EUROPEAN MECHANICS SOCIETY

Newsletter 30

November 2006

President's Address

This newsletter contains essential information regarding the elections to the EUROMECH Council for 2007. Members are invited to vote on the candidates listed in the ballot sheet enclosed with this newsletter.

The Advisory Board has prepared a list of seven candidates to fill four vacant seats on the EUROMECH Council. All these seats are for a six-year term, starting on 1 January 2007. Short biographical statements by the candidates are included in the newsletter.

I have been re-appointed as president by the Council until the end of 2007 and I am willing to continue serving EUROMECH in subsequent years. The Advisory Board has therefore decided to have me appear as candidate unopposed in the first slot on the election ballot. Six candidates have been selected for the remaining three slots on the election ballot, having regard for subject and geographical balance on the Council. It is very gratifying to see that such distinguished scientists are prepared to devote some of their time to serve EUROMECH.

Please vote and be sure to send in your ballot paper to the Treasurer, Wolfgang Schröder, in order to meet the deadline of 15 December 2006. You should vote for at most one candidate in each slot on the ballot paper.

Patrick Huerre

President, EUROMECH

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EUROMECH Council Elections

Voting Instructions and Ballot paper

At the end of 2006, four seats on the EUROMECH Council will become vacant. In accordance with the statutes, the Advisory Board has drawn up a list of seven candidates. All seats correspond to a six-year term of office.

All candidates are Members of EUROMECH and have given confirmation of their willingness to become members of the Council if elected. (F) stands for research interests in Fluid Mechanics, and (S) in Solid Mechanics. Short biographical statements by the candidates are included in the following pages.

The four slots appearing on the ballot correspond to the four vacant seats on the council. **Please vote with a cross for at most one candidate in each slot appearing on the ballot.** Otherwise, your vote will not be valid.

Please insert the Ballot paper in the white envelope with the red label, containing no marks to ensure anonymity, and return it in the mailing envelope to the Treasurer of EUROMECH before **15 December 2006**. Be sure to write your name and sign on the back of the mailing envelope, so that membership can be checked.

Note: The following elected members will continue for three years:

J. A. C. Ambrosio (S), Portugal
D. Lohse (F), The Netherlands
H. Myhre Jensen (S), Denmark
B. A. Schrefler (S), Italy
W. Schröder (F), Germany

You will find the ballot paper enclosed with the present Newsletter.

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Patrick Huerre is Director of research at CNRS and Professor at Ecole Polytechnique. He is the Director of the Hydrodynamics Laboratory (LadHyX) in Palaiseau. He obtained his PhD from Stanford University in 1976 and was a Professor of Aerospace Engineering at the University of Southern California in Los Angeles from 1978 to 1989, whereupon he returned to Europe.

Patrick Huerre's primary research interests are in the areas of hydrodynamic instabilities, transition to turbulence and aerodynamic sound generation, with particular emphasis on the dynamics of large scale vortices in shear flows such as mixing layers, jets, wakes and boundary layers.

Patrick Huerre is a member of the *Academie des Sciences* and a Fellow of the *American Physical Society*. He was co-Editor in chief of the European *Journal of Mechanics/B-Fluids* and is presently Associate-Editor of the *Journal of Fluid Mechanics*. He is chair of the Fluid Dynamics Symposium panel of IUTAM.

Patrick Huerre has been President of EUROMECH since 2003.

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Nikita Morozov is member of the Russian Academy of Science (since 2000), head of the Elasticity Department of St. Petersburg State University (since 1971) and a vice-chairman of the Russian national committee for theoretical and applied mechanics. He received his Ph.D. (1958) and D.Sc. (1967) from St. Petersburg State University.

His research interests include such areas as dynamics of fracture, nanomechanics, and application of singular integral equations and asymptotic methods to problems in elasticity and thermodynamics. Being a department head in a large and successful school of St. Petersburg's mechanists, with representatives in many of European and American universities, Nikita Morozov is one of the top Russian scientists. At the same time he is a coordinator of multiple Russian and international projects. He is author of more than 200 papers and 7 monographs.

Academician Nikita Morozov is a member of the editorial board of several Russian and international journals. The journal list includes Applied Mathematics and Mechanics, Mechanics of Solids, Strength of Materials and Archives of Mechanics. He has been an organizer and chairman of many international and Russian conferences. Among these are EUROMECH colloquium 468 "Multi-scale Modelling in the Mechanics of Solids" and the ICF - Interquadrennial Conference on "Scale Interaction in Fracture". He is also a member of IUTAM, GAMM and ESIS.

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Henryk Petryk is Professor at the Institute of Fundamental Technological Research (IPPT), Polish Academy of Sciences, Warsaw, Poland, and Head of the Division of Mechanics of Inelastic Materials at IPPT. His research interests have been in the area of solid mechanics, in particular in the fields of micromechanics, theory of plasticity, material instability, and recently in the micromechanical modelling of shape memory alloys and of the effects of severe plastic deformation of metals. He has presented a number of invited courses and lectures as Visiting Professor in Germany, France, Japan, Italy, China (totalling 26 months), and as an invited Sectional Lecturer at XIX Congress of IUTAM (International Union of Theoretical and Applied Mechanics), Kyoto, 1996.

Professor Petryk is Member of Scientific Council of the International Centre for Mechanical Sciences (CISM), Udine, Italy, Vice-Chairman of the Committee for Mechanics of the Polish Academy of Sciences (National Committee of IUTAM), Vice-Chairman of the Scientific Council of IPPT, Editor-in-Chief of *Archives of Mechanics* and Associate Editor of *Comptes Rendus Mecanique (Paris)*. For ten years (1995-2004) he was Associate Editor of the *European Journal of Mechanics A/Solids*.

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Oliver Jensen has been Professor of Applied Mathematics at the University of Nottingham since 2000, where he is presently Head of the School of Mathematical Sciences. He obtained his PhD in 1990 from the University of Cambridge, gained postdoctoral experience in the Department of Biomedical Engineering at Northwestern University and held lecturing positions at the University of Newcastle upon Tyne (1992-1996) and the University of Cambridge (1996-2000). His primary research interests are in fluid mechanics applied to topics in medicine and biology (particularly interfacial flows and flow-structure interactions in cardiovascular and respiratory applications) and more generally in mathematical modelling of biological systems. He is presently involved in large multidisciplinary projects in cancer, tissue regeneration and plant growth.

Professor Jensen is co-editor of the IMA journal Mathematical Medicine & Biology and he sits on the editorial boards of *Proceedings of the Royal Society A*: *Mathematical, Physical & Engineering Sciences* and *Theoretical and Computational Fluid Dynamics*. He also leads the Marie Curie Early Stage Training Network MMBNOTT.

Oliver Jensen looks forward to helping promote Euromech, particularly at the interface between mechanics and the biological sciences.

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Grae Worster obtained a PhD in Geological Fluid Mechanics from the University of Cambridge in 1983, focusing on convection in fluids of high Prandtl number and introducing ideas on the solidification of multi-component melts. He has since been an Instructor of Applied Mathematics at MIT, a Research Fellow at Trinity College, Cambridge, an Assistant Professor at Northwestern University, and on the faculty of DAMTP in Cambridge since 1992. For eight years he was Director of the Summer School in Geophysical and Environmental Fluid Dynamics, held annually in DAMTP.

His primary research interests involve the solidification of fluids, particularly the interactions between buoyancy-driven convection and phase change in multi-component systems. He is additionally interested in double-diffusive convection and thin-film flows. His investigations utilize a broad range of mathematical and numerical techniques combined with laboratory experiments to develop robust, predictive models of natural and industrial systems. He has been particularly interested recently in processes involved in the formation and evolution of sea ice, the casting of alloys and the freezing of soils and other colloidal systems.

An associate editor of the Journal of Fluid Mechanics since 1993, Professor Worster additionally co-edited the volume Perspectives in Fluid Dynamics. He has been on the organizing committee for two international conferences – Interactive Dynamics of Convection and Solidification (NATO ASI series) and the Conference on Mathematical Geophysics – editing the proceedings for the former. He is a member of the American Physical Society, Division of Fluid Dynamics, and a Fellow of EUROMECH.

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Olivier Allix research aims at proposing and developing methods and concepts to solve industrial challenges. Primarily focused on the modelling, identification and simulation of damage in composites, especially delamination, his current research interest also concerns: multiscale approaches for non-linear structural mechanics, such as buckling and crack propagation, modelling and prediction of failure in dynamics, and identification in the case of corrupted measurements. On these subjects Professor Allix has co-authored 60 papers published in international journals and has been responsible for 17 research contracts of 3 years each.
His activities have also included the organization of several international workshops and conferences (among them he has been co-chairman of a EUROMECH Colloquium) and participation in several academic and industrial committees. These include service as Vice-President of the European Computational Solid Mechanics Association. He also serves on the editorial board of 3 scientific journals. In 2006 Olivier Allix was elected fellow of IACM (Int. Assoc. of Computational Mechanics) and of EUROMECH.

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Michel Raous is Research Director at the Laboratory of Mechanics and Acoustics of the CNRS in Marseille. He served as head of the LMA, having130 staff, for 6 years (2000-2005). He is Docteur-es-Sciences (1980) and Engineer of the Ecole Nationale Supérieure de Physique (1970).

He works on structure mechanics and especially on contact mechanics, both on theoretical (mechanical modelling, mathematical formulations) and on numerical (numerical analysis, simulations, applications to industrial problems) aspects, specialising in nonsmooth/nonconvex mechanics. His recent work concerns the coupling of adhesion and friction (interface modelling or ductile crack propagation) and the study of instability phenomena related to friction, such as stick-slip and squeal.

He has organised various meetings, including: 2nd Contact Mechanics International Symposium at Carry-le-Rouet, EUROMECH 273 on "Unilateral contact and dry friction" with Jean-Jacques Moreau and Michel Jean, "IV National Colloquium on Computational Mechanics" with Bruno Cochelin and mini-symposia on contact mechanics at congresses that include:26th National Congress of Numerical Analysis, ASME-ESDA'96, and 4thWCCM. He has also organised various thematic schools, including IPSI courses in 1996 and 2004 at the Institute for the Promotion of the Engineering Sciences, a IUTAM-CISM course in 2000 on "Friction and instabilities" in Udine with J.A.C. Martins (IST-Lisbon), and a CEA-EDF-INRIA course in 1999 with L. Johnson (UK) and J.M. Georges (F).

His membership of scientific committees includes: the scientific committee of the CISM (1995-2000), the editorial board of Archives of Rational Mechanics, scientific committees of national and international conferences (EUROMECH 273, EUROMECH 434, EUROMECH 435, international symposia on contact mechanics, national colloquia on computational mechanics, international conferences on nonsmooth/nonconvex mechanics, the Colloquium on Nonsmooth Mechanics and Analysis for the 80th anniversary of J.J. Moreau, and the IUTAM Symposium on Computational Mechanics in Hannover during 2006.

Prize Paper: Focusing of strong shocks in an annular shock tube

Veronica Eliasson[1] won the EUROMECH Young Scientist Prize, awarded at the sixth EUROMECH Fluid Mechanics Conference Stockholm, June 2006

Introduction

The main reason for interest in the problem of shock wave focusing is that very high pressures and temperatures can be achieved in the vicinity of the focusing centre. This, together with the nonlinear features of the focusing process presents a challenging problem. There are several aspects of shock wave focusing that are of special interest to our research group, such as the coupling between the local strength of the shock wave and the shape of the shock wave, and stability during the focusing and reflection process. The aim of the experimental work is to find a stable shape of the shock wave that can converge and focus energy in the most optimal way.

Experimental studies of shock wave focusing have been an active research area since the 1950s. The first pioneering experiments were made by Perry and Kantrowitz [1]. A horizontal shock tube with a teardrop inset in the test section was used to create cylindrical converging shocks. These researchers studied both converging and reflecting shocks, visualized by a schlieren technique, at two different shock Mach numbers (1.4 and 1.8). They also observed the presence of light in the centre of the test section during the focusing process. This was taken as an indicator of the presence of high temperatures as the light was believed to be caused by ionized gas. Since then, many experimental and numerical studies have been performed in various problems involving shock wave focusing, e.g. [2-8]

1. Experimental setup

The experimental setup consists of a light source, an air-cooled Nd:Yag (NewWave Orion) pulse laser, a horizontal shock tube and a schlieren optics system. The shock tube has a test section where shocks are focused and reflected. The process is visualized by the schlieren system with a CCD camera. A time delay unit (Stanford Research System, DG535) is used to control the timing when the images are taken during the focusing and reflection process. The experimental setup is shown in Figure 1. The 2.4 m long circular shock tube is divided into two main parts, the high pressure part and the low pressure part which are separated by a 0.5 mm thick aluminium membrane. To create a shock wave the low pressure part is evacuated to a

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given pressure. The high pressure part is filled with gas and at a certain pressure difference between the two parts the membrane bursts, creating a shock wave which becomes planar in the inlet section of the low pressure part. The plane shock wave is transformed into an annular shape in the transformation section and then focused in the test section located at the rear part of the shock tube. The transformation section consists of a conically diverging section. An inner body mounted coaxially inside the outer tube forms the annular section and is held in place by two sets of four supports. These supports are shaped as wing profiles and the second set is rotated 45° with respect to the first set to minimize flow disturbances. It has been shown in earlier works; e.g. [5], [6] and [10], that supports inside annular shock tubes can generate disturbances in the flow and hence influence the shape of the converging shock wave.

To control the shape of the converging shock wave we used two different methods. In the first method the initial shape of the shock wave is changed as soon as it enters the test section. This is accomplished by changing the shape of the reflector boundary, i.e. the outer boundary of the test section. Four different reflector boundaries have been used in the present experiments: a circle, a smooth pentagon, a heptagon and an octagon, see Figure 2.
In the second method, the shape of the shock is tailored by artificial disturbances in the flow field. The disturbances are caused by between 1 and 16 cylinders with different diameters (7.5, 10 and 15 mm), placed in various patterns and positions inside the test section. Figure 3(a) shows three cylinders of varying size and in Figure 3(b) a setup of 16 cylinders is seen from the rear end of the shock tube.

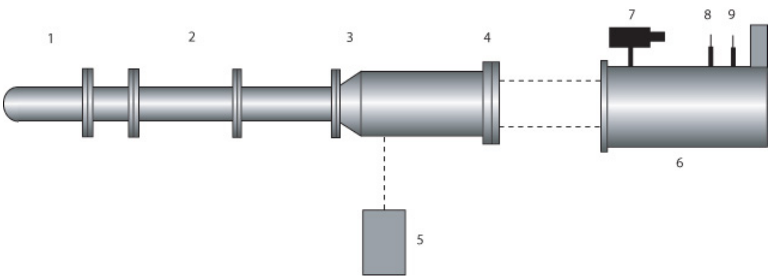

Figure 1. Schematic overview of the experimental setup: 1. The high pressure part, 2. Low pressure part: inlet section, 3. Low pressure part: transformation section, 4. Low pressure part: test section, 5. Pulse laser, 6. Schlieren optics, 7. PCO CCD camera, 8. Lens, 9. Schlieren edge.

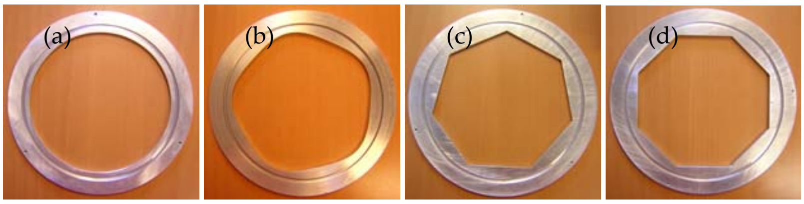

Figure 2. The four reflector boundaries used in the experiments, (a) a circle, (b) a smooth pentagon, (c) a heptagon and (d) an octagon.

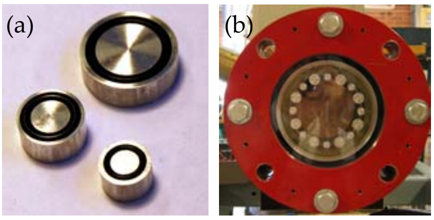

Figure 3. (a) the obstacles used to create disturbances in the flow field, (b) an example with 2 x 8 cylinders placed in the test section.

2. Results

The four reflector boundaries have been tested and numerous patterns of obstacles have been used to create various shapes of converging shock waves. In this report we choose to show results from the heptagonal reflector boundary and the circular boundary used together with obstacles inside the test section. The Mach number for the following results is between 2.1 and 3.6 measured in the annular part of the shock tube just before the shock wave enters the test section.

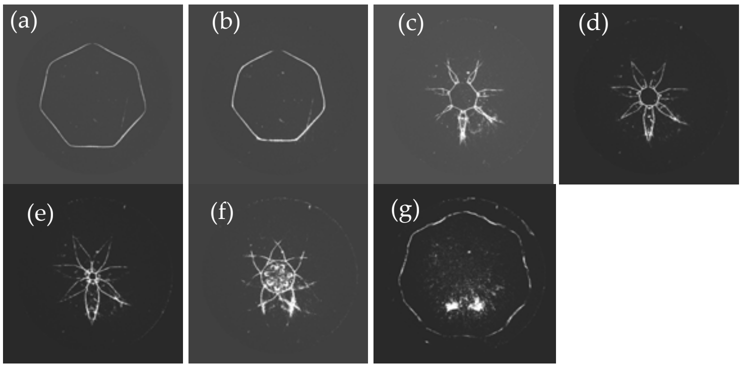

Figure 4. Schlieren photographs of a converging and diverging shock wave with a heptagonal reflector boundary.

Schlieren photographs of the focusing and reflecting process for the heptagonal reflector boundary are presented in Figures 4(a) to 4(g). When the shock wave enters the test section it assumes the heptagonal shape of the reflector boundary, as shown in 4(a) and 4(b). In the time interval between 4(b) and 4(c) the shock wave transforms into a double heptagonal shape. In 4(c), the shock wave has again assumed a heptagonal shape but now with opposite orientation. In 4(d), the shock wave is a double heptagonal and in 4(e) it is back to a heptagonal shape again, this time oriented in the same way as in 4(a). This reconfiguring process, from heptagonal to double heptagonal and then again back to heptagonal shape with an opposite orientation, continues during the whole focusing process if there are no disturbances present in the flow.

The reconfiguring process is due to the nonlinear coupling between the local strength of the shock and the shape of the shock front. It means that regions with high curvature, i.e. corners, travel faster than regions with low curvature, i.e. plane sides. We will refer to this behavior as stable, because the shock wave retains its symmetry during the focusing process and it is possible to determine in advance how the shape will evolve. When the shock wave reaches the focusing centre, it starts to reflect. At first it acquires the cylindrical shape in 4(f), but is later influenced by the flow ahead of it, transforming to a perturbed heptagon. The time interval between the first and the last photograph is 75 µs.

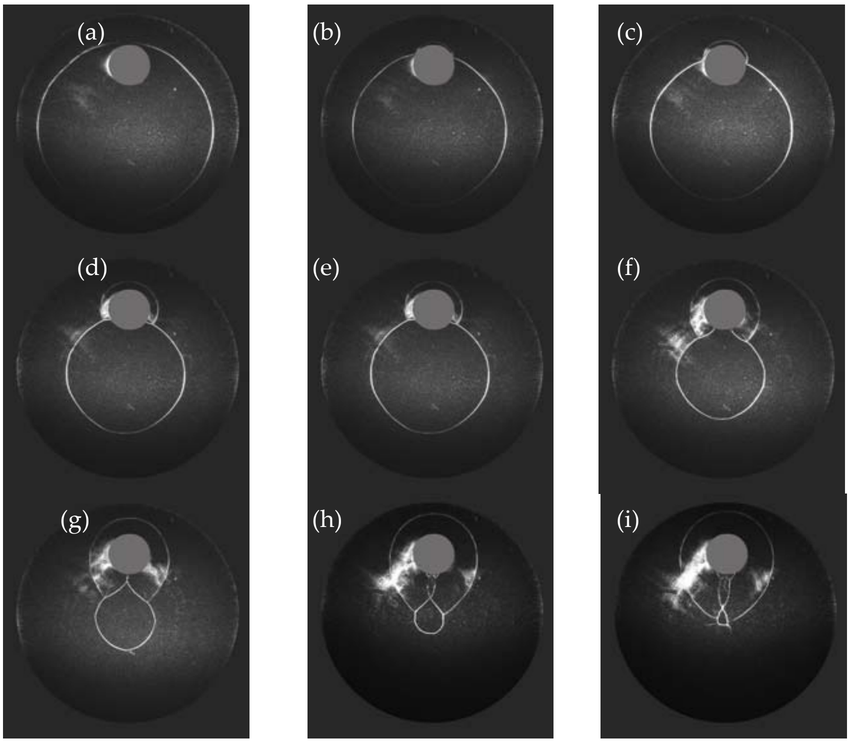

Figure 5. Schlieren photographs of a cylindrical converging shock wave disturbed by one cylindrical obstacle. Each photograph is from an individual run in the shock tube.

Figures 5(a) to 5(i) are schlieren photographs showing the focusing process for a cylindrical shock wave disturbed by a single cylindrical obstacle with a diameter of 15 mm (indicated by the grey circle). When the incident wave hits the cylinder in 5(b) a reflected wave is formed and starts to propagate outwards against the flow direction in 5(c), In 5(d) the Mach shocks are visible. The Mach shocks become curved in 5(e) and reflect off each other in 5(f). The reflection between the two Mach shocks can be considered as a Mach shock reflecting off a wall, where the wall represents the symmetry line between the two shocks. In 5(g) and 5(h) it is clearly seen that the part of the converging shock that is undisturbed by the cylinder has a cylindrical shape no longer. In 5(h) the triple point between the initial, reflected and Mach shocks is seen to build a corner region. In 5(i) the shape of the shock is additionally affected by the disturbances caused by the supports for the inner body in the annular part of the tube.

A case with eight cylindrical obstacles, each having a radius of 15 mm, is shown in Figures 6(a) to 6(f). At first an octagonal like shape is seen with curved sides. The curved sides first flatten out and develop into plane sides, as shown in the transition from 6(a) to 6(b). When the converging shock wave consists of plane sides and corners, the previously described reconfiguring process will start, meaning that the shock wave periodically transforms from octagon to double-octagon and back. The shock wave is completely focused in 6(d) and is diverging in 6(e) and 6(f).

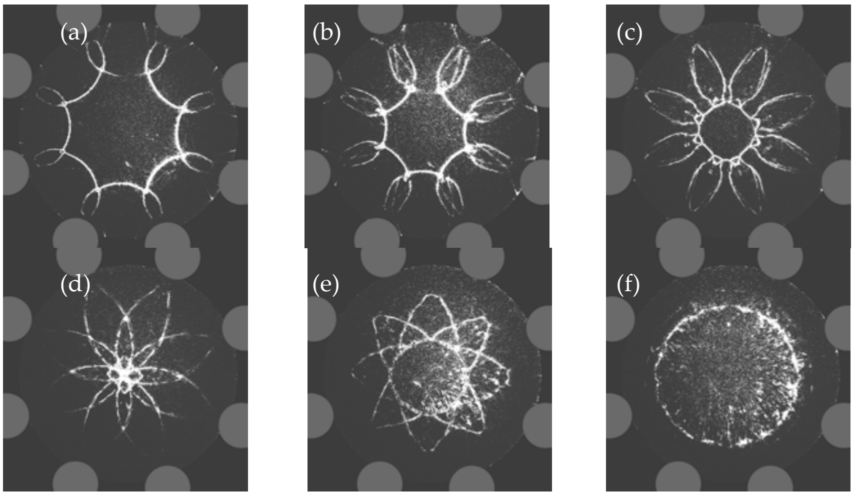

Figure 6. Schlieren photographs of a cylindrical converging and diverging shock wave disturbed by eight cylindrical obstacles.

3. Numerical results

To perform numerical simulations of the focusing process, an 'artificially upstream flux vector splitting scheme' (AUFS) for Euler equations, introduced in [11], was used. To close the Euler equations the ideal gas law was used as the equation of state. The scheme has proven a robust, stable and accurate numerical tool, able to predict and reproduce the major features of the shock focusing process. Two examples are plotted in Figure 7. The numerical shock fronts are displayed as black curves overlapping the white experimental shock shapes.

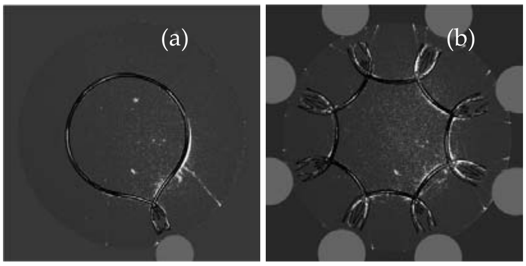

Figure 7. Density gradient profiles from the numerical simulations compared to experimental schlieren photographs for the case of (a) one and (b) eight cylindrical disturbances.

4. Conclusions

Experiments have been performed in a horizontal shock tube to study shock wave focusing and reflection. The initial form of the converging shock can be tailored by an appropriate choice of the form of the reflector or by introducing obstacles in a specific pattern in the flow. We have shown experimentally that it is possible to create polygonal shock waves that remain stable during the focusing process and are not sensitive to disturbances created by the supports of the inner body of the annular part of the shock tube, as opposed to cylindrical shock waves, which are unstable.

The nonlinear dynamics of the shock are seen in the experiments, e.g. a shock wave with n corners (plane sides) transforms into a shock wave with $2n$ corners (plane sides) and then back again to n corners (plane sides) now oriented in the opposite direction to the first one. If there are no other disturbances present in the flow the process will continue until the shock wave reaches the centre of convergence and starts to reflect. During the reflection process the shock wave will first assume a cylindrical shape. After some time the shape of the shock wave will be disturbed by the flow ahead of it and it will then change into a form that resembles the shape it had during the focusing process.

The dynamics of the shock can be modelled accurately by the Euler equations using AUFS except for in the vicinity of the focusing centre. The scheme proved to be stable and robust. The numerical analysis should be expanded to account for the high temperature effects in the vicinity of the centre of convergence.

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Prize Paper: Analysis of the inversion of the von Kármán street in the wake of a confined square cylinder

Simone Camarri won the EUROMECH Young Scientist Prize, awarded at the sixth EUROMECH Fluid Dynamics Conference Stockholm, June 2006

Simone Camarri[2] and Flavio Giannetti[3]

Abstract

This study considers the incompressible 2D laminar flow around a square cylinder symmetrically positioned in a channel. In this type of flow, even if vortices of opposite sign are alternately shed from the body into the wake as in the unconfined case, an inversion of their position with respect to the flow symmetry line takes place further downstream. Thanks to a dedicated numerical investigation, an interpretation of the inversion is given in terms of interference between the wake and the vorticity of the incoming flow, which is shown to play a dominant role in the phenomenon.

1. Introduction

The present study investigates a peculiar phenomenon that occurs in the flow around a square cylinder positioned in a channel, i.e. the inversion of the von Kármán street in the wake. More precisely, if the flow comes from left to right, clockwise and counter-clockwise rotating vortices are shed from the upper and lower sides of the cylinder, respectively, as in the unconfined case. However, at a certain distance along the wake, which depends on both the flow Reynolds number and the blockage ratio β (the ratio between the length of the cylinder sides and the channel height), the position of the vortices with respect to the symmetry line becomes inverted, i.e. clockwise and counter-clockwise vortices are located in the lower and upper parts of the flow, respectively.

To the authors' knowledge, the inversion of the von Kármán street has been studied in detail only in [5] and in [6], in which it is argued that the phenomenon occurs only for $\beta \geq 0.1$ and is essentially caused by the effect of the lift-up of the vorticity layers that are adjacent to the confining walls.

The aim of the present study is to investigate in grater detail the inversion for low values of the blockage ratio ($\beta \leq 0.167$), for which the interaction between the wake and the flow near the confining walls is weaker with respect to the

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configuration considered in [6]. This is done through numerical simulations and a linear stability analysis of the considered flow.

2. Flow configuration and numerical tools

The incompressible flow over an infinitely long square cylinder symmetrically confined by two parallel plane walls is considered. Far upstream, the incoming flow is assumed to have a Poiseuille profile with maximum centre-line velocity U_c. A sketch showing the geometry, the frame of reference and the adopted notation is shown in Figure 1.

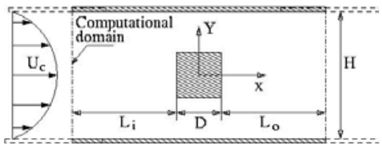


Figure 1: Flow configuration, frame of reference and computational domain (not in scale)

Values of the Reynolds number $Re = DU_c/\nu$ and of the blockage ratio $\beta = D/H$ are considered for which (1) vortex shedding is present, (2) the flow is two-dimensional and (3) the incoming Poiseuille flow is stable.

The conservative forms of the flow equations for Newtonian fluids are discretised in space on a staggered mesh by a centred and second-order accurate finite-difference scheme; a mixed Crank-Nicholson/Adams-Bashforth scheme is used for time advancing. Convective boundary conditions are applied on the outflow boundary and the velocity is assumed to vanish on the confining walls and on the cylinder. The same scheme has been used for the spatial discretization of the linearised Navier-Stokes equations for the linear temporal stability analysis, and the resulting generalised eigenvalue problem is solved with an inverse iteration algorithm. More details concerning the selected numerical tools can be found in [2] and [3].

Two grids have been used for $\beta = 0.125$, a uniform grid, UG8 (with $L_i/D = 12$, $L_o/D = 51$ and $\Delta x/D = \Delta y/D = 6.25 \cdot 10^{-2}$) and a stretched one, SG8 (with $L_i/D = 12$, $L_o/D = 35$, $\Delta x_{min}/D \cong \Delta y_{min}/D \cong 10^{-2}$ on the cylinder, with 660 and 260 points in the x and y directions, respectively). Two stretched grids have also been used for $\beta = 0.167$ and $\beta = 0.1$, with approximately the same domain dimensions and spatial resolution of SG8. The adequacy of the spatial resolution and of the computational domain dimensions has been verified through preliminary simulations for $\beta = 0.125$, not reported here for the sake of brevity.

3. Results and discussion

In Figure 2(a) the Strouhal number ($St = fD/U_c$, f being the vortex-shedding frequency) as a function of the Reynolds number is plotted for the blockage ratios $\beta = 0.167$, 0.125 and 0.1. For $\beta = 0.125$, the results are in good agreement with those obtained in [1] with a finite volume method, the maximum difference in *St* being approximately equal to 0.8% for *Re* = 166.

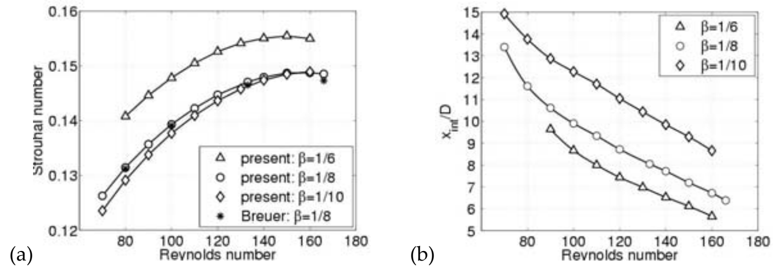


Figure 2: (a) *St* vs. *Re* obtained on grid SG8 and results from [1]; (b) x_{inv}/D vs. *Re*.

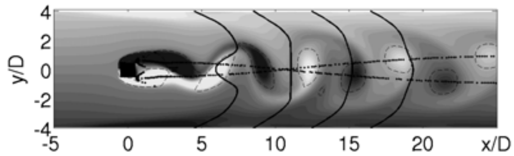


Figure 3: Grid SG8, Re = 90: trajectories of the wake vortices (identified as proposed in [4]). The vorticity, made non-dimensional with D and U_c, ranges from –0.8 (dark grey) to 0.8 (white). Time-averaged stream-wise velocity profiles are also plotted.

In Figure 3 an instantaneous vorticity field, obtained for $\beta = 0.125$ with grid SG8, is plotted; the trajectories of the vortices are obtained by following in time the local minima of pressure. Figure 3 shows that inversion of the wake occurs at about 10 diameters behind the cylinder, and Figure 2(b) shows that the x-section at which the vortex trajectories intersect (x_{inv}) increases with decreasing β and decreases almost linearly with increasing *Re*.

The selected flow differs from the unconfined case with uniform free-stream velocity, due to three principal factors: (1) the vorticity of the incoming flow, (2) the confinement effect and (3) the production of new vorticity due to the no-slip boundary conditions on the confining walls. Some simulations have therefore been carried out on grid UG ($\beta = 0.125$) for isolating the effects of each factor on the inversion of the Kármán street.

In order to keep only the effect of confinement, two simulations have been carried out for *Re* = 90 and *Re* = 160, imposing symmetrical boundary conditions on the confining walls and a constant inflow profile. In this case no inversion of the wake vortices was observed.

At a later stage, both the effect of flow confinement and that of the vorticity of the incoming flow were kept. This was done by imposing the Poiseuille profile at the inflow, as in the real case, and symmetrical boundary conditions on the confining walls, thus interrupting the vorticity production mechanism mentioned above and avoiding the presence of an intense vorticity layer near the confining walls. An instantaneous vorticity field obtained for Re = 90 is plotted in Figure 4, where the inversion of the wake vortices can again be observed. A similar result is found for Re = 160.

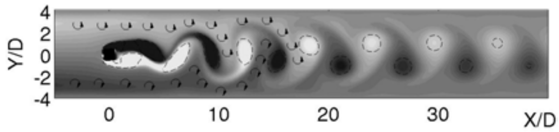


Figure 4: Grid UG, Re = 90, Poiseuille incoming flow, symmetry conditions imposed on the confining walls: non-dimensional vorticity, ranging from –0.5 (dark grey) to +0.5 (white).

It may thus be deduced that, at least for β = 0.125 and 90 ≤ Re ≤ 160, the flow confinement and the free-stream vorticity are sufficient to cause the inversion of the Kármán street. Thus, for low values of the blockage ratios, the vorticity layer near the confining walls does not play the dominant role in the inversion highlighted in [6] for the case β = 0.3. The sign of the incoming-flow vorticity in Figure 4 has been highlighted by drawing arrows indicating the direction of rotation of the fluid particles. This figure shows that the free-stream vorticity is convected into the wake thanks to the velocity induced by the wake vortices and, in turn, induces a velocity on the wake vortices which tends to push them in the inverted position that can be observed further downstream. The new vorticity that is generated near the confining walls in the original flow (when no-slip boundary conditions are applied) reinforces this mechanism, because it is positive for y > 0 and negative for y < 0, like the vorticity of the incoming flow.

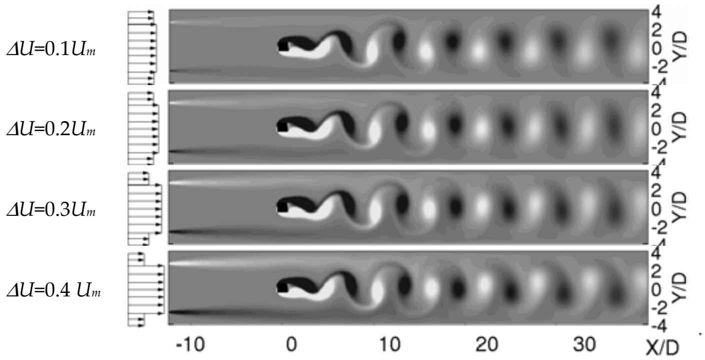


Figure 5: Grid UG, piece-wise constant inflow profile (sketched on the left-hand side of the figures), symmetry boundary conditions on the confining walls, $Re_m = 90$: instantaneous vorticity (light and dark colours stand for positive and negative vorticity, respectively).

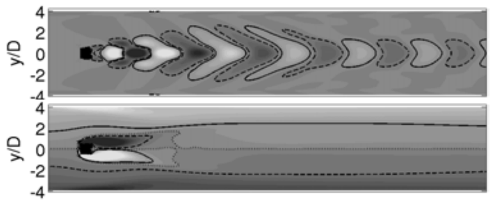
To confirm the proposed interpretation of Figure 4, further simulations have been carried out, in which symmetry boundary conditions are again imposed on the confining walls and the Poiseuille flow is replaced with the piece-wise constant velocity profile sketched in Figure 5. The new profile has two vorticity sheets placed at $y/D = \pm 2.67$, corresponding, on each side ($y > 0$ and $y < 0$), to the centre of gravity of the vorticity distribution of the original Poiseuille profile. The mass flow rate is the same as that of the Poiseuille profile, and the mean velocity over the channel height U_m is the reference velocity for the tests, which have been carried out for $Re_m = U_m D/\nu = 90$. Increasing values of the velocity discontinuity ΔU were analysed, and the results are shown in Figure 5. They are consistent with our interpretation of the role of the incoming-flow vorticity: the vertical distance between the wake vortices decreases when ΔU is increased from $0.1U_m$ to $0.2U_m$, inversion occurs when $\Delta U = 0.3U_m$ and the inversion point is closer to the cylinder when ΔU is further increased to $0.4U_m$.

Returning to the original flow, Figure 3 shows that the velocity defect in the wake disappears after the inversion of the Kármán street, as a result of the velocity induced by the wake vortices. Actually, the disappearance of the velocity defect at a finite distance from the cylinder is a fundamental difference from the unconfined case, where this happens only asymptotically far in the wake.

To further investigate the connection between the velocity defect and the inversion of the wake vortices, a linear stability analysis of the flow has been carried out for $Re = 90$ (grid UG), considering as the base flow the time-averaged flow field (see Figure 3). Using the time-averaged flow as the base flow allows us to retain some non-linearity in the stability analysis, a particularly significant feature in our case, where the recovery of the velocity defect in the wake is drastically enhanced by the Kármán street. An unstable mode is found, whose frequency ($St = 0.1368$) is almost identical to that of vortex-shedding in the simulation ($St = 0.1370$). The time-averaged flow has been computed and, as shown in Figure 6, the wake vortices in the resulting flow field cross the centre-line approximately where the velocity defect of the wake disappears, i.e. at a position that is independent of the relative weight by which the linearly unstable mode is added to the base flow.

(a)

(b)



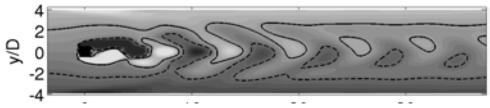
(c) 

Figure 6: Re = 90: vorticity of (a) the linearly unstable mode, (b) the time-averaged flow field and (c) sum of the previous two fields. Positive and negative values are indicated with light (continuous isocontours) and dark (dashed isocontours) grey. The dotted line in (b) is the isocontour of the zero value.

The vorticity of the unstable mode and of the averaged flow field are, respectively, symmetrical and anti-symmetrical with reference to the centre-line $y = 0$, as happens in the unconfined case. However, the disappearance of the wake defect implies a change in the sign of vorticity in the base flow moving downstream near the centre-line, as can be deduced from Figure 6(b). Thus, in the sum of fields (a) (symmetrical) and (b) (anti-symmetrical), the sign of the vortices near $y = 0$ must change in crossing the point where the wake defect disappears, since, at that point, field (a) is unchanged and symmetrical, while the sign of (b) is reversed. The same behaviour is observed when the stability analysis is carried out for steady unstable flow fields, but in that case, the disappearance of the velocity defect in the base flow takes place at a distance which is definitely larger than in the case of the time-averaged flow field.
Since in the stable channel flow the Poiseuille profile is recovered at a finite distance behind the cylinder, the correlation between velocity defect and inversion suggests that the Kármán street should always invert, provided the vortices are not completely diffused when the wake defect disappears. This is in contrast with the result reported in [5], where the inversion was not observed for the case $\beta = 0.05$ for $Re = 75$; however, the coarse grid and the upstream scheme adopted in [5] might have caused premature diffusion of the wake vortices. Indeed, the same configuration has been simulated here (with L_{in}=12D, L_{out} = 115.5D and a uniform discretization $\Delta x = \Delta y = 0.125$), and inversion of the Kármán street has been observed about 70 diameters behind the cylinder (not shown here for the sake of brevity).

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Prize Paper: On the Modelling of Axially Moving Strings

Ulrike Zwiers won the EUROMECH Young Scientist Prize,
awarded at the sixth European Solid Mechanics Conference
Budapest, August 2006

Ulrike Zwiers[4] and Manfred Braun[5]

Abstract

The linear equation governing the transverse vibrations of an axially accelerated string is derived using Hamilton's principle. As the resulting equation reveals a conflict with an equation commonly referred to in literature, an interpretation of this alternative formulation is provided. The models are compared with each other using a numerical analysis based on Galerkin's method.

1. Introduction

Many different engineering devices such as power transmission belts, magnetic tapes, elevator and crane hoist cables, band saw blades, and textile fibres are collectively termed axially moving continua. During the past several decades, those systems have been studied extensively by many researchers, referring frequently to the translating uniform string as the simplest representation of distributed gyroscopic systems.

A string is a one-dimensional continuum that offers no resistance to bending. The gravitational force is assumed to be sufficiently small compared with the tension force such that the equilibrium configuration can be represented by a straight line.

The research on axially moving strings can be dated back to the 19th century and is still of interest nowadays. The state of research is reviewed in several survey papers, e.g., [1], [2], [9]. In the majority of cases, however, the string is assumed to travel at constant speed, while the accelerated string problem is analysed to a significantly lesser extent. The steady-state motion might be the most important application. In actual operation, however, a motion at constant speed is always embedded between transient stages of acceleration and deceleration. Miranker [4] was probably the first who derived the linear equation governing the transverse vibrations of a tape moving at a time-dependent axial velocity $v(t)$ in the form

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$$\ddot{u} + 2v\dot{u}' + \left(v^2 - c^2\right)u'' - \dot{v}u' = 0, \tag{1}$$

where u denotes the transverse displacement and c is the wave speed defined as the square root of the tensile force acting within the tape divided by the linear density of the tape. Superposed dots and attached primes are used to indicate partial derivatives with respect to time and space coordinate, respectively.

Most studies on accelerated continua, even in recent years, are based on equation (1), e.g. [6], [7], [8], [10]. It seems, however, that this equation does not correctly describe the dynamics of an axially accelerated string. The term $\dot{v}u'$ appearing in (1) results from the questionable assumption of a constant tensile force, which does not apply to the case of an accelerated motion.

2. Derivation of The Governing Equation

The derivation presented in the following refers to a string moving axially at a time-varying transport speed $v(t)$ between two supports separated by a distance ℓ, as illustrated in Figure 1. The support rolls represent spatially fixed boundaries that allow the string to move freely without friction in the horizontal direction, while vertical displacements are inhibited. The cross section of the string has constant area A. The density ρ of the material and its Young's modulus E are also assumed to be constant. The longitudinal elongation of the string as well as its bending stiffness and rotary inertia are neglected.

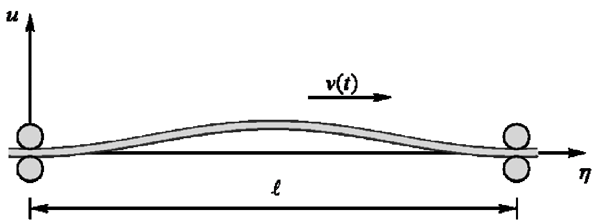

Figure 1: Axially moving string

Axially moving strings represent open systems with material particles entering and leaving the boundary of the system. In its classical form, however, Hamilton's principle applies only to closed systems, composed of the same set of particles at all times. Thus, the modelling of an axially moving string requires an extended form of Hamilton's principle that allows modelling of systems whose constituent set of particles changes with time. Referring to the work of McIver [3], Hamilton's principle can be extended to

$$\int_{t_1}^{t_2} \left(\delta E - \delta U + \delta W_c - \delta W_m \right) \mathrm{d}t = 0, \tag{2}$$

where δE and δU denote the variation of total kinetic and potential energy, respectively, W_c is the virtual work performed by non-conservative forces, and W_m denotes the virtual transport of momentum across the open boundaries. Hamilton's principle as stated above is valid for both systems of changing mass and systems of constant mass with a changing set of particles.

In the case of an axially moving string, the total kinetic energy is

$$E = \frac{1}{2} \rho A \int_{\eta_1}^{\eta_2} \left[v^2 + \left(\dot{u} + v u' \right)^2 \right] \mathrm{d}\eta, \tag{3}$$

while the total potential energy due to transverse displacement of the string is given by

$$U = \frac{1}{2} \int_{\eta_1}^{\eta_2} \overline{T} u'^2 \mathrm{d}\eta, \tag{4}$$

where $\overline{T}$ denotes the tensile force within the string and η is the Eulerian coordinate that allows a spatial description of the problem.

Focusing on the case of a string moving between fixed track idlers, as illustrated in Figure 1, the boundary conditions $u(0,t) = u(\ell,t) = 0$ imply vanishing variations δu at the supports. In addition, there are no non-conservative forces acting on the system, so that W_c and W_m in (2) are both zero. It should be noted, however, that this is true only for the particular problem at hand. There are various cases where those terms do not vanish, for example in boundary control problems, systems of varying length, and problems involving friction or damping.

Before actually applying Hamilton's principle, the tensile force $\overline{T}$ is determined first by referring to the balance of linear momentum which reduces in the absence of distributed forces and under the simplifying assumptions introduced above to

$$\rho A \frac{\mathrm{D}^2 \boldsymbol{r}}{\mathrm{D}t^2} = \frac{\partial}{\partial \xi} \left(T \frac{\partial \boldsymbol{r}}{\partial \xi} \right). \tag{5}$$

The undisturbed motion of an axially moving straight string is described by

$$\overline{\boldsymbol{r}} = \left(\eta_0 + \xi \right) \boldsymbol{e}_x, \tag{6}$$

where $\boldsymbol{e}_x$ is the unit vector that defines the spatially fixed direction of motion, $\eta_0(t)$ accounts for the motion of the string, and ξ represents the Lagrangian coordinate identifying material points along the string. The transport speed of the string is now given by $v = \dot{\eta}_0$. Substitution of (6) into equation (5) and integration yields

$$\overline{T}(\xi,t)=\overline{T}_0(t)+\rho A\xi\dot{v}(t), \tag{7}$$

Thus, in general, the tension of the axially moving straight string is a function of both ξ and t. The tension is independent of the material coordinate ξ only in case of a constant transport speed.

The variation of the reduced form of (2) is performed for arbitrary virtual displacements δu as

$$\int_{t_1}^{t_2}\left(\frac{\partial E}{\partial \dot{u}}\delta\dot{u}+\frac{\partial E}{\partial u'}\delta u'-\frac{\partial U}{\partial u'}\delta u'\right)\mathrm{d}t=0. \tag{8}$$

Substituting the energy terms (3) and (4) into this equation and collecting the terms in the resulting expression according to the occurrence of $\delta\dot{u}$ and $\delta u'$ leads to

$$\int_{\eta_1}^{\eta_2}\int_{t_1}^{t_2}\rho A\left(\dot{u}+vu'\right)\delta\dot{u}\ \mathrm{d}t\ \mathrm{d}\eta+\int_{t_1}^{t_2}\int_{\eta_1}^{\eta_2}\left[\rho A\left(\dot{u}+vu'\right)-\overline{T}u'\right]\delta u'\,\mathrm{d}\eta\ \mathrm{d}t=0,$$

Partial integration of the inner integrals gives

$$\int_{\eta_1}^{\eta_2}\rho A\left(\dot{u}+vu'\right)\delta u\Big|_{t_1}^{t_2}\mathrm{d}\eta-\int_{\eta_1}^{\eta_2}\int_{t_1}^{t_2}\rho A\left(\ddot{u}+\dot{v}u'+v\dot{u}'\right)\delta u\ \mathrm{d}t\ \mathrm{d}\eta+$$

$$+\int_{t_1}^{t_2}\left[\rho Av\left(\dot{u}+vu'\right)-\overline{T}u'\right]\delta u\Big|_{\eta_1}^{\eta_2}\mathrm{d}\eta-\int_{t_1}^{t_2}\int_{\eta_1}^{\eta_2}\left[\rho Av\left(\dot{u}'+vu''\right)-\overline{T}'u'-\overline{T}u''\right]\delta u\ \mathrm{d}\eta\ \mathrm{d}t=0.$$

Since the boundary terms have to vanish separately, only the double integral

$$\int_{t_1}^{t_2}\int_{\eta_1}^{\eta_2}\left[\rho A\left(\ddot{u}+2v\dot{u}'+v^2u''+\dot{v}u'\right)-\overline{T}'u'-\overline{T}u''\right]\delta u\ \mathrm{d}\eta\ \mathrm{d}t \tag{9}$$

Remains, which has to vanish for arbitrary variations $\delta u(\eta,t)$. Thus, the differential equation

$$\rho A\left(\ddot{u}+2v\dot{u}'+v^2u''+\dot{v}u'\right)-\overline{T}'u'-\overline{T}u''=0 \tag{10}$$

is obtained. As the resultant stress of a string in accelerated motion is not constant but depends on the accelerated mass which is proportional to the length coordinate of the string, as stated in (7), the terms $\rho A\dot{v}u'$ and $\overline{T}'u'$ in (10) cancel and the governing equation of motion reduces to

$$\ddot{u}+2v\dot{u}'+\left(v^2-c^2\right)u''=0, \tag{11}$$

where $c=c(\eta,t)$ denotes the local propagation speed defined by $c^2=\overline{T}/(\rho A)$.

At first sight, it might be surprising that the equation governing the transverse vibrations of an axially accelerated string is the same as in the case of a non-accelerated string. It should be recalled, however, that for an accelerated string, the tensile force $\overline{T}$ is a linear function of the spatial coordinate as stated in (7), while the force is constant in case of a string moving axially at constant speed.

It is worth noting that equation (11) could have been obtained alternatively by applying the Euler operator

$$\frac{\mathrm{d}}{\mathrm{d}t}\left(\frac{\partial}{\partial \dot{u}}\right)+\frac{\mathrm{d}}{\mathrm{d}\eta}\left(\frac{\partial}{\partial u'}\right)-\frac{\partial}{\partial u} \tag{12}$$

on the Lagrange function $E-U$, as suggested by Miranker [4].

3. Interpretation of Miranker's Equation

Clearly, Miranker's equation (1) would result from (10) if $\overline{T}'=0$, i.e., under the assumption of a constant tensile force. Since the tensile force of an accelerated string is non-constant, but of the form in (7), Miranker's equation does not correctly model the problem of a string moving at an arbitrary transport speed relative to some space-fixed observer. Instead, it can be shown that Miranker's equation actually describes the problem sketched in Figure 2, where a tensioned string is spatially fixed while the boundaries that delimit a string segment of constant length move at a generally time-varying transport speed.

The undisturbed straight string is defined by

$$\overline{\boldsymbol{r}}=\xi \boldsymbol{e}_{\mathrm{x}}, \tag{13}$$

a time-invariant expression which yields, after substitution into equation (5), the condition

$$\overline{T}'=0. \tag{14}$$

Now, Miranker's equation is easily obtained following the derivation presented above, in which it is worth noting that the boundaries move in the opposite direction to the moving string addressed before.

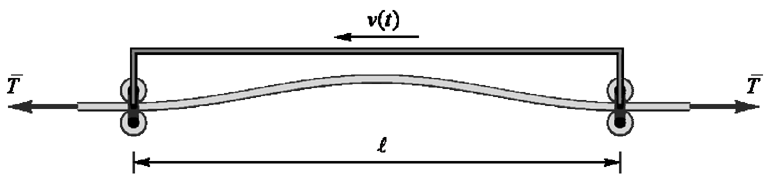

Figure 2: Spatially fixed string with moving boundaries

4. Numerical Analysis

The Lagrangian formulation of Miranker's equation (1) corresponds to the well-known homogeneous wave equation for which the general solution is available in closed-form, as discussed, e.g., in [5]. For the corrected equation (11), on the other hand, no analytical solution is currently available. Since the general solution of Miranker's equation does not satisfy the specific boundary

conditions anyway, a numerical analysis is performed to gain a first insight into the behavior of both models.
According to Galerkin's method, a series solution of the form

$$u(\eta,t)=\sum_{k=1}^{m}\phi_k(t)\sin\frac{k\pi\eta}{\ell} \tag{15}$$

is assumed, in which $\phi_k(t)$ are the generalized displacements and $\sin(k\pi\eta/\ell)$ is the corresponding kth eigenfunction of the simply supported non-moving string. In the Galerkin approach of the weighted residual method, a weighted average of the residual R is required to vanish over the domain of the equation, i.e.

$$\int_0^{\ell} R w_l(\eta)\,\mathrm{d}\eta=0 \qquad l=1,2,\ldots,m, \tag{16}$$

where the weight functions $w_l(\eta)$ are also the eigenfunctions of the non-moving string.
Substituting (15) and its appropriate derivatives into the governing equations (1) and (11), respectively, yields the corresponding residuals which lead, by substitution into (16) and performing the integration, to a set of ordinary differential equations of the form

$$\boldsymbol{M}\ddot{\boldsymbol{\phi}}+\boldsymbol{G}\dot{\boldsymbol{\phi}}+\boldsymbol{K}\boldsymbol{\phi}=\boldsymbol{0}. \tag{17}$$

Both Miranker's equation (1) and the corrected equation (11) yield the same mass and gyroscopic matrices whose elements are

$$M_{lk}=\int_0^{\ell}\sin\frac{k\pi\eta}{\ell}\sin\frac{l\pi\eta}{\ell}\mathrm{d}\eta=\begin{cases}0, & k\neq l,\\ \frac{\ell}{2}, & k=l\neq 0,\end{cases}$$

and

$$G_{lk}=\int_0^{\ell}2v\frac{k\pi}{\ell}\cos\frac{k\pi\eta}{\ell}\sin\frac{l\pi\eta}{\ell}\mathrm{d}\eta=\begin{cases}0, & k\neq l,\ k+l \text{ even},\\ \frac{4klv}{l^2-k^2}, & k\neq l,\ k+l \text{ odd},\\ 0, & k=l.\end{cases}$$

As for the stiffness matrix, Miranker's equation (1) gives a skew-symmetric matrix with the elements

$$K_{lk} = \int_0^{\ell} \left(\left(c^2 - v^2 \right) \frac{k^2 \pi^2}{\ell^2} \sin \frac{k\pi\eta}{\ell} + \frac{\dot{v} k \pi}{\ell} \cos \frac{k\pi\eta}{\ell} \right) \sin \frac{l\pi\eta}{\ell} \mathrm{d}\eta$$

$$= \begin{cases} 0, & k \neq l,\ k+l \text{ even}, \\ \dfrac{2kl\dot{v}}{l^2 - k^2}, & k \neq l,\ k+l \text{ odd}, \\ \dfrac{k^2\pi^2}{2\ell}\left(c^2 - v^2\right), & k = l, \end{cases}$$

while the corrected equation (11) yields a non-symmetric matrix due to the circulatory term appearing in the original differential equation, in which the elements of the stiffness matrix are

$$K_{lk} = \int_0^{\ell} \left(c^2 - v^2 + \eta\dot{v} \right) \frac{k^2 \pi^2}{\ell^2} \sin \frac{k\pi\eta}{\ell} \sin \frac{l\pi\eta}{\ell} \mathrm{d}\eta$$

$$= \begin{cases} 0, & k \neq l,\ k+l \text{ even}, \\ -\dfrac{4k^3 l\dot{v}}{\left(l^2 - k^2\right)^2}, & k \neq l,\ k+l \text{ odd}, \\ \dfrac{k^2\pi^2}{4\ell}\left(2\left(c^2 - v^2\right) + \ell\dot{v}\right), & k = l. \end{cases}$$

It depends, of course, greatly on the chosen parameters whether or not the differences between Miranker's equation and the corrected equation become apparent in simulation. Figure 4 shows the simulation results for an exponentially decaying transport speed, in which the parameters are chosen to provide a visual impression of the fundamental differences between the two models, thereby motivating further studies on this subject.

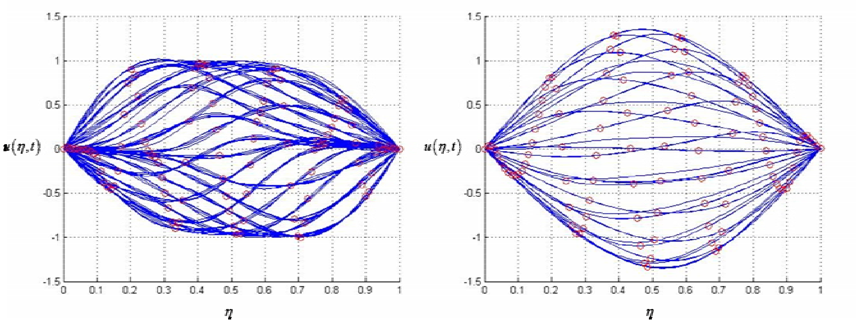

Figure 4: Displacements for an exponentially decaying speed: Miranker's model (left) and corrected model (right)

5. Concluding Remarks

An introduction to the accelerated string problem is given, including a re-derivation of the governing equation of motion using Hamilton's principle and an interpretation of an alternative equation commonly referred to in literature. As a first approach to study the characteristics of both models, a numerical analysis based on Galerkin's method is presented.

In a next step, both models should be further investigated and compared, especially regarding stability and energy transfer. Analytical methods, such as perturbation analysis or even the method of characteristics, are favoured to obtain closed-form solutions at least to the problem of constantly accelerated motion.

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EUROMECH Fellows: Nomination Procedure

The EUROMECH Council has pleasure in announcing 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, the European Mechanics Society, 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.

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:…………………………………………………………………………

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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:

- I.D. Abrahams
- H.H. Fernholz (Chair)
- P. Huerre
- D. Lohse
- W. Schröder

Chairman's address

Professor H.H. Fernholz
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Fax : +49-30-3142-1101
Email: fernholz@pi.tu-berlin.de

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:

- A. Benallal
- I. Goryacheva
- H.M. Jensen
- F.G. Rammerstorfer (Chair)
- B.A. Schrefler

Chairman's address

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Fax : +43-1-58801-31799
Email: ra@ilsb.tuwien.ac.at

EUROMECH Conferences in 2007 and 2008

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, and much of the communication which takes place is necessarily more in the nature of the imparting of information than the 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.

EMMC10
10th EUROMECH-MÉCAMAT Conference
DATES: 11-14 June 2007
LOCATION: Kazimierz Dolny, Poland
CONTACT Prof. W.K.Nowacki, IPPT-Polish Academy of Sciences
E-MAIL: wnowacki@ippt.gov.pl
WEBSITE: http://www.lmt.ens-cachan.fr/emmc10/index.html

EETC11
11th EUROMECH European Turbulence Conference
DATES: 25 – 28 June 2007
LOCATION: Faculty of Engineering of the University of Porto
Porto, Portugal
CONTACT: etc11@fe.up.pt.
WEBSITE: http://www.fe.up.pt/etc11

EMMC11
11th EUROMECH-MÉCAMAT Conference
DATES: 2008
LOCATION: Turin, Italy
CONTACT:
E-MAIL: jfgangho@hotmail.com, pastrone@dm.unito.it

ENOC6
6th EUROMECH Nonlinear Oscillations Conference
DATES: 30 June – 4 July 2008
LOCATION: St. Petersburg, Russia
CONTACT: Prof. Alexander L. Fradkov ,
E-MAIL: fradkov@mail.ru

EFMC7
7th EUROMECH Fluid Mechanics Conference
DATES: 14 – 18 September 2008
LOCATION: Manchester, UK
CONTACT: Prof. Peter Duck,
E-MAIL: duck@ma.man.ac.uk

Third Announcement and Call for Papers
11th EUROMECH European Turbulence Conference
ETC11

25–28 June 2007

Faculty of Engineering of the University of Porto, Portugal

http://www.fe.up.pt/etc11

The 11th EUROMECH European Turbulence Conference (ETC11), organized by the EUROMECH - European Mechanics Society, will take place at the Faculty of Engineering of the University of Porto (FEUP) in Porto, Portugal.

The conference aims to provide an international forum for exchange of information on most fundamental aspects of turbulent flows, including instability and transition, intermittency and scaling, vortex dynamics and structure formation, transport and mixing, turbulence in multiphase and non-Newtonian flows, reacting and compressible turbulence, acoustics, control, geophysical and astrophysical turbulence, and large-eddy simulations and related techniques, MHD turbulence and atmospheric turbulence.

Following the established tradition, the conference programme will comprise 8 invited talks (two per day), selected papers and poster sessions.

Contributions are solicited from the worldwide turbulence research community.

The paper selection will be made by the EUROMECH Turbulence Conference Committee on the basis of two-page abstracts submitted via the conference webpage, at **www.fe.up.pt/etc11** by 6 October 2006.

All accepted papers and posters will appear in a conference proceedings to be distributed among the participants. A smaller set of papers may be published after the conference in a special issue of a scientific journal. For further information and updates please visit the conference website or contact the organizers at etc11@fe.up.pt.

EUROMECH Colloquia in 2007 and 2008

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 2006, and preliminary information for some Colloquia in 2007, are given below.

EUROMECH Colloquia in 2007

481. Recent Advances in the Theory and Applications of Surface and Edge Waves

Chairperson: Prof. Yibin Fu
Department of Mathematics Keele University
Staffordshire ST5 5BG
Phone: +44(0)1782 583650; Fax: +44(0)1782 584268
Email: y.fu@keele.ac.uk
Co-Chairperson**:** Prof. Julius Kaplunov
Date and location: 11-14 June 2007, Keele University, UK
Website: http://www.keele.ac.uk/depts/ma/euromech/

482. Efficient Methods for Robust Design and Optimization

Chairperson: Dr.-Ing. habil. Fabian Duddeck
Reader for Computational Mechanics
Department of Engineering
London University, Queen Mary College
Mile End Road, London E1 4NS, UK
Phone: +44(0)20 7882 3749; Fax: +44(0)20 8983 1007,
E-Mail: f.duddeck@qmul.ac.uk
Co-Chairpersons:
Prof. Dr.-Ing. Kai-Uwe Bletzinger,
Prof. Dr. techn. Christian Bucher,
Prof. Hermann G. Matthies Ph.D,
Dr. Marcus Meyer,
Date and location10-12 September 2007, London, UK

483. Non-linear Vibrations of Structures

Chairman: Prof. P.L. Ribeiro,
IDMEC/DEMEGI, Faculdade de Engenharia
Universidade do Porto,
Rua Doutor Roberto Frias,
4200-465 Porto, Portugal
Phone: +351 22 508 1713; Fax: +351 22 508 1445
E-mail: pmleal@fe.up.pt
Co-chairman: Prof. Marco Amabili
Euromech contact person: Prof. J. Ambrosio
Date and location: 9-11 July 2007, University of Porto, Portugal
Website: http://www.fe.up.pt/nlvs2007

488. The Influence of Fluid Dynamics on the Behaviour and Distribution of Plankton
Chairperson: Dr. David Lewis
Department of Mathematical Sciences
University of Liverpool
Mathematical Sciences Building
Liverpool, L69 7ZL, UK
Phone: +44(0)151 794 4014; Fax: +44(0)151 794 4061
E-mail: d.m.lewis@liv.ac.uk Co-chairman: *to be decided*
Co-Chairperson:Dr. Rachel Bearon
Date and location: 13-15 June 2007, Liverpool, UK
Website: http://www.liv.ac.uk/maths/Euromech488/index.html

489. Porous media: Modelling of multiphase materials
Chairperson: Prof. Ragnar Larsson
Dept of Applied Mechanics/ Div. of material and computational mechanics
Chalmers University of Technology
S-412 96 Gothenburg, Sweden
Phone: +46 31 7725267; Fax: +46 31 7723827
Email: ragnar@chalmers.se
Co-Chairperson: Prof. Dr.-Ing. Stefan Diebels
Date and location: 19-21 September 2007, Chalmers University of Technology, Gothenburg, Sweden
Website: http://www.am.chalmers.se/~ragnar/Euromech_489_home/

490. Dynamics and Stability of Thin Liquid Films and Slender Jets
Chairperson: Dr. Omar K. Matar
Department of Chemical Engineering
Imperial College London
South Kensington Campus
London SW7 2AZ, UK
Phone: +44(0)207 594 5571; Fax: +44(0)207 594 5629

E-mail: o.matar@imperial.ac.uk
Co-Chairpersons:
Richard V. Craster (Imperial College London)
Andreas Münch (Humboldt-Universitat zu Berlin)
Thomas P. Witelski (Oxford University)
Date and location: 26-28 September 2007, Imperial College, London, UK

491. Vortex dynamics from quantum to geophysical scales
Chairperson: Dr. Andrew D. Gilbert,
Mathematics Research Institute,
School of Engineering, Computer Science and Mathematics,
University of Exeter,
Exeter EX4 4QE, U.K.
Phone: +44(0)1392 263981; Fax: +44(0)1392 263997
Email: A.D.Gilbert@exeter.ac.uk
Co-Chairpersons:
Dr. Konrad Bajer, Institute of Geophysics, Warsaw University, Poland.
Prof. Carlo F. Barenghi, School of Mathematics, University of Newcastle, U.K.
Date and location: 11-14 September 2007, Exeter, U.K
Website: www.secam.ex.ac.uk/~adg/euromech491.html

492. Shear-banding phenomena in micellar fluids
Chairperson: Dr H. J. Wilson
Department of Mathematics
University College London
Gower Street, London WC1E 6BT
Phone: +44(0)20 7679 1302; Fax: +44(0)20 7383 5519
Email: helen.wilson@ucl.ac.uk
Co-chairperson: Dr. M. P. Lettinga
Date and location: 3-5 September 2007, London, UK
Website: http://www.ucl.ac.uk/euromech492/

493. Interface Dynamics, Stability and Fragmentation
Chairperson: Prof. Emmanuel Villermaux,
Université de Provence, IRPHE,
49, rue Frédéric-Joliot Curie
13384 Marseille Cedex, France
Phone: +33 4 96 13 97 42 ; Fax: +33 4 96 13 97 09
E-mail: villerma@irphe.univ-mrs.fr
Co-chairperson: Prof. J.Hinch
Date and location: 29-31 August 2007, Grenoble, France

494. Symposium on Micro PIV and Applications in Microsystems
Chairperson: Dr Ralph Lindken

Laboratory for Aero- and Hydromechanics
J. M. Burgers centrum
Leeghwaterstraat 21
2628CA Delft, The Netherlands
Phone: +31 15 278 2991 ; Fax: +31 15 278 2947
E-mail: r.lindken@wbmt.tudelft.nl
Co-chairperson: Prof. J. Westerweel
Date and location: May 2007, Delft, The Netherlands

EUROMECH Colloquia in 2008

495. Advances in simulation of multibody system dynamics
Chairperson: Prof. Dmitry Pogorelov
Department of Applied Mechanics
Bryansk State Technical University
b.50 let Oktyabrya, 7
241035 Bryansk, Russia
Phone: +7 4832 568637; Fax: +7 4832 568637
Email: pogorelov@tu-bryansk.ru
Co-Chairperson: Em. Prof. Dr.-Ing. Werner Schiehlen
Date and location:18-21 February 2008, Bryansk, Russia

496. Control of Fluid Flow
Chairperson: Prof. Peter Schmid
Laboratoire d'Hydrodynamique (LadHyX)
Ecole Polytechnique
F-91128 Palaiseau, France
Phone: +33 1 69 333780; Fax: +33 1 69 333030
e-mail:peter.schmid@ladhyx.polytechnique.fr
Co-Chairperson: Dan Henningson
Date and location: May 2008, Paris, France

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-Chairperson: Dr. Brian R. Duffy,
Date and location: Summer 2008, Edinburgh, UK

EUROMECH Colloquium 477

"Particle-laden flow: from geophysical to Kolmogorov scales"

21-23 June 2006, Twente, The Netherlands

Chairperson: Professor. B.J. Geurts
Co-chairpersons: Professor Prof. H.J.H. Clercx, Dr. W.S.J. Uijttewaal

The dispersion of particles in a flow is of central importance in various geophysical and environmental problems. The spreading of aerosols and soot in the air, the growth and dispersion of plankton blooms in seas and oceans, and the transport of sediment in rivers, estuaries and coastal regions are striking examples. These problems are characterized by strong nonlinear coupling between several dynamical mechanisms such as convective sweeping, rotation, buoyancy, bio-physical influences and interactions between particles and fluid. As a result, processes on widely different length- and time-scales are of simultaneous importance. These range from the minute Kolmogorov scales associated with the particles themselves, to much larger scale structures that can be appreciated best via satellite observations. The multiscale nature of this challenging field motivated this colloquium, supported by the recently established Dutch Platform for Geophysical and Environmental Fluid-mechanics (PGEF).

A total of 55 participants from 13 countries and 4 continents contributed to the colloquium. The six keynote speakers provided reviews and recent research findings in areas that are central to the theme of the colloquium. These keynote lectures constituted the framework for the rest of the program, which included 33 presentations of 20 minutes each. A book of abstracts was composed, documenting various experimental, theoretical and computational studies that are presently being carried out in this complex multi-disciplinary field of science and engineering. These abstracts form the basis for extended papers that will appear in proceedings to be published next year. Moreover, selected papers will be combined into a focal issue of the Journal of Turbulence in 2007.

Issues related to the large-scale environmental aspects of particle-laden flows were addressed by Jim Best, who considered turbulence modulation arising in high density clay-laden flows, and by Bernard Legras, who focused on transport processes in the stratosphere and their relevance to climate and weather predictions. Fundamental aspects of transport of particles formed the topic of the second day of the colloquium. John Eaton combined insights from experimental and computational research to understand the distortion of flow in the neighborhood of embedded particles. Guido Boffetta presented aspects of Lagrangian statistics in turbulence, addressing the dispersion of `constellations' of two, three and four embedded point particles. Bridging the environmental and the fundamental aspects of particle-laden flows was the topic of the final day of the colloquium. Vincenzo Armenio discussed the Lagrangian dispersion of particles, in the context of phenomena occurring in the Gulf of Trieste. Joe Fernando gave the closing keynote lecture, which provided a clear overview of transport processes in particle-laden flow and prospects for multi-resolution, multi-physics modelling and monitoring.

The colloquium was organized under the auspices of EUROMECH and was supported financially by a number of institutions. Those operating on a European scale included ERCOFTAC (European Research Council on Flow, Turbulence and Combustion) and COST Action P20 `LES-AID' (COoperation in the field of Science and Technology). Dutch institutions included the Netherlands foundation for fundamental research of matter (FOM), the Netherlands Royal Academy of Arts and Sciences (KNAW), the J.M. Burgers Centre for fluid mechanics (JMBC), the Netherlands science foundation (NWO), the foundation for technical sciences (STW), Delft University of Technology (TUD) (Water Research Centre Delft), Eindhoven University of Technology (TU/e), the University of Twente (UT) and the Twente institute for Mechanics, Processes and Control (IMPACT). This support was crucial to the organization of this colloquium and is gratefully acknowledged.

We hope that the contributions to this colloquium will stimulate further interesting discussions and lead to new insights and fruitful collaborations.

EUROMECH Colloquium 478

"Non-equilibrium Dynamical Phenomena in Inhomogeneous Solids"

13-16 June 2006, Tallin, Estonia

Chairperson: Professor Jüri Engelbrecht, Tallinn
Co-Chairperson: Professor Gerard A. Maugin, Paris

Solution of dynamic problems in the general area of deformation, damage initiation and growth, and failure of materials and structures, requires the effective prediction of material properties and performance. Few materials are used solely in their ideal equilibrium state. Non-equilibrium phases can be associated with inherent abilities to undergo structural changes, which are manifested in rearrangement of particles, crack propagation, phase transformation, and inhomogeneities of various kinds.

The colloquium provided a forum for presentation and critical discussion of the state of the art, covering various mathematical formulations, constitutive modelling and numerical simulations in the prediction of the response of inhomogenous materials to various types of dynamic loading. The goal of the colloquium was to promote advances in the formulation and solution of real-life problems with an emphasis on dynamical aspects, with development of a multidisciplinary vision to account for all the complex dynamics involved in the physical description. There were 40 participants from 16 countries and a total of 32 presentations.

Recurring issues addressed in the talks and discussed were:

- Material forces:

  Continuum mechanics can provide tools to analyse and describe various phenomena in inhomogeneous materials. Different aspects of the role of configurational forces in dynamics and electrodynamics of solids were discussed. Material description using continuum mechanics featured in many presentations during the Colloquium.

- Thermodynamics:

  Thermodynamic considerations and constraints give another general approach to analyse the thermomechanical behaviour of materials. It was emphasized that thermodynamic description of non-equilibrium states and irreversible processes is highly important to the understanding of phenomena, development of new models, and in the construction of algorithms for numerical simulations.

- Martensitic transformations

  Materials subject to phase transformations under applied thermal or mechanical loading provide many examples of complex material behaviour. Experimental results, theoretical models, and numerical simulations of martensitic transformations in solids and the corresponding microstructure formation were discussed intensively. A sound theoretical framework, based on understanding of complex phenomena, is needed to allow development of new models and experimental techniques. Applications of shape memory alloys to retrofitting of structures and buildings were also considered.

- Phenomenology and various applications

  The use of thermomechanical methods to solve problems in areas such as crack and damage propagation, hole growth, nanoparticle transformation, and growth of biological materials show the power of the phenomenological description and its range of applicability.

- Wave propagation in inhomogeneous solids

  Different aspects of linear and non-linear wave propagation in microstructured solids were presented and discussed. Both theoretical considerations and numerical simulations demonstrated the richness of dynamic phenomena in materials behaviour.

The participants proposed to establish a Network of Excellence to maintain and develop further the level of mutual understanding reached at the Colloquium.

We would like to thank the Centre for Nonlinear Studies and EUROMECH for making the colloquium possible, in particular through their financial and organizational support.

EUROMECH Colloquium 486

"Deformation Processes in Paper and Wood Materials"

12 – 15 June, 2006, Place: Sundsvall, Sweden

Chairperson: Prof. Per A Gradin, Mid Sweden University
Co – chairperson: Prof. Tetsu Uesaka

Historically, research and development inside the paper industry has been carried out mainly by chemists and it is only recently that mechanists and physicists have also participated in this area. Mechanics is now a growing field in wood and paper research and it was therefore felt that a colloquium concerning wood and paper mechanics would be appropriate under the auspices of EUROMECH.

There were 32 participants in the colloquium, primarily from Sweden. The relatively small number of participants from other countries was probably due to the plan for Progress in Paper Physics Seminar in the USA during early October 2006. Many potential participants from outside Sweden had chosen to attend this more established event in the paper physics area.

There were 19 presentations at the colloquium, all of high quality. The majority of were about modelling and simulation. One of the presentations focused on numerical simulation of instabilities in paper webs induced by a non–uniform moisture distribution. This is a large problem in heat set offset printing and the presentation gave an explanation of the so called fluting phenomenon. Another presentation was related to the flow in a fibre suspension, covering models that make it possible to predict fibre orientations after the fibre suspension has been deposited on the wire in a paper machine. Constitutive models were the area of interest in one presentation, focusing on modelling of plasticity and delamination in paperboard. Continuum damage mechanics applied to paper was addressed in another presentation. Application of damage mechanics to paper is a new approach and there was considerable discussion regarding this.

A number of controversial questions in the area of paper mechanics/physics led to arrangement of five special sessions. In these sessions one senior researcher was "pro" and one was "con" regarding a specific question. Each was given half an hour to present their arguments, followed by a discussion in which everyone participated. The controversial questions concerned:

- Test methods (two cases);
- Accelerated creep;
- Fibre to fibre bond strength;
- Fracture toughness.

These special sessions were greatly appreciated and the discussions proved to be very lively. An exceptionally high level of participation was noted. One of the participants from the USA said that he had never been at a conference or seminar where the atmosphere was so open and friendly and the discussions so fruitful.

There was a good mix of younger and more senior researchers. In the spirit of the EUROMECH colloquia, the discussions were not limited to the colloquium itself, but continued outside the formal sessions. According to the original plans, no proceedings were going to be published. After the colloquium, it was, however, decided to put together all the presentations and to distribute them to the attendants. Copies can be obtained from the chairman.

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.

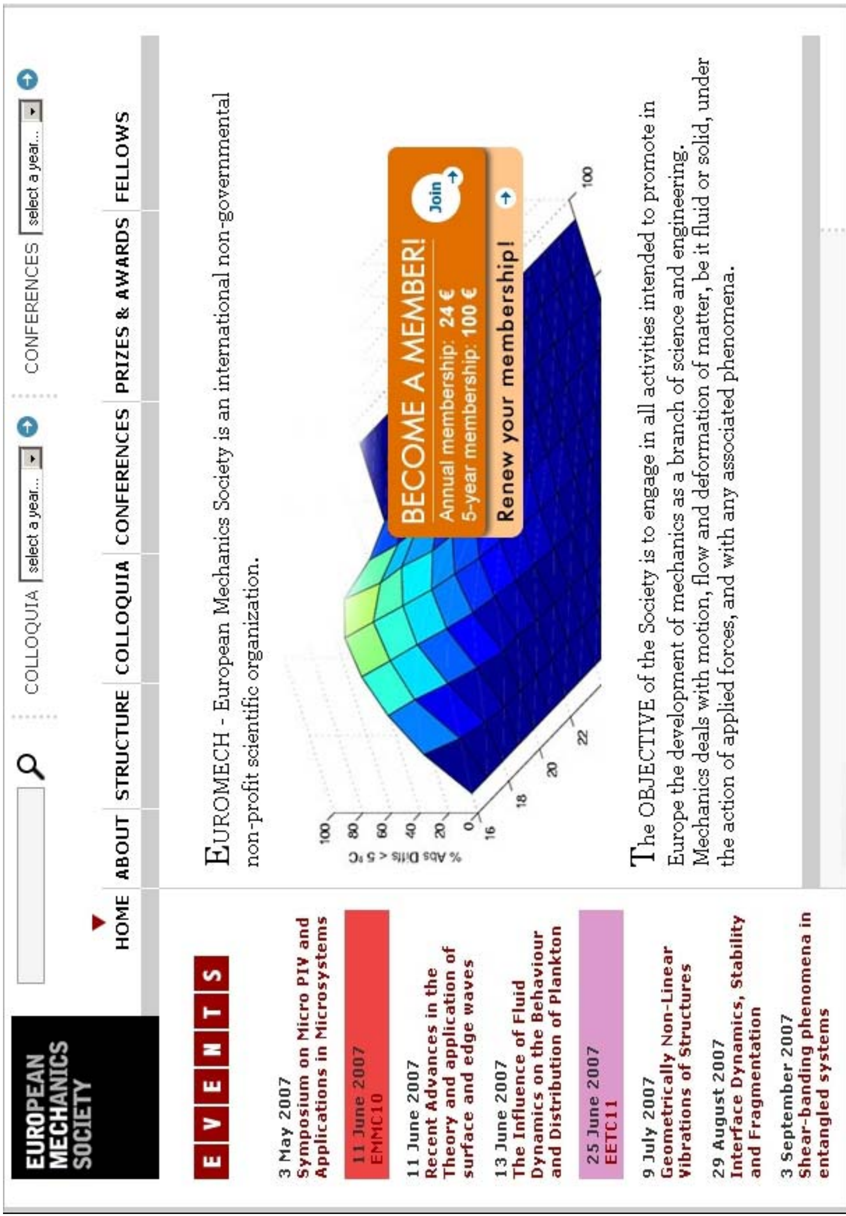
Activities within the field of mechanics range from fundamental research on the behaviour of fluids and solids to applied research in engineering. The approaches used comprise theoretical, analytical, computational and experimental methods. The Society shall be guided by the tradition of free international 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.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