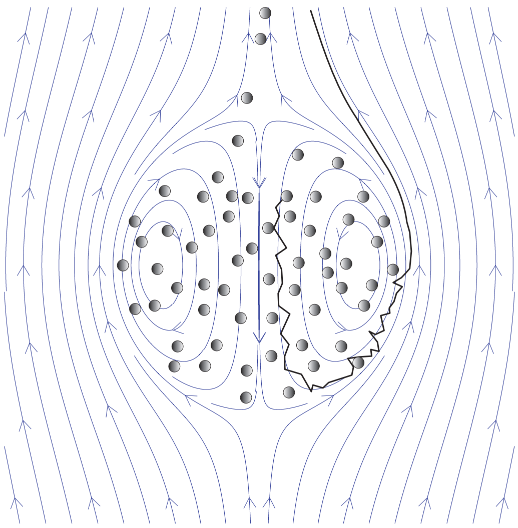


Figure 4: *Numerical simulations of the flow produced by a cloud of particles. The apparent motion is a toroidal re-circulation with vertical axis. Fluctuations cause some particles to make random crossing of the (imaginary) interface and be convected to the rear and eventually leave the cloud in a vertical tail.*

The Stokes equations which govern the motion of the particles are linear and instantaneous. They are thus reversible in time. How can particles behave in such a complex way? Why such a sensitivity to initial conditions? Chaos arises when the number of particles is larger than two. Its origin is in the coupling between the fluid flow and the spatial distribution of the particles. At a given time, the fluid flow is completely determined by the particle positions; but the fluid flow advects the particles and thus modifies instantly the latter distibution. This permanent retro-action between the flow and the microstructure gives rise to a highly non-linear coupling at the origin of the observed chaotic behaviors.

3 Cloud of particles

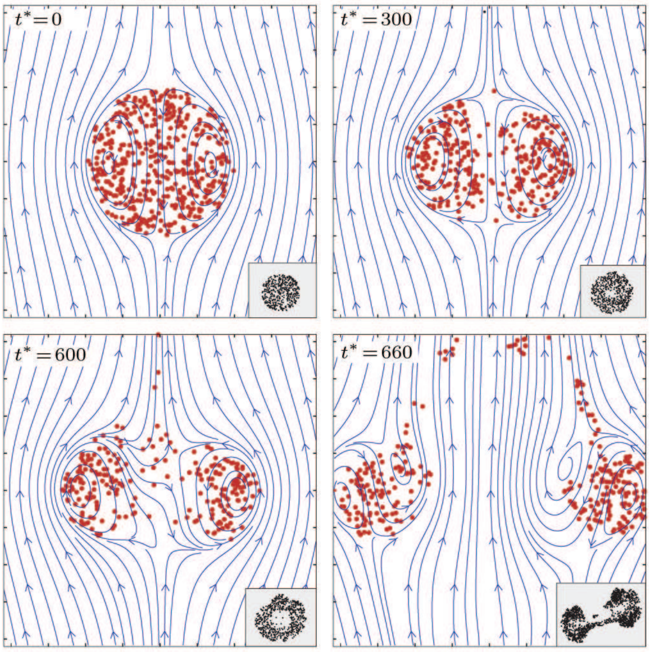


Figure 5: *Flow computed at successive times in the vertical plane through the vertical axis of symmetry and in the instantaneous reference frame of the cloud. The initially spherical cloud ($t^* = 0$) slowly evolves toward a torus ($t^* = 300$). When the external fluid pokes through the cloud ($t^* > 600$), the cloud destabilises into self-similar droplets. Time is normalised by the time it takes for the cloud to move by one radius ; $t^* = t/(R/V_n)$ with R and V_n respectively the radius and the sedimentation velocity of the cloud at $t^* = 0$. Insets : bottom views of the cloud.*

We are now going to examine the motion of a large number of particles. The particles are displaced randomly inside a prescribed volume of the fluid in such a way that they form what we will call a "cloud of particles".

The most astonishing and certainly the most spectacular feature observed is the collective motion followed by the particles during their fall. The apparent general motion is a toroidal recirculation. The outcome of this dynamic is that the cloud remains a cohesive entity for very long times, maintaining a sharp boundary between its particle-called interior and the clear fluid outside. Note that this collective motion is not due to a cohesive force (such as electrostatic or Van-der-Waals forces) but results only from the long range hydrodynamic interactions between the particles.

A simple model to describe these interactions between the particles is to consider that each particle induces into the ambient fluid a flow perturbation equivalent to the one produced by a point particle. This approximation is natural in dilute systems as the inter-particle distance is large compare to the particle size; particles only suffer the first order term of the flow perturbation generated by the fall of the other particles (the term decreasing as $1/r$).

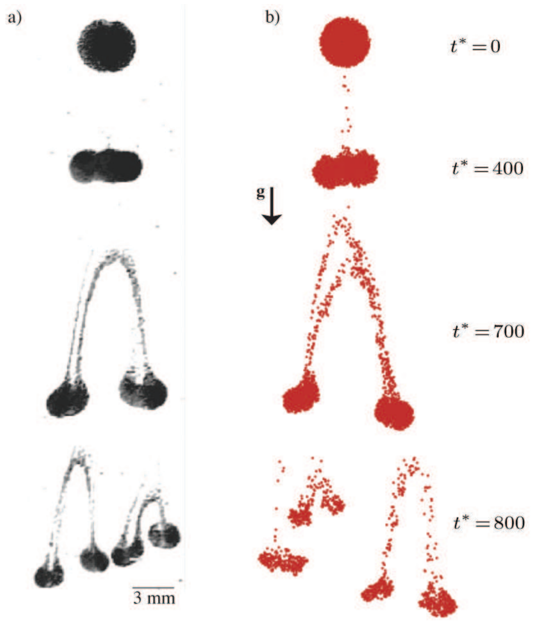


Figure 6: *Successive images of the fall of a cloud of particles in a viscous fluid. a) Laboratory experiment using glass particles of* 100 *µm diameters and a container filled with silicon oil* 1000 *times more viscous than water. b) Numerical simulations [5]. Movies are available to download at the following link [9].*

The toroidal recirculation motion is also observed when a liquid drop settles into a lighter fluid [3, 1]. A cloud of particles might be described as an effective fluid that is heavier than the outer fluid, but this analogy is limited; suspensions have intrinsic characteristics that cannot be described within such a frame. The leakage mechanism clearly illustrates these differences. As it settles, the cloud slowly loses particles by shedding them along a vertical tail emanating from its rear (cf. Figure 4). The multi-body nature of the hydrodynamic interactions and the permanent rearrangement of the particles inside the cloud generate important velocity fluctuations (as can be seen schematically on the broken line in Figure 4). Some particles spontaneously make a random crossing of the (imaginary) boundary and are advected away from the cloud in a tail. Random velocities imply an irreversible diffusive transport of the particles outside the cloud despite the reversible nature of the Stokes equations.

The leaking particles are those located in the outer layer of the toroidal circulation. This depletes the region near the vertical axis of the cloud and quickly leads to the formation of a torus. The torus aspect ratio (ratio of its horizontal to vertical dimension) increases. Beyond a critical aspect ratio, the flow topology changes dramatically : the external fluid pokes through the center of the ring formed by the cloud instead of flowing around the cloud (cf. Figure 5). Note that the streamlines which pass through the cloud have an opposite direction to those of the initial toroidal circulation. New recirculations are thus formed prior to droplet formation. The torus breaks up into two (or very occasionally up to four) droplets, each of which forms a torus which, if it contains enough particles, again breaks up, and so on in a repeating cascade (cf. Figure 6).

4 Conclusions

Despite its conceptual simplicity, the sedimentation of a cloud of particles at zero Reynolds number is very rich in behaviours. The system becomes chaotic when the number of particles is larger than two. Trajectories are tortuous and extremely sensitive to initial conditions akin to the three body problem. Sedimentation is a unique opportunity to study this problem experimentally. For further information the reader can refer to [4].

For a large number of particles, the evolution is complex. The cloud of particles first evolves toward a torus which in turn destabilises into smaller droplets. Irreversible phenomena such as the particle leakage are observed.

A simple numerical model, based on the point-particle approximation is sufficient to capture the cloud evolution in its details (cf. Figure 6). This study showed how long-range hydrodynamic interactions govern the evolution of these systems.

Another striking phenomenon is the general toroidal recirculation motion followed by the particles. This collective dynamic which is an outcome of the slow decrease of the hydrodynamic interactions might seem to be of academic interest only. It is in fact of major importance in a large number of real systems. For instance, one observes large swirls during the sedimentation of a homogeneous suspension of particles [6] ; clusters which organise into streamers characterise the sedimentation of a suspension of fibres [7]. These structures, which arise from long range collective interactions and whose typical length-scales are much larger than the particle size, deeply influence the behaviour of these systems [8].

References

[1] EKIEL-JEŻEWSKA, M. L., METZGER, B. & GUAZZELLI, É. 2006 Spherical cloud of point particles falling in a viscous fluid. *Phys. Fluids* **18**, 038104.

[2] GUYON E., HULIN J. P., PETIT L. 1982 Hydrodynamique physique, *Savoirs Actuels* EDP Sciences/CNRS Editions.

[3] HADAMARD, J. S. 1911 Mouvement permanent lent d'une sphère liquide et visqueuse dans un liquide visqueux. *C. R. Acad. Sci. (Paris)* **152**, 1735–1738.

[4] JÁNOSI, I. M., TÉL, T., WOLF, D. E., GALLAS, J.A.C. 1997 Chaotic particle dynamics in viscous flows: The three-particle Stokeslet problem. *Phys. Rev. E* **56**, 2858–2868.

[5] METZGER B., NICOLAS M. L., AND GUAZZELLI É. 2007 Falling clouds of particles in viscous ßuids. *J. Fluid Mech*, **580**, 283–301.

[6] GUAZZELLI É. 2001 Evolution of particle-velocity correlations in sedimentation, *Phys. Fluids*, **13**, 1537Ð1540.

[7] METZGER B., J. E. BUTLER, AND GUAZZELLI É. 2007 Experimental investigation of the instability of a sedimenting suspension of fibres. *J. Fluid Mech*, **575**, 307-332.

[8] GUAZZELLI É. 2006 Conference in honour of Professor Roland Borghi, Marseille , FRANCE 2006, *Comptes rendus. MŽcanique* **334**, 539-544.

[9] http://iusti.polytech.univ-mrs.fr/∼metzger/CloudSedimentation.html

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 2: ..………..…………………………………………………….

OFFICE ADDRESS:……….………….………………………………….……….….

……………………………………………………………………………………….…

……………………………………………………………………………………….…

EMAIL ADDRESS:…………………………………………………………………….

SIGNATURE & DATE: …………………………………………………………….

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;
- Eponsor's signature/date.

ADDITIONAL INFORMATION

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

TRANSMISSION

Send the whole nomination packet to:

Professor Patrick Huerre
President EUROMECH
Laboratoire d'Hydrodynamique, École Polytechnique
91128 Palaiseau Cedex, France
E-mail: huerre@ladhyx.polytechnique.fr

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

Chairman's address
Professor A. Kluwick
Institut für Strömungsmechanik und Wärmeübertragung
Technische Universität Wien
Resselgasse 3,
A -1040 Wien, Austria
Tel. : +43 1 58801 32220
Fax : +43 1 58801 32299
Email: akluwick@mail.tuwien.ac.at

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

Chairman's address
Professor W. Schiehlen
Institut für Technische und Numerische Mechanik
Universität Stuttgart
Pfaffenwaldring 9
D-70550 Stuttgart, Germany
Tel. : +49 711 685-66391
Fax : +49 711 685-66400
Email: schiehlen@itm.uni-stuttgart.de

EUROMECH Conferences in 2009

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.

2009

EETC12
12th EUROMECH European Turbulence Conference
DATES: 7 – 10 September 2009
LOCATION: Marburg, Germany
CONTACT: Prof. Bruno Eckhardt
E-MAIL: bruno.eckhardt@Physik.Uni-Marburg.de

ESMC7
7th European Solid Mechanics Conference
DATES: 7 – 11 September 2009
LOCATION: Lisbon, Portugal
CONTACT: Prof. Jorge Ambrosio
E-MAIL: jorge@dem.ist.utl.pt

EUROMECH Conference Reports

7th EUROMECH Fluid Mechanics Conference

The 7th EUROMECH Fluid Mechanics Conference took place on September 14-18th 2008 at the University of Manchester. The conference was attended by 439 researchers from around the world, including 179 who were under the age of 35. The main purpose of the Conference was to bring together researchers with a common interest in fluid mechanics.

The 312 oral presentations in 68 contributed sessions covered the entire range of topics in fluid mechanics including the theoretical, computational and experimental areas of the discipline. Each of the 12-minute oral presentations in these sessions was followed by time for questions and further discussion.

In addition, four day-long minisymposia were hosted, focusing on:

- Subcritical flow instability;
- Internal bio-fluids;
- Granular flows;
- Nature-inspired fluid mechanics.

These minisyposia included contributed papers. They also included invited papers in each session by experienced researchers, with the aim of providing training to early-stage researchers in the selected areas of fluid mechanics research.

Eight plenary lectures were presented by internationally-recognized researchers. F. Busse was awarded the EUROMECH Fluids Prize and gave the EUROMECH Fluids Lecture entitled "What can Thermal Convection Teach Us about the Nature of Turbulence?"

The two coffee breaks and the lunch that took place each day, as well as the three social events, provided many opportunities for further discussion, interaction and networking. This was also the first large-scale meeting to take place in the newly opened University Place conference facility. Much positive feedback was received by the organisers regarding the facilities, the organisation of the event and the quality of the papers presented. The conference banquet was held at Manchester United Football Club.

The conference website:
http://www.mims.manchester.ac.uk/events/workshops/EFMC7/
remains live. It includes abstracts of all presentations, together with the plenary lectures.

EUROMECH Colloquia in 2009 and 2010

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 2008, and preliminary information for some Colloquia in 2009, are given below.

EUROMECH Colloquia in 2009

497. Recent Developments and New Directions in Thin-Film Flow

Chairperson: Prof. Stephen K. Wilson
Department of Mathematics
University of Strathclyde, Livingstone Tower
26 Richmond Street
Glasgow, G1 1XH, UK
Phone: +44(0)141 548 3820
Fax: +44(0)141 548 3345
E-Mail: s.k.wilson@strath.ac.uk
Co-Chairpersons: Prof. G. M. Homsy, Dr. Brian R. Duffy
Date and location: 6-10 July 2009, Edinburgh, UK
Website: http://icms.org.uk/workshops/thinfilms

503. Non-linear Normal Modes, Dimension Reduction and Localization in Vibrating Systems

Chairperson: Prof. Giuseppe Rega
Dipartimento di Ingegneria Strutturale e Geotecnica
Università di Roma La Sapienza
Via A. Gramsci 53
00197 Roma, Italy
Phone: +39-06-49919195
Fax: +39-06-49919192 or +39-06-3221449
E-mail: Giuseppe.Rega@uniroma1.it
Co-Chairperson: Prof. Alexander Vakakis
Date and location: 27 September-2 October 2009, Rome, Italy
Website: http://w3.uniroma1.it/dsg/euromech503/

504. Large Eddy Simulation for Aerodynamics and Aeroacoustics

Chairperson: Prof. Dr.-Ing. Michael Manhart
Fachgebiet Hydromechanik
Arcisstraße 21

80333 München, Germany
Phone: +49 (0) 89 289 22583
Fax: +49 (0) 89 289 28332
E-mail: m.manhart@bv.tum.de
Co-Chairperson: Prof. Christophe Brun
Date and location: 23-25 March 2009, München, Germany
Website: http://www.hy.bv.tum.de/Euromech504/

506. CPNLS-09 Solitons in their roaring forties: coherence and persistence in non-linear waves
Chairperson: Prof. Jean Guy Caputo
Laboratoire de Mathematiques
INSA de Rouen, BP 8, 76131
Mont-Saint-Aignan cedex, France
Phone: +33 2 35 52 83 44
Fax: + 33 2 35 52 83 32
E-mail: caputo@insa-rouen.fr
Co-Chairperson: Prof. Mads Peter Soerensen
Date and location: 6-10 January 2009, Nice, France

507. Immersed boundary methods: current status and future research directions, co-sponsored by ERCOFTAC
Chairperson: Dr. M. Pourquie
Laboratory for Aero- and Hydrodynamics
Dept. of Mechanical Engineering
Mekelweg 2
2628 CD Delft, The Netherlands
Phone: +31-15-2782997
Fax: +31-15-2782947
E-Mail: m.j.b.m.pourquie@tudelft.nl
Co-Chairperson: Prof. S. Turek
Date and location: 15-17 June 2009, Amsterdam, The Netherlands
Website: http://www.ahd.tudelft.nl/academy/

508. Wind turbine wakes
Chairperson: Prof. Antonio Crespo
Departamento de Ingenieria Energetica y Fluidomecanica, E.T.S.I. Industriale
Universidad Politecnica de Madrid
Jose Gutierrez Abascal
228006 Madrid, Spain
Phone: +34 91 336 3152
Fax: +34 91 336 3006
E-Mail: crespo@etsii.upm.es
Co-Chairperson: Prof. Gunner Chr. Larsen
Date and location: 20–22 October 2009, Madrid, Spain

509. Vehicle aerodynamics
Chairperson: Dr. Martin Schober
MLN/TSSA Bombardier Transportation
Am Rathenaupark 16761
Hennigsdorf, Germany
Phone: +49 3302 89 3405
Fax: +49 3302 89 3669
E-mail: Martin.Schober@de.transport.bombardier.com
Co-Chairpersons: Prof. Lennart Löfdahl, Dr. Christian Navid Nayeri
Date and location: 24-26 March 2009, Berlin, Germany

510. Mechanics of generalized continua: a hundred years after the Cosserats
Chairperson: Prof . Gérard A. Maugin
Institut Jean Le Rond d'Alembert
Université Pierre et Marie Curie
Case 162, Tour 55, 4 Place Jussieu
75252 Paris Cedex 05, France
Phone:+33 1 44 27 53 12
Fax:+33 1 44 27 52 59
E-mail: gam@ccr.jussieu.fr
Co-Chairpersons: Prof. A.V. Metrikine, Prof. V.I. Erofeyev
Date and location: 13-16 May 2009, Paris, France
Website:http://www.dalembert.upmc.fr/home/maugin/index.php?option=com_content&task=view&id=14&Itemid=33

512 Small scale turbulence and related gradient
Chairperson: Prof. Daniela Tordella
Dipartimento di Ingegneria Aeronautica e Spaziale
Politecnico di Torino
Corso Duca degli Abruzzi 24, 10129 Torino, Italy
Phone: +39 011 564 6812
Fax: +39 011 564 6899
Email: daniela.tordella@polito.it
Co-Chairperson:Prof. K.R.Sreenivasan
Date and location: 26-29 October 2009, Turin, Italy
Website: http://www.euromech512.polito.it/

EUROMECH Colloquia in 2010

505. Multiscale effects in fatigue metals

Chairperson : Dr. Andrei Constantinescu
CNRS Ecole Polytechnique
Laboratoire de Mécanique des Solides
91128 Palaiseau cedex, France
Phone:+33 1 69 33 57 56
Fax: +33 1 69 33 57 06
E-mail: andrei.constantinescu@lms.polytechnique.fr
Co-Chairperson: Dr. Pedro Donatella Portella
Date and location: 5-9 July 2010, Palaiseau, France
Website:http://www.lms.polytechnique.fr/users/constantinescu/Euromech/index.html

511. Biomechanics of Human Motion. New Frontiers of Multibody Techniques for Clinical Applications

Chairperson : Prof. Jorge A.C. Ambrosio
IDMEC- Instituto Superior Tecnico
Av. Rovisco Pais 1
1049-001 Lisbon, Portugal
Phone: +351 2184 17680
Fax: +351 2184 17915
E-mail: Jorge@dem.ist.utl.pt
Co-Chairpersons: Prof. Frans van der Helm, Prof. Andrés Kecskemethy
Date and location: March 2010, Açores, Portugal

513. Dynamics of non-spherical particle suspensions

Chairperson Prof. Helge I. Andersson
Department of Energy and Process Engineering
Norwegian University of Science and Technology
7491 Trondheim, Norway
Phone: +47 73 59 35 56
Fax: +47 73 59 34 91
E-mail: helge.i.andersson@ntnu.no
Co-Chairperson: Prof. Alfredo Soldati
Date and location: October / November 2010 , Trondheim, Norway

515. Advanced applications and perspectives of mutibody system dynamics

Chairperson: Prof. Dr. Evtim Zahariev
Institute of Mechanics
Bulgarian Academy of Sciences
Acad. G. Bonchev St., bl. 4
1113 Sofia, Bulgaria
Phone: +359-2-9547147
E-mail: evtimvz@bas.bg

Co-chairperson: Prof. Marco Ceccarelli
Date and location: 7-11 July 2010, Blagoevgrad, Bulgaria

517. Interfaces and inhomogeneous turbulence
Chairperson: Prof. Ian Eames
University College London
Torrington Place
London, WC1E 7JE, UK
Phone: +44 20 7679 3550
Fax: +44 20 7388 0180
E-mail: i_eames@meng.ucl.ac.uk
Co-chairpersons: Prof. Jerry Westerweel, Prof Carlos B. da Silva
Date and location: June 2010, UCL, London, UK.

518. Biomechanics of the Eye
Chairperson: Dr. Jennifer Siggers
Department of Bioengineering
Imperial College London
London SW7 2AZ, UK
Phone: +44 (0)20 7594 3663
Fax: +44 (0)20 7594 9817
E-mail: j.siggers@imperial.ac.uk
Co-chairperson: Dr. Rodolfo Repetto
Date and location: 21-23 July 2010, Imperial College, London, UK.

519. Mixing and dispersion in flows dominated by rotation and buoyancy
Chairperson: Prof. Herman Clercx
Fluid Dynamics Laboratory, CC 2.15
Department of Applied Physics
Eindhoven University of Technology
PO Box 513
NL-5600 MB Eindhoven, The Netherlands
Phone: + 31 40 247 2680 or + 31 40 247 3110
Fax: + 31 40 246 4151
E-mail: h.j.h.clercx@tue.nl
Co-chairperson: Dr. Beat Lüthi
Date and location: 20-23 June 2010, Conference Centre Rolduc, Limburg, NL.

520. High Rayleigh number convection
Chairperson: Prof. Francesca Chilla
Ecole Normale Supérieure de Lyon
Laboratoire de Physique
46 allée d'Italie
69007 Lyon, France
Email: francesca.chilla@ens-lyon.fr
Date and location: 25-29 January 2010, Les Houches, France

EUROMECH Colloquia Reports

EUROMECH Colloquium 499

"Nonlinear mechanics of multiphase flow in porous media: phase transitions, instability, non equilibrium, modelling"

9-12 June 2008, Nancy, France.

Chairperson: Prof. Mikhail Panfilov
Co - Chairperson: Prof. Majid Hassanizadeh

Colloquium 499 was devoted to presentation of recent developments concerning the fundamental mechanics of multiphase flow through porous media, and exchange of ideas in this field. Physical effects produced by the flow, including coupled compositional, thermal, chemical, capillary and microbiological phenomena were persistent themes, together with conceptual mathematical models of such processes.

There were 62 participants in the colloquium, all of whom were authors or co-authors of presentations. There were 40 scientists from France, 17 from other European countries, 4 from the USA and 1 from Tunisia, giving a total of 47 presentations, which included 5 plenary lectures by:

- Alkiviades Payatakes, University of Patras, Greece;
- Tara LaForce, Imperial College, UK;
- Daniel M. Tartakovsky, University of California, USA;
- Stephane Zaleski, University of Paris, France;
- Dmitry Silin, National Lawrence Berkeley Laboratory, USA.

The sessions alternated with open round-table discussions on the principal scientific problems.

Recurring issues during the talks could be divided into four main areas, with subdivisions that characterised new approaches to research. These were:

<u>Conceptual Models of Multiphase Flow in Porous Media</u>

- Density functional approach;
- Introduction of disconnected phases;
- Introduction of the meniscus continuum with vector capillarity;
- Introduction of the fluid interface as the new phase;
- Improvement of the capillary relaxation model.

<u>Multi-phase Flow with Phase Transitions, Dissolution and Reactions</u>

- Three-phase flow with dissolution;
- Flow with phase transitions: method of negative saturations;
- Flow with non-equilibrium phase transitions: oscillatory regimes;
- Partial dissolution in two-phase compositional models;
- Flow with no mass conservation: reactions, precipitation.

Flow Coupled with Bacterial Activity

- Homogenized models of bacteria population growth;
- Dissipative structures activated by bacteria in gas storage containers.

Heterogenous Media: Instability, Dispersion and homogenisation

There was much positive feedback from participants, who liked the structure of the colloquium and appreciated its organisation to allow a fruitful exchange of ideas.

EUROMECH Colloquium 504

"Large Eddy Simulation for Aerodynamics and Aeroacoustics"

23-25 March 2009, Munich, Germany

Chairperson: Professor M. Manhart
Co-chairperson: Dr. Christophe Brun

Colloquium 504 allowed novel methods for Large Eddy Simulation (LES) of complex flows and Computational Aero-Acoustics (CAA) to be considered and discussed. Noise prediction by CAA depends mainly on the quality of the simulation of the turbulent flow field, so the two approaches have been considered as a common topic. The aim of the colloquium was to assess and improve the state of the art for prediction and analysis of complex turbulent flow fields with special emphasis on prediction and analysis of aerodynamic noise. It provided a link between classical Fluid Dynamics and Acoustics.

Demand by industry for accurate three-dimensional and time-resolved flow and noise predictions has led to widespread use of LES for the prediction of turbulent flow fields. However, the prediction of high Reynolds number flows with complex geometry or physics is difficult, due to computational requirements that often exceed the capacities of available hardware. In this colloquium a number of strategies were presented to overcome this bottleneck. These included:

- High-order adaptive schemes;
- Implicit sub grid scale modeling;
- Wall models;
- Coupling of LES with Reynolds averaged models (RANS).

The impact of these strategies on the quality of solutions and efficiency of the solvers was demonstrated for a broad range of flows. There was particular emphasis on the prediction of internal and external aerodynamic effects, including aero-acoustic noise. The main classes of problems were wall bounded and free shear flows ranging from channel, duct and pipe flow with distortion to wakes behind bluff bodies, jets and mixing layers.

43 participants from 7 countries attended the colloquium. Four keynote speakers discussed:

- Aspects of LES of wall proximate separated flows at elevated Reynolds numbers;
- LES of subsonic jet noise and key requirements for fidelity;
- Use of 4D synthetic turbulence for computational aeroacoustics
- Scale resolving simulation models for engineering flows.

These keynote lectures provided a reference framework for the rest of the program, which included 30 presentations grouped in sessions focusing on:

- Hybrid RANS-LES methods;
- SGS;
- Wall modelling and numerical aspects;
- Hybrid methods for noise prediction;
- Noise control and industrial applications.

The presentations stimulated vigorous discussion, the most controversial topic turning out to be hybrid methods for RANS-LES coupling. A book of abstracts documenting the main aspects of the presentations was distributed to the participants.

Colloquium 504 was supported financially by EUROMECH. It was also supported by the International Graduate School of Science and Engineering (IGSSE) of the Technische Universität München, allowing waiver of tuition fees and payment of expenses to young scientists. The support of these two institutions is 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 co-operation 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

EUROPEAN MECHANICS SOCIETY

COLLOQUIA select a year... CONFERENCES select a year...

HOME | ABOUT | STRUCTURE | COLLOQUIA | CONFERENCES | PRIZES & AWARDS | FELLOWS

EVENTS

1 January 2009
Wind turbine wakes

6 January 2009
CPNLS-09 Solitons in their roaring forties : coherence and persistence in nonlinear waves

3 February 2009
Recent Developments and New Directions in Thin-Film Flow

23 March 2009
Large Eddy Simulation for Aerodynamics and Aeroacoustics

24 March 2009
Vehicle aerodynamics

13 May 2009
Mechanics of generalized continua: a hundred years after the Cosserats

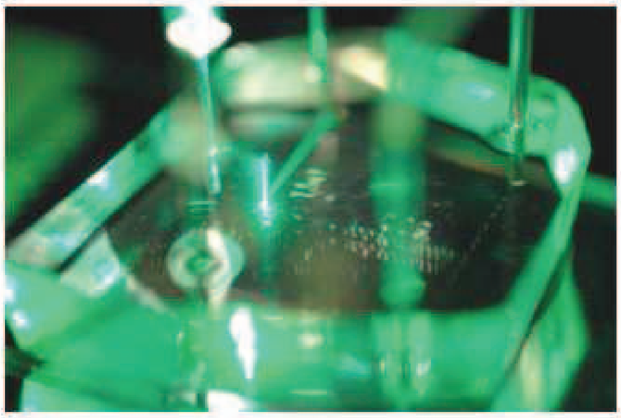
15 June 2009
Immersed boundary methods: current status and future research directions, co-sponsored by ERCOFTAC

7 September 2009
EETC12

7 September 2009
ESMC7

27 September 2009
Nonlinear Normal Modes, Dimension Reduction and Localization in Vibrating Systems

EUROMECH - European Mechanics Society is an international non-governmental non-profit scientific organization.



BECOME A MEMBER!
Annual membership: 24 €
5-year membership: 100 €
Join
Renew your membership!

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.

Search with SCOPUS

SEARCH

Latest articles

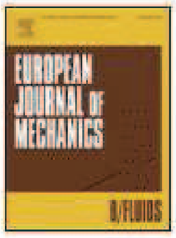
Criticality manifolds and their role in the generation of solitary waves for two-layer flow with a free surface
Bridges, T.J.
European Journal of Mechanics, B/Fluids [2009]

Numerical study of the generalized cylindrical Couette flow of rarefied gas
Shakhov, E.M.
European Journal of Mechanics, B/Fluids [2009]

Numerical analysis of a weighted-residual integral boundary-layer model for nonlinear dynamics of falling liquid films
Oron, A.
European Journal of Mechanics, B/Fluids [2009]

Weakly nonlinear EHD stability of slightly viscous jet
Elcoot, A.E.K.
European Journal of Mechanics, B/Fluids [2009]

Interactive boundary layer models for channel flow
Cousteix, J.
European Journal of Mechanics, B/Fluids [2009]



Job Advertisement

Chair in Engineering Mechanics
Chair in Engineering Mechanics at the Department of Engineering Sciences at Uppsala University, Sweden.

If you want to make a job advertisement, please contact the webmaster.

Quick links

CISM