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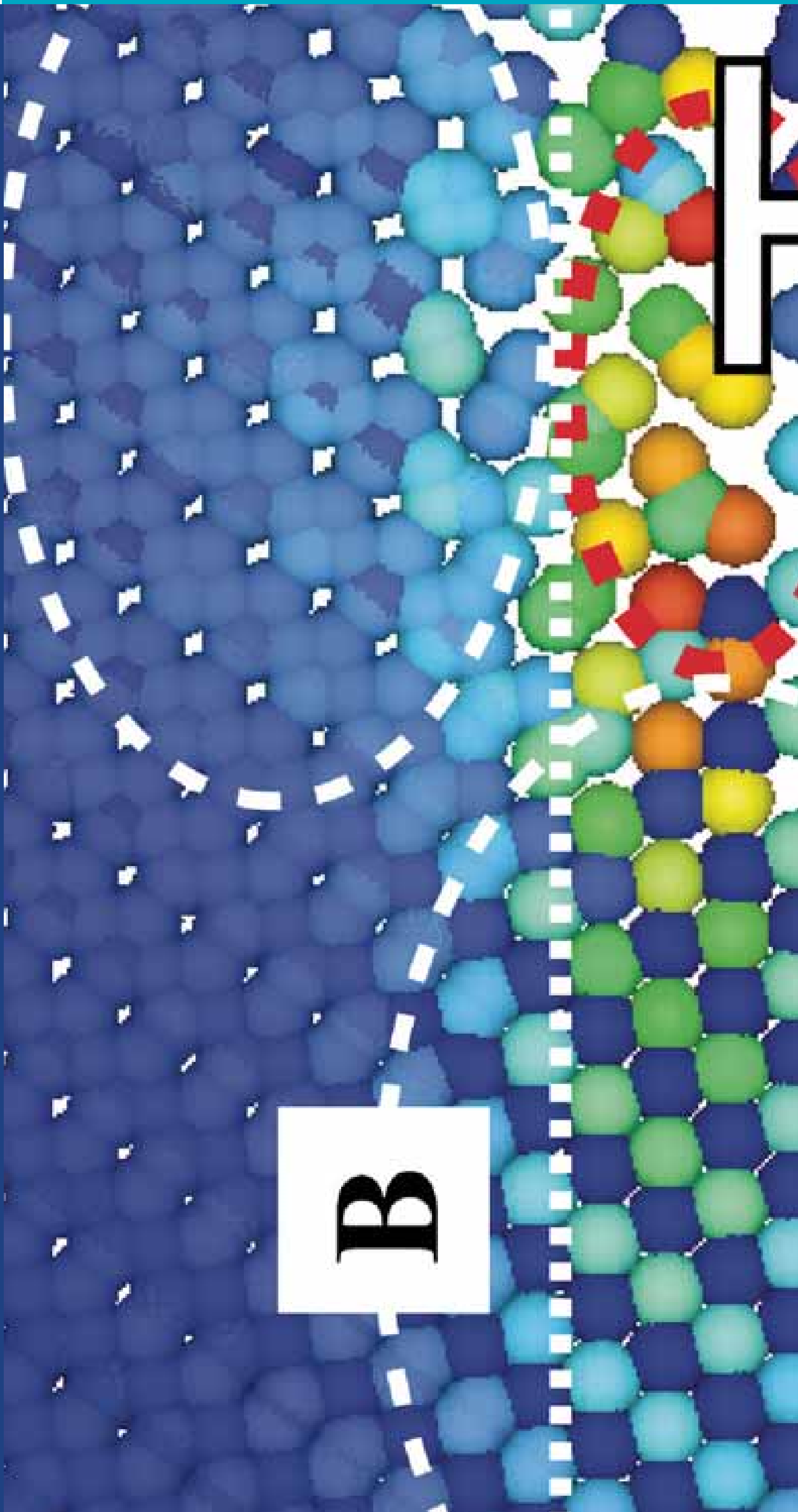

Bulletin for
The International Association
for Computational Mechanics

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contents

editorial

This issue inaugurates a new period in the IACM. The Executive Council (EC) met in Sydney on the occasion of the 9th World Congress on Computational Mechanics (WCCM) and elected new officers for the next four year period. The new IACM President is Prof. Genki Yagawa from Toyo University in Japan. The three Vice-Presidents are Prof. Wing-Kam Liu (Northwestern University, USA), Prof. Peter Wriggers (Leibniz University Hannover, Germany) and Prof. Mingwu Yuan (Beijing University, China). Each one of them represents one of the three world regions where IACM operates, namely, the Americas, Europe-Africa and the Asia-Pacific region. The new Secretary General is Prof. Antonio Huerta (Technical University of Catalunya, Spain). In the following pages of this bulletin you can find a message from the President of the IACM and of each of the newly elected officers. I take this opportunity to express my best wishes for the initiatives and activities of the new IACM officers.

The WCCM 9th in Sydney was a successful event. It was held in conjunction with the 4th Congress of the Asian-Pacific Association for Computational Mechanics (APCOM). The joint event gathered some 1400 participants from all over the world and covered a wide range of topics in the field of computational methods for engineering and applied sciences. Once again we express our acknowledgement and thanks to the organizers of WCCM 9th for an excellent job.

The ball has started to roll towards the WCCM-10 to be held in the city of Sao Paulo (Brazil) on 8-13 July 2012. The congress will be organized by the Brasilian Association for Computational Mechanics (ABMEC) under the chairmanship of Prof. Paulo Pimenta. WCCM-10 promises to be another successful IACM world event gathering in Sao Paulo many scientists from North, Central and South America, as well as from other parts of the world. I strongly suggest marking WCCM 10 in our agendas.

2011 will be a year full of events directly organized or sponsored by the IACM. The Thematic Conferences on Computational Methods, an original initiative of the European Community on Computational Methods in Applied Sciences (ECCOMAS), are now being replicated in other parts of the world. An example is the Thematic Conference on Isogeometric Analysis held at Univ. of Texas in Austin on January 2011. Some other 23 thematic conferences on different topics related to Computational Mechanics will take place in Europe in 2011, as a clear evidence of the vitality of the field. Other IACM events in 2011 will be the conference on Finite Elements in Fluids in Munich (23 - 25 March 2011) and a number of IACM Special Interest Conferences in addition to many national meetings organized by the IACM affiliated organizations worldwide (ie. USACM, SEMNI, PACM, APMTAC, etc.). Please check the IACM web page for the details of each conference.

The many events worldwide on the field of Computational Mechanics will be an opportunity for the members of the IACM community to meet in 2011.

Let us hope that we can meet many times around a good scientific discussion!

Eugenio Oñate
Editor of IACM Expressions

Future Challenges of IACM

Personal Expressions

from our IACM Executive Council Members

It is our great pleasure to celebrate the 30th Anniversary of the International Association for Computational Mechanics (IACM) in 2011. This is not a goal but should be a start line of new challenges. IACM was launched in 1981 and has very much evolved and grown over the years since its start thanks to initiative of distinguished individuals, the continuing efforts of its officers and members as well as the dramatic evolution of computer technology.

"…. Computational Mechanics plays a key role in the modern society, …. expanding the realm of technology, and building a vast system of knowledge for the benefit of people."

The objectives of IACM, are, as listed in the Constitution, to stimulate and promote education, research and practice in Computational Mechanics comprising Mechanical, Civil, Aeronautic, Space, Naval, Biomedical, Chemical, and Electrical Engineering and Material Sciences among other scientific and technical fields, to foster the interchange of ideas among the various fields contributing to this science, and to provide forums and meetings for the dissemination of knowledge.

Figure 1:
Genki Yagawa
IACM President

Computational Mechanics in the large deals with computer methodologies for the "analysis": mechanics of materials, thermodynamics, fluid dynamics, mechanical dynamics among others, the "synthesis" and the "production-related engineering design and integration", in which not only classical mechanics, but also statistical and quantum mechanics are deeply involved. The analysis, extended to the quantum, atomic and molecular scale to be treated, is expected to develop a methodology to predict and understand the fundamental processes of the molecular behaviors of microscopic scale. The multiscale analysis combines the micro phenomena with the macro phenomena and the design techniques. Furthermore, Computational Mechanics incorporates such fields as electromagnetics and chemistry so that we are able to observe virtually more complex behaviors in nature and design it. These have been accelerated by the development of massively parallel computing.

Thus, Computational Mechanics plays a key role in the modern society, with information science, physics, chemistry, biology, mechanical intelligence, robotics, MEMS, digital engineering and production integration, new energy, biotechnology, medical science, etc., expanding the realm of technology, and building a vast system of knowledge for the benefit of people.

One of the most important themes of Computational Mechanics in the 21st century, as well as those of other engineering fields, is to pursue the "Science and Technology for Society". In particular, our goal is to realize the wealthy, safe and secure society worldwide.

by:
Genki Yagawa
IACM President

This year, at the executive council meeting of IACM in Sydney the new President and the Vice-Presidents representing the different regions (Asia and Pacific, America and Europa and

Africa) were elected. As new Vice-president of the Europe and Africa region I like to share some ideas and thoughts regarding the future of Computational Mechanics and the role of IACM in Europe.

Computational Mechanics is visible in many fields in engineering and science - including solids and fluids interactions but also areas of biomedical, geological and acoustic applications. Research in the field has lead to sophisticated software products that enable engineers and designers to create modern buildings, machine tools and many products. Still there are research areas that will create new methodologies and approaches in engineering and science. Among these are coupled problems and multi-physics applications, that also include approaches for continuum/ molecular and atomistic coupling or continuum and discontinuum coupling. Due to the complexity of the associated simulation models adaptivity will see a revival, especially in the area of model adaptivity. All these complex formulations and approaches need new types of high performance computing that are directly related to the latest hardware development and the complex coupling of different models anddiscretization techniques. Computational Mechanics has gained through its far reaching application spectrum an enormous interest and still has potential to grow in the near future.

The last conferences of IACM and ECCOMAS have confirmed this trend. There is large group of scientists and researchers working in the field of Computational Mechanics in America, Asia and Europe. Especially the last European conference, the ECCM 2010 in Paris, with over 2000 participants underlined the increasing demand for scientific exchange and networking in the area of Computational Mechanics. Scientists came from over 40 countries such that this event also emphasized the good collaboration of IACM and ECCOMAS.

One of the new key ideas was to arrange this conference by colleagues from two European countries, in this case: France and Germany. To intensify collaboration in Europe even more, it would be great if this pilot scheme could be followed up by other conference organizers and could

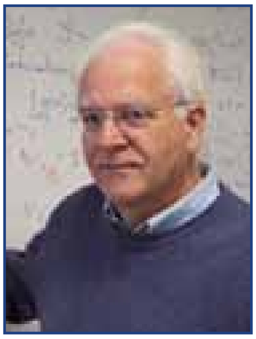
" .... intensify the collaboration and ... organize a joint African-European conference on Computational Mechanics ... "

help to foster interdisciplinarity and collaboration.

While many colleagues from America, Europe and Asia have since a long time very good links and networks, much can be done for the African side. Here my plan is to intensify the collaboration and eventually organize a joint African-European conference on Computational Mechanics with strong links to IACM. Another possibility is a promotion of the African conferences on Computational Mechanics within Europe and to encourage the exchange of PhD students among these parts of the world and thus link the European and IACM efforts to strengthen the international visibility of Computational Mechanics.

by:
Peter Wriggers
IACM Vicepresident Europe

Figure 2:
Peter Wriggers
IACM Vicepresident



I was born in 1939. I graduated from Dept. of Mathematics and Mechanics of Peking University in 1960 and post-graduated from the same dept. in 1964. I visited and worked with Edward L. Wilson at UC Berkeley from 1980 to 1982. My research interest are on a variety of finite elements, different algorithms for static and eigenvalue problems, dynamic substructuring and mesh generation, moving grid algorithms.

" ... the development of computational method in multi-discipline, multi-physics and multi-scale numerical simulation, especially, for super large-size engineering problems ... "

I have organized and developed a large commercial general purpose structural analysis software package for more than

25 years and more than 1000 users nationwide. As the Chairman I successfully organized the Sixth World Congress on Computational Mechanics in Beijing, September 2004.

As the Vice-President of IACM, I think first of all it is not only an honor but a responsibility. IACM is an international platform for academic exchange of the latest research achievements and enhancement of the collaboration in computational mechanics. For promoting the international exchange and collaboration, the main way is to organize conferences and symposia in various sizes and themes. I think now the development of computational method in multi-discipline, multi-physics and multi-scale numerical simulation, especially, for super large-size engineering problems by using high performance parallel computing is the most attractive field to be focused in. I will do my best to promote the exchange and collaboration in this field. Of course to organize thematic symposia is the main way.

Figure 3:
Mingwu Yuan
IACM Vicepresident

I will endevour to charge the affairs in the Asian and Australian region.
I think the academic research in these regions is relatively behind that of American and European.

So to extend the new national association like Viet Nam and Indonesia etc. to be the affiliation member of IACM family is very important task. Also to promote and enhance the exchange and collaboration between countries in these regions is also very important. I will do domy best during my duty period.

by:
Mingwu Yuan
IACM Vicepresident Asia-Pacific

Professor Wing Kam Liu is the Walter P. Murphy Professor of Mechanical Engineering at Northwestern University; Founding Director of the NSF Summer Institute on Nano-Mechanics, Nano-Materials and Nano/Micro-Manufacturing; Founding Chairman of the prestigious ASME NanoEngineering Council; and Co-Director of the Northwestern University Predictive Science and Engineering Design Program. He is the newly elected Vice-President of IACM (America) and a past President of USACM.

He was the General Chairman of the 2006 IACM 7th World Congress for Computational Mechanics (WCCM) held in Century City, California, the Co-Chairman of the 6th WCCM held in Beijing, China, 2004, and the General Chairman of McNU'97 in 1997. He is the Founder and Co-Chair of the 2010 First World Congress on NanoEngineering for Medicine and Biology. Professor Liu has written three books: Meshfree Particle Methods (with Shaofan Li, Springer, 2004); Nonlinear Finite Elements for Continua and Structures (co-authored with Ted Belytschko and Brian Moran, Wiley, 2000); and Nano Mechanics and Materials: Theory, Multiscale Methods and Applications (co-authored with Eduard Karpov and Harold Park, Wiley, 2006).

"…. the most important mission of IACM is to address society's needs through quality education, cutting-edge research, service and outreach."

Professor Liu has made fundamental, innovative contributions to the theory and methodologies of simulation-based engineering. In 2001 the Institute for Scientific Information (ISI) identified Professor Liu as "one of the most highly cited, influential researchers in Engineering, and an original member of the highly cited researchers database."

Among his most noteworthy contributions are:

(1) Development of multiscale methods that bridge the scales from quantum mechanics to the macroscale. Using these methods, he has developed software for the design and use of nano-particles in materials design, bio-nanotechnology, and drug delivery.
(2) Development of new shell elements, arbitrary Eulerian-Lagrangian methods and explicit-implicit integration techniques that have significantly enhanced the accuracy and speed in software for crashworthiness and prototype simulations.
(3) Development of new meshfree formulations, known as reproducing

kernel particle methods, providing exceptional accuracy for the simulation of solids undergoing extremely large deformation.

As the Vice President of IACM of America, he envisions that the most important mission of IACM is to address society's needs through quality education, cutting-edge research, service and outreach. Service involves the training of the next generation of students (both undergraduates and graduates), future and practicing engineers, scientists and educators. Cutting-edge research supports a knowledge-based economy. This is crucial as we are dealing with a global and diverse market. To support knowledge-based economic development, we need to disseminate knowledge through exchange of new ideas and provide valuable networking opportunities for students (they are our future members!), engineers, scientists, and professors. In addition, it is necessary for IACM to identify and promote important areas of technology, and augment current research and development focusing on simulation based engineering and science.

Hence, in addition to the usual Congresses and Thematic Conferences, I encourage IACM leaders to organize special symposia and workshops to be presented at alternating international conferences among America, Asia and Pacific Rims, and Europe and Africa. The symposia will be organized to include participants from the different regions, and will focus on the major educational and research activities of current and future topics of interests.

The symposium will serve to
1) broadly disseminate IACM educational activities,
2) create a global community among our students and researchers, and
3) foster an international perspective and appreciation of educational systems across different cultures.

by:
Wing Kam Liu
IACM Vicepresident Americas

The executive council meeting of IACM in Sydney renewed all its elected officers. I was honored, by the council members election, to be your Secretary General for the period 2010-2014.

Figure 4:
Wing Kam Liu
IACM Vicepresident

Let me first introduce myself. I am a Professor of Applied Mathematics at the Universitat Politècnica de Catalunya (Barcelona, Spain) since 1993. I obtained my Ph. D. from Northwestern University in 1987 where I realized that my research interests are focused in computational methods in applied sciences and engineering. More particularly, I have worked in error estimation and adaptivity, convection-dominated transport as well as incompressible flows and non-linear computational mechanics both, in finite elements and mesh-free methods. Research, as usual, has coexisted with other activities, in particular, university, community and governmental services.

As Secretary General of IACM I am responsible for the organization and coordination of the IACM Secretariat and the administration of IACM finances.

"…. transmit to young and promising researchers in any field of Simulation-Based Engineering Science that IACM is their natural environment to participate, meet, communicate and promote."

Moreover, I must ensure a good liaison with all the affiliated societies (national and regional associations) and IACM, as well as affiliated members. These obvious tasks, I understand are crucial for the future of IACM. But, in my mind, it is also mandatory to transmit to young and promising researchers in any field of Simulation-Based Engineering Science that IACM is their natural environment to participate, meet, communicate and promote. I can assure you that as secretary general I will try to make my best to make them feel that IACM is their home.

by:
Antonio Huerta
IACM Secretary General

Figure 5:
Antonio Huerta
IACM Secretary General

Atomistic Simulations of Hydrogen Embrittlement

by
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Introduction

Related to environmental problems, attention is paid to hydrogen as a new energy source. Fuel cells will be utilized not only in residential use but also in automobiles. When they are utilized in automobiles, we have to arrange hydrogen infrastructure such as hydrogen stations. We need to transport and reserve high-pressure hydrogen to maintain hydrogen infrastructure. Reservoirs and piping in hydrogen systems should be designed to endure the internal pressure of 70MPa. Under such high-pressure hydrogen environment, hydrogen embrittlement, reduction of ductility due to hydrogen shown in *Figure 1*, is one of the critical issues for structural integrity of hydrogen systems.

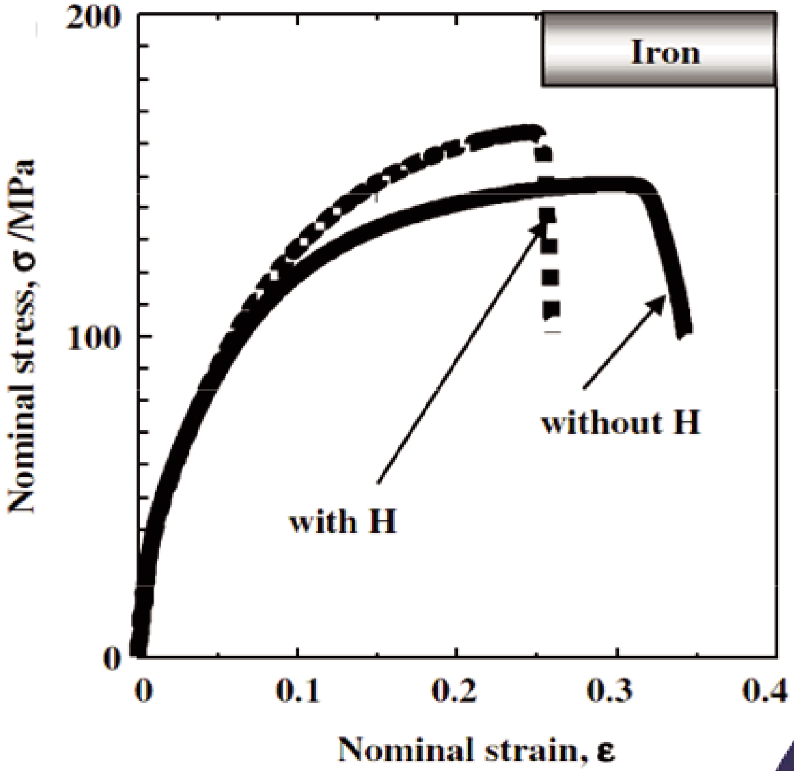

Figure 1:
Tensile curves of iron with/without hydrogen charging

Despite the extensive investigation concerning hydrogen related fractures, the mechanism has not been enough clarified yet. Atomistic simulations such as the first principle calculations, the molecular dynamics method, the molecular statics method and so on are powerful tools to study the mechanism for the hydrogen embrittlement Several examples of atomistic simulations for hydrogen embrittlement of αFe or bcc iron are shown in this article.

Interatomic potential for αFe-H system

Adequate selection of interatomic potential is of crucial importance for molecular dynamics and statics calculations. Only three kinds of interatomic potential have been proposed so far for the αFe system. They are the embedded-atom-method (EAM) potential by Ruda et al.,

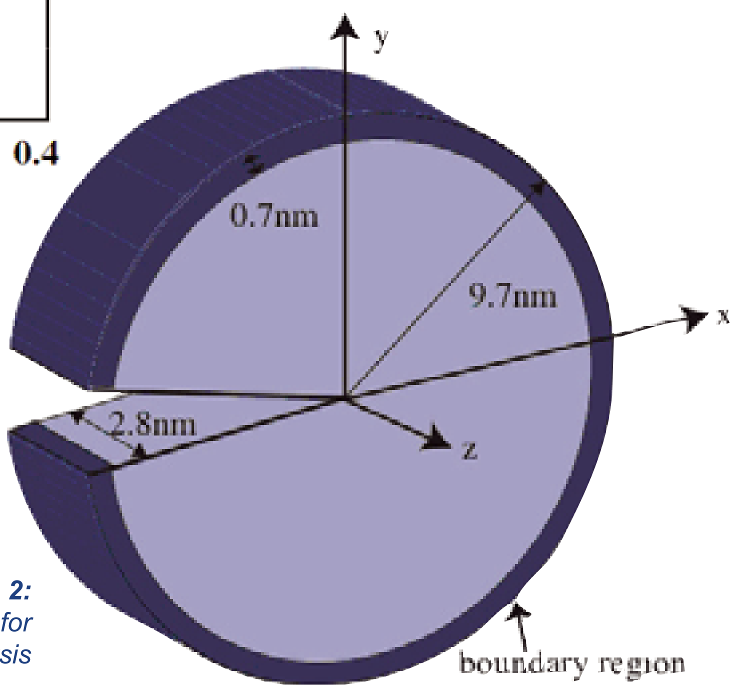

Figure 2:
Analysis model for crack propagation analysis

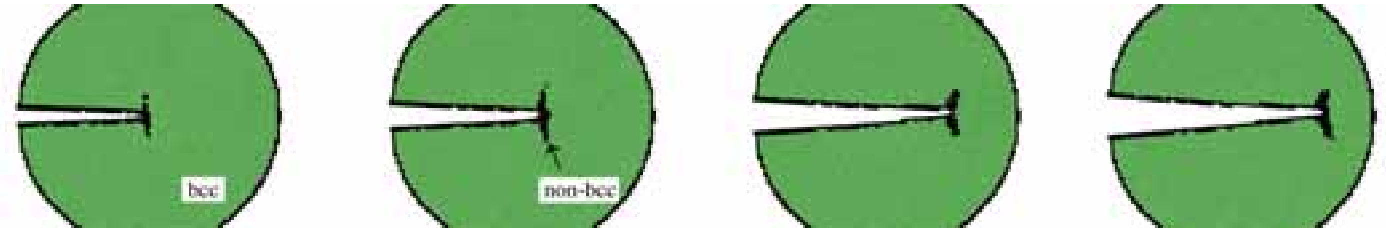

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Figure 3:
Snapshots of crack propagation behavior for Case 1

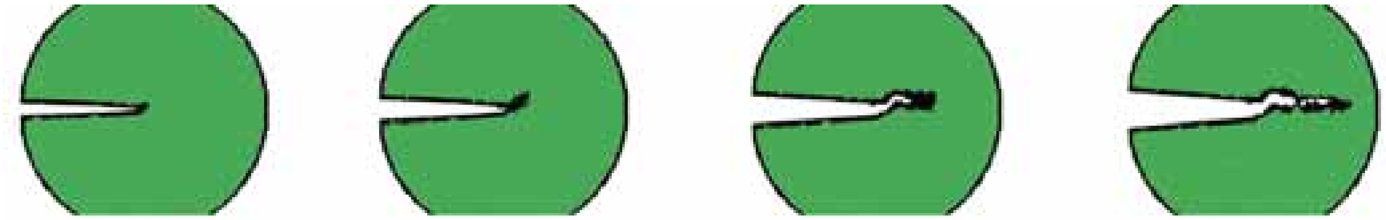

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Figure 4:
Snapshots of crack propagation behavior for Case 2

the Morse type potential by Hu et al. and the EAM potential by Wen et al. (abbreviated as EAM-W). According to evaluating material properties of αFe-H system, EAM-W is the best potential and employed it in the molecular dynamics and statics simulations.

Molecular dynamics analyses of crack propagation

Figure 2 shows the analysis model with a crack. This analysis model is a quasi three-dimensional model, on which a periodic boundary condition in the *z*-direction is imposed. Crack propagation analyses were performed by imposing the displacement rate corresponding to the rate of the stress intensity factor on the atoms in the boundary region of the analysis model.

The results of crack propagation analyses are shown for the following three cases. In Case 1, there is no slip plane in the circular region and the temperature is above the ductile-brittle transition temperature (DBTT). In Case 2, there are {112} slip planes in the circular region, and the temperature is below the DBTT. In Case 3, there are {112} slip planes in the circular region, and the temperature is above the DBTT.

A crack propagation behavior in Case 1 is shown for the case without hydrogen in *Figure 3*, where a green part indicates the bcc crystal structure and a black one other crystal structures. Similar crack propagation behavior is also obtained for the case with hydrogen atoms. In Case 1, a crack propagates straight without dislocation emission. Such a crack propagation behavior is completely brittle. A typical crack propagation behavior in Case 2 is shown in *Figure 4* for the case with hydrogen atoms. Similar crack propagation behavior is observed for the case without hydrogen atom. In Case 2, a crack propagates nearly straight, and such a crack propagation behavior is rather brittle. Crack propagation behaviors in Case 3 are shown in *Figures 5(a)* through 5(c) for the cases with hydrogen atoms; *Figures 5(a) and 5(b)*, and for the case without hydrogen atom; Figure 5(c). As shown in *Figures 5(a) and 5(b)*, not only dislocation emissions from the crack tip but also crack propagation along the {112} slip planes are observed in the cases with hydrogen atoms. On the other hand, as shown in *Figure 5(c)*, only crack-tip blunting caused by dislocation emissions is observed without crack propagation in the case where no hydrogen atom is included. It is concluded from the simulation results that hydrogen atoms trapped near the dislocation cores promote the cleavage of slip planes.

Molecular statics analyses of interaction between dislocation and hydrogen

It is observed in the crack propagation analyses that hydrogen atoms tend to move to dislocation cores on the {112} slip planes. Such a phenomenon was examined in detail using the molecular statics method. *Figure 6* shows the distribution of hydrogen trap energy at each hydrogen trap site denoted by a small circle. The hydrogen trap energy is strongest around the dislocation core. It is also relatively strong around the high

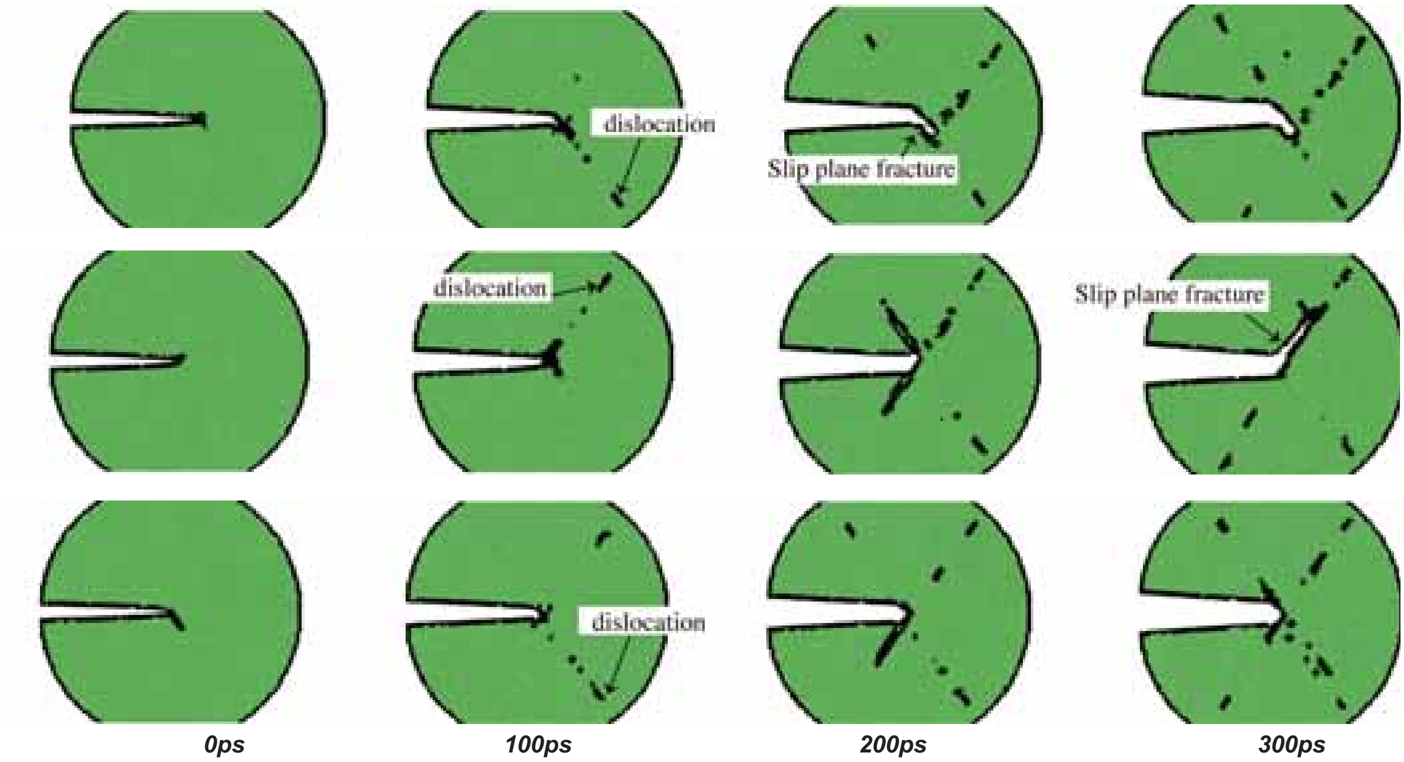
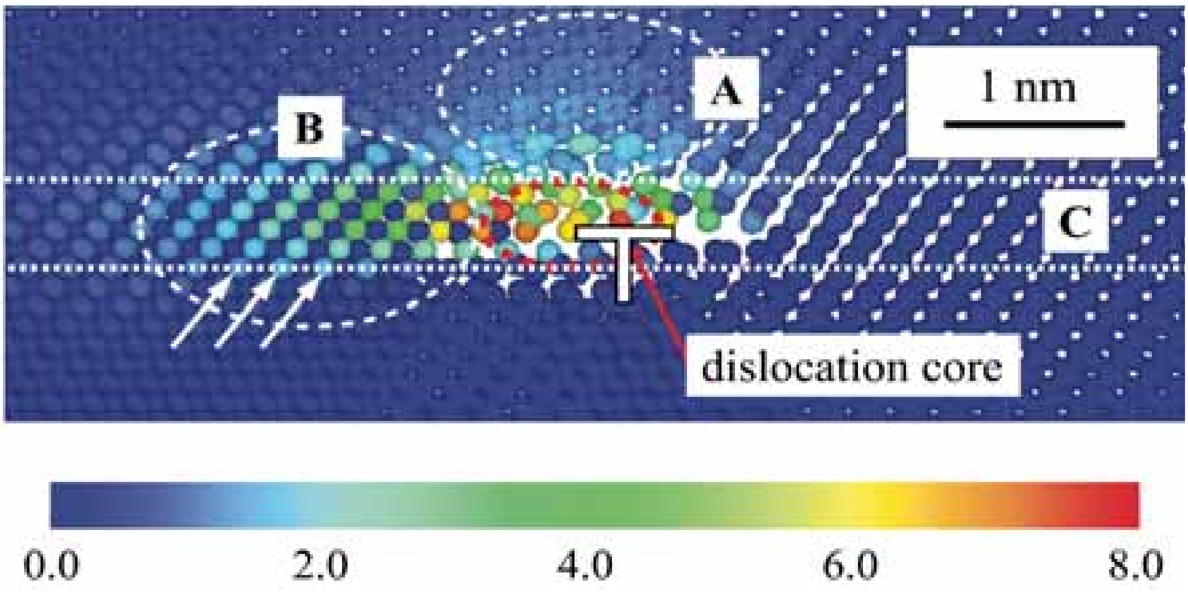


Figure 5:
Snapshots of crack propagation behaviors for Case 2 ; Hydrogen atoms are included in cases of (a) and (b), and no hydrogen atom is included in case of (c)

hydrostatic stress region (region A) and along the slip plane (region B). The result suggests that a lot of hydrogen atoms accumulate on the slip plane around the dislocation core.

In situ TEM observation revealed that the distance between dislocations decreases when hydrogen gas is introduced during TEM observation. This fact indicates the increase in dislocation mobility by hydrogen atoms. This phenomenon is known as an evidence of HELP (Hydrogen Enhanced Localized Plasticity). We examined the effect of hydrogen atoms on the dislocation mobility from the viewpoint of energy barrier for dislocation motion. According to *Figure 6*, the probability of hydrogen occupation is the highest at the dislocation core. Thus hydrogen atoms were placed at a dislocation core, and the energy barrier for dislocation motion was obtained using one of the molecular statics methods, NEB (Nudged Elastic Band) method for the following three cases; (a) without hydrogen atom, (b) with a hydrogen atom at the dislocation core in the initial state and the dislocation moving forward by 1*b* (*b*: Burger's vector), and (c) with a hydrogen atom 1*b* ahead of the initial dislocation and the dislocation moving to the hydrogen atom. *Figure 7* shows the results. It is found from this figure that hydrogen

Figure 6:
Distribution of hydrogen trap energy at each trap site of hydrogen



atoms trapped at the dislocation core cause the reduction of energy barrier for dislocation motion, which results in increase of dislocation mobility.

Mechanism for hydrogen embrittlement

The molecular statics analysis using EAM-W provides the result that hydrogen atoms existing on a slip plane promote the separation of the slip plane because of decrease in its surface energy caused by hydrogen atoms. Considering this fact and the results shown in the previous sections in this article, we can propose the following mechanism for hydrogen embrittlement of Fe:
(1)Dislocations are emitted from a crack tip and they exist along a slip plane;
(2)A lot of hydrogen atoms are trapped at dislocation cores and along a slip plane in the vicinity of the dislocation core;
(3)The hydrogen atoms at a dislocation core reduce the energy barrier for dislocation motion and increases dislocation mobility, and thus the distance between dislocations is reduced;
(4)Separation of a slip plane is caused due to the hydrogen atoms trapped by a dislocation, and such separation is connected among pile-up dislocations.

Our proposed mechanism for the hydrogen embrittlement agrees well with several experimental observations showing that the fracture of hydrogen charged test specimens occurs at {112} slip planes.

This research was performed as a part of the Fundamental Research Project on Advanced Hydrogen Science funded by the New Energy and Industrial Technology Development Organization (NEDO). This research project stared in FY(fiscal year) 2006 and will end in FY 2012.
A research group at Kyoto University consisting of Professor N. Miyazaki, Assistant Professors R. Matsumoto and S. Taketomi, and graduate students has been involved in this research project. We have already published several papers on atomistic simulations on hydrogen embrittlement in addition to macroscopic hydrogen diffusion behaviors in iron [2, 3]. If you are interested in our research activities on the atomistic simulations of hydrogen embrittlement, please refer to References [4-10].

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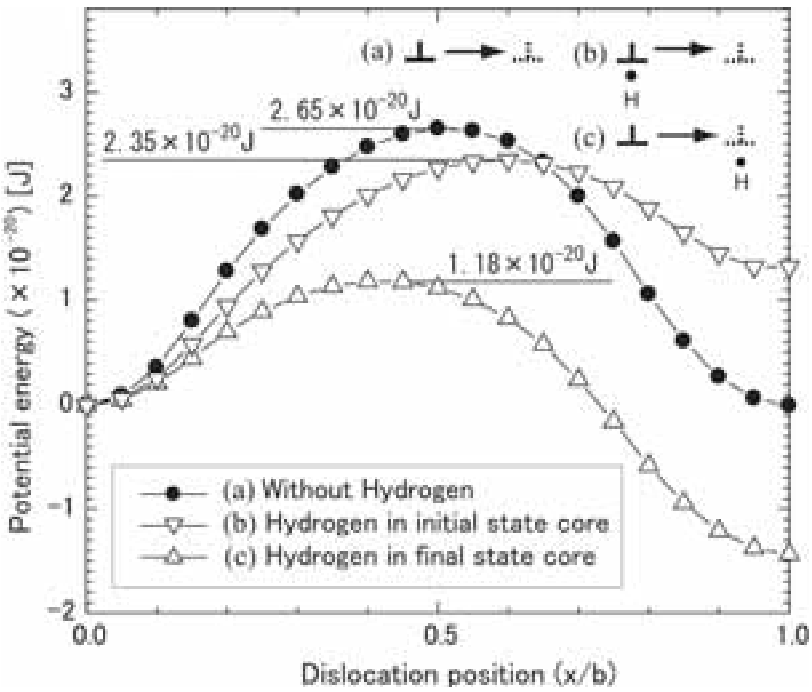
Figure 7:
Variations of the energy barrier for dislocation motion



Japanese Female Researchers in Computational Mechanics

by
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I was asked to write about the Japanese female researchers in the field of computational mechanics by Professor Genki Yagawa, the President of IACM. When I was a college student in the 1980s, there were almost no female students in the engineering department. As a matter of fact, I was the only female student in the Department of Nuclear Engineering during a ten-year period! However, I have recently noticed an increase in the number of female students in Japan and also observed an improved situation for female researchers in Japan.

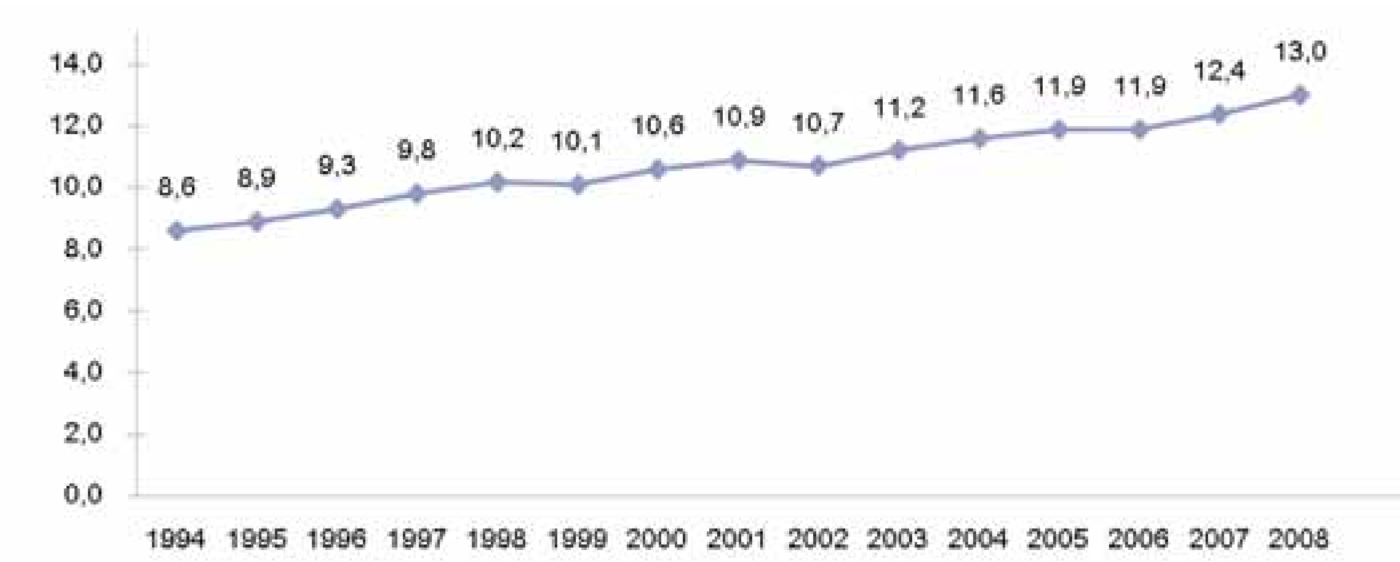
To understand the situation in more detail, I conducted an investigation. I learned that the ratio of female members of JSCES (The Japan Society for Computational Engineering and Science) was 2.2% in 2009. Although this was an increase from the ratio of 0.45% ten years ago in 1999, the ratio of women in the Japanese organization is still significantly low. Since the field of mechanics tends to have few female researchers and students, I looked more closely at the numbers of women. To my surprise, there has been a slow but steady increase from 8.6 % in 1994 to 13.0 % in 2008 in the number of female researchers in Japan as shown in *Figure 1* [1].

A comparison of the ratios of female researchers in nine countries shows, as illustrated in *Figure 2* [2], that the situation in Japan is not as good as it is in many other countries.

The statistics in *Figures 1* and *2* show the numbers of females in all research fields, including literature, social studies, science, and engineering. Although there is no detailed information by category, I suspect that the ratio in science and engineering must be very low. As an example, the ratio of female faculty members in the Faculty of Letters is 12.7% at the University of Tokyo, while that in the Faculty of Engineering is 3.5% .

Due to a declining birth rate in Japan, the Japanese Government has been

Figure 1:
Transition of the ratio of female researchers in Japan



promoting gender equality since 1986. In fact, the University of Tokyo founded the Committee for Gender Equality in 2006 to achieve diversity and work life balance on campus. Since then, the University of Tokyo has conducted many new activities, one of which was to establish a nursery school on each campus. There are currently seven nursery schools. As a matter of fact, my child is going to one of the nursery schools, which helped me return to work right after my leave of absence for my child's birth. Even though the movement for gender equality is just beginning, it has already shown some progress.

The goal of gender equality in not only limited to the University of Tokyo but also applies to all Japanese universities by the support of The Ministry of Education, Culture, Sports, Science and Technology (MEXT).

Although Japan has been facing a very difficult time since the Lehman shock, the goal of gender equality must not be forgotten, and achievement of the goal will require continuous efforts over time. It might be a slow process, but through these efforts, I hope to see many female scientists and engineers in Japan in the fore-seeable future.

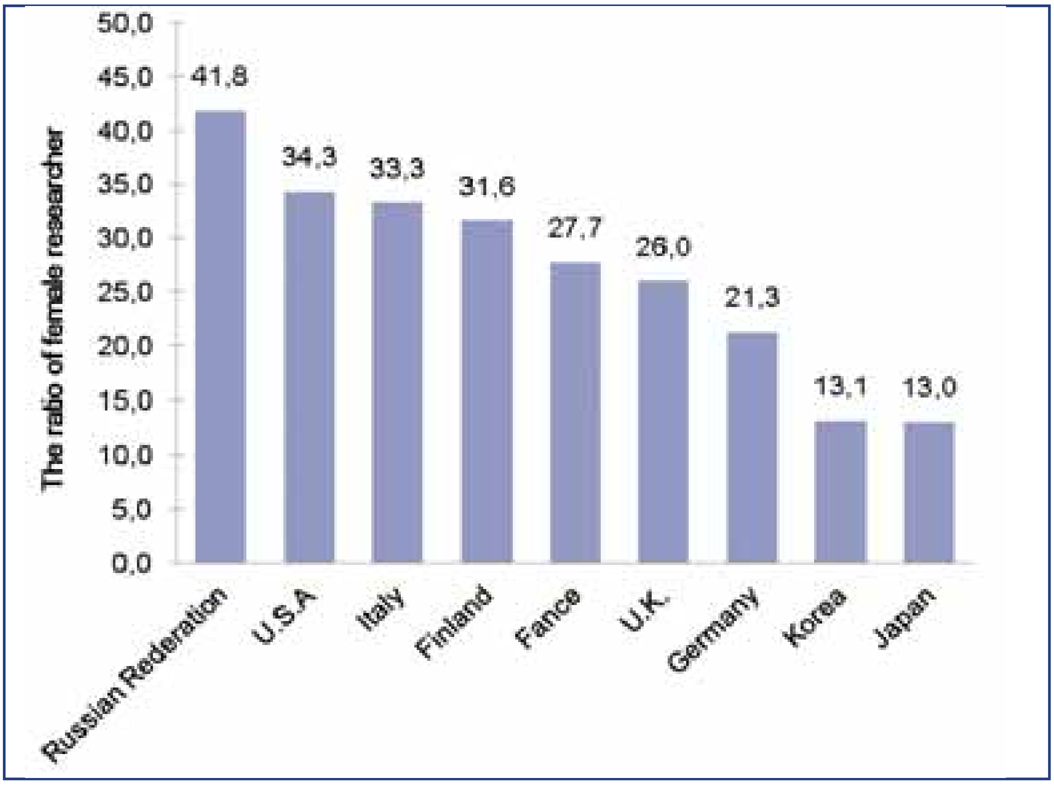


Figure 2:
An international comparison of the ratio of female researchers in 2009 [1]

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"Women have been trained to speak softly and carry a lipstick. Those days are over."

Bella Abzug

"If A equals success, then the formula is A equals X plus Y plus Z. X is work. Y is play. Z is keep your mouth shut."

Albert Einstein

"If you have knowledge, let others light their candles in it."

(Sarah) Margaret Fuller

"No need to explain it to me Dad, I wrote it!"

A New Paradigm for Discretizing Difficult Problems: Discontinuous Petrov Galerkin Method with Optimal Test Functions

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"... approximability and discrete stability imply convergence."

We present a new methodology for discretizing difficult boundary-value problems based on the paradigm of hybrid methods and the idea of computing optimal test functions on the fly.

1. Discrete Stability

Finite Elements fall into the category of Galerkin methods and focus on the solution of a class of variational problems of the form:

$$\begin{cases} u \in U \\ b(u,v) = l(v), \quad v \in V \end{cases} \tag{1.1}$$

Here U and V are two Hilbert spaces, $l(v)$ is an (anti)linear and continuous form on V, and $b(u; v)$ is (anti)linear in V. For linear problems, $b(u; v)$ is also linear in u. We assume that

- form b is continuous,

$$|b(u,v)| \le M \|u\|_U \|v\|_V \tag{1.2}$$

- form b satisfies the inf-sup condition,

$$\inf_u \sup_v \frac{|b(u,v)|}{\|u\|_U \|v\|_V} \ge \gamma > 0 \tag{1.3}$$

- form l satisfies the compatibility condition:

$$l(v) = 0, \quad \forall v \in V_0 \tag{1.4}$$

  where V_0 is the null space of the adjoint problem:

$$V_0 = \{ v \in V \, : \, b(u,v) = 0, \quad \forall u \in U \} \tag{1.5}$$

For simplicity of the discussion, we will assume that V_0 is trivial which implies satisfaction of 1.4 for any functional l. The conditions guarantee the well-posedness of the problem, i.e. the solution exists, it is unique, and it depends continuously upon the load represented by functional l,

$$\|u\|_U \le \frac{1}{\gamma} \|l\|_{V'} \tag{1.6}$$

where $\|\cdot\|_{V'}$ denotes the norm in the dual space V'. The result is known as a Nečas or Babuška Theorem and, in fact, it is a rather simple reformulation of Banach Closed Range Theorem, see e.g. [43], p.518. Note that, from the very beginning, we consider the case when the spaces U and V may be different.

A (conforming) Petrov–Galerkin discretization of the problem is defined by introducing finite-dimensional subspaces $U_h \subset U, V_h \subset V,$ of equal dimension, and replacing the infinite-spaces in (1.1) with their finite-dimensional counterparts,

$$\begin{cases} u_h \in U_h \subset U \\ b(u_h, v_h) = l(v_h), \quad v_h \in V_h \subset V \end{cases} \tag{1.7}$$

If the discrete problem also satisfies the *discrete inf-sup condition:*

$$\inf_{u \in U_h} \sup_{v \in V_h} \frac{|b(u,v)|}{\|u\|_U \|v\|_V} \ge \gamma_h > 0 \tag{1.8}$$

the discrete problem is not only well-posed and stable, but also the famous Babuška's Theorem [3] implies that

$$\|u - u_h\|_U \le \frac{M}{\gamma_h} \inf_{w \in U_h} \|u - w\|_U \tag{1.9}$$

i.e. the discretization error is bounded by the *best approximation error* premultiplied with stability constant M/γ_h. If the best approximation error goes down with $h \to 0$ and the discrete inf-sup constant stays away from zero:

inf $_h \gamma_h > 0$, the approximation error will converge to zero with the same rate as the best approximation error. The result is known under the famous phrase: *approximability and discrete stability imply convergence*.

It is not an exaggeration to say that the main activity of the numerical analysis community for the last 40+ years has been to construct various numerical schemes that are discretely stable in the sense of the inf-sup condition. The main issue with such construction is that, except for a rather small class of coercive (elliptic) problems (Cea's Lemma [21]), the continuous inf-sup condition *does not* imply its discrete counterpart. In other words, from the fact that the continuous problem is well-posed *it does not follow* that the discrete one is, and that the discretization is convergent. The challenge of securing discrete stability led to many important theories and concepts including: Mikhlin's theory of asymptotic stability for compact perturbations of coercive problems [47, 24], Brezzi's theory for problems with constraints [13], concept of stabilized methods starting with SUPG method of Tom Hughes [36, 17, 38], the "bubble methods" [1, 44, 14, 16, 33, 34, 15], stabilization through least-squares [37], stabilization through a proper choice of numerical flux1 including a huge family of DG methods starting with the method of Cockburn and Shu[23], and a more recent use of exact sequences [2].

Robustness

The discrete stability issue is especially delicate when we discretize a family of problems parametrized with a parameter, e.g. convection-dominated diffusion (diffusion constant), deformation of thin-walled structures (thickness), wave propagation problems (wave number), nearly incompressible materials (Poisson ratio), etc. If the mathematics of the limiting problem changes (e.g. the case of pure convection is essentially different from convection-diffusion problems), *we speak of singular perturbation problems*. A stable discretization method for such problems is called *robust*[2] if the stability constant M/γ_h is not only mesh independent but also does not depend upon the perturbation parameter. The difference between just discrete stability and robustness is a delicate one.

[1]Concept attributed to Peter Lax.

[2]Term introduced by Olek Zienkiewicz in late eighties.

For instance, for convection dominated diffusion, the classical approach based on continuous elements and Bubnov-Galerkin method is stable (in H^1-norm) but not robust [46] - the stability constant blows up with the decreasing diffusion. As a result of it, the solution develops "wiggles" and is frequently called to be "unstable".

2. Petrov-Galerkin Method with Optimal Test Functions

The following idea was put forth in [27]. Define a new "energy (residual) norm:"

$$\|u\|_E := \sup_{v\neq 0} \frac{|b(u,v)|}{\|v\|} = \|Bu\|_{V'}, \text{where } B : U \to V', \quad b(u,v) = \langle Bu, v \rangle \qquad (2.10)$$

The continuity and inf-sup conditions imply that the new norm is equivalent with the original norm on U. Also, with the new norm in use, the corresponding new continuity and inf-sup constants are equal to one. Recalling that the Riesz operator $R_V : V \to V'$ is an isometry, we obtain an equivalent representation for the energy norm:

$$\|u\|_E = \|R_V^{-1} Bu\|_V = \|v_u\|_V \qquad (2.11)$$

where $v_u \in V$ is the solution of an auxiliary variational problem (inversion of the Riesz operator),

$$\begin{cases} v_u \in V \\ (v_u, \delta v)_V = b(u, \delta v), \quad \delta v \in V \end{cases} \qquad (2.12)$$

Select now your favorite trial basis functions $e_i \in U_h$. For each trial basis function e_i , we determine the *corresponding optimal test function* $\hat{e}_i$ by solving problem (2.12). In other words, the main idea is to use test functions that *realize the inf-sup condition*. The test space V_h is defined then as the span of the optimal test functions [3].

We list now the main consequences of the optimal testing.

- Since the optimal test functions realize the supremum in the inf-sup condition, the discrete inf-sup constant matches the exact one, $\gamma_h = \gamma$.

[3]In other words, $V_h := R_V^{-1} BU_h$.

"The difference between just discrete stability and robustness is a delicate one."

"*Is it possible to choose the test norm in such a way that the corresponding energy norm would coincide with a norm we want?*"

Thus, for the energy norm, $M = \gamma_h = 1$ and the method delivers the *best approximation error* in the energ norm. This is known for the Bubnov–Galerkin method and the small class of coer cive and self-adjoint problems. In fact, for this class of problems and the (standard energy) test norm: $\|v\|^2 := b(v,v)$ the corresponding energy norm coincides with the test norm and the optimal test space coincides with the trial space. The discussed concept of optimal testing generalizes this classical result to any well-posed variational linear problem.

- It follows directly from the definition of optimal test functions that the stiffness matrix is hermitian (symmetric in the real case) and positive-definite. In fact, the method can be reinterpreted as the least-squares method applied to the preconditioned problem:

$$R_V^{-1}Bu = R_V^{-1}l \tag{2.13}$$

In this sense, the method is related (but not equivalent) to classical least-squares, see e.g. [18, 11, 8]. The symmetry and positive-definitness enables use of iterative solvers.

- There is no need for a-posteriori error estimation. The energy norm of the error can be computed *without knowing the exact solution.* Computing the energy norm of the error reduces again to the inversion of the Riesz operator,

$$\|u-u_h\|_E = \|v_{e_h}\|_V \text{ where } \begin{cases} v_{e_h} \in V \\ (v_{e_h},\delta v)_V = l(\delta v) - b(u_h,\delta v), \quad \delta v \in V \end{cases} \tag{2.14}$$

As the method delivers the best approximation error in the computable energy norm, the energy error should go down with the very first refinement (no preasymptotic stability behavior). This is very important for adaptivity.

Optimal Test Norm

The method delivers the best approximation in the energy norm. The energy norm is dictated by the problem (operator B) and the choice of the test norm (Riesz operator R_V). For different test norms, we obtain different versions of the method. It is legitimate to ask the question: *is it possible to choose the test norm in such a way that the corresponding energy norm would coincide with a norm we want?* Of course, we have to obey mathematics and choose a norm for which the problem is well-posed, i.e. either the original norm in U or a norm equivalent with it. The answer is "yes" and the answer comes again from the Banach Closed Range Theorem. With the test norm selected as,

$$\|v\| = \sup_{u\neq 0} \frac{|b(u,v)|}{\|u\|_U} = \|B'v\|_{U'} = \|R_U^{-1}B'v\|_U \tag{2.15}$$

the corresponding energy norm coincides with the original norm $\|\cdot\|_U$. Above, B' denotes the transpose of B, and R_U is the Riesz operator for space U. The optimal test functions solve then the adjoint equation:

$$R_U^{-1}B'\hat{e}_i = e_i \tag{2.16}$$

a concept that was pursued for a long time e.g. in [41, 36, 30, 31, 35, 7]. With the optimal test norm (2.15), the method delivers the best approximation error in the original trial norm $\|\cdot\|_U$.

3. The Discontinuous–Petrov Galerkin (DPG) Method

The general abstract results discussed in the previous section would be worth only a small exercise in a numerical or functional analysis textbook without the idea of the DPG method. The name "DPG" can be found in the earlier works of Bottasso, Micheletti, Sacco and Causin [9, 10, 19, 20]. One starts with a system of first-order differential equations. The equations are multiplied with test functions, integrated over the domain, and then integrated by parts. Contrary to classical variational formulations where only some of the equations are relaxed and the remaining ones are enforced in a strong form, in the DPG method all equations are considered in a weak sense. Formulations like this are sometimes termed as *ultra-weak variational formulations*, see e.g. [39]. The novelty of the approach proposed in [27] was to combine the ultra-weak DPG formulation with the idea of the optimal test functions discussed above.

We will use now the linear acoustics equations to illustrate the approach. Let Ω be a domain partitioned into elements K with a predefined, fixed normal n_e for each edge e in the mesh, for instance implied by global orientations of edges.

We start with the system of first order acoustics equations in the frequency domain,

$$\begin{cases} ikp + \mathrm{div}\,\boldsymbol{u} = 0 \\ ik\boldsymbol{u} + \boldsymbol{\nabla} p = \boldsymbol{0} \end{cases} \qquad (3.17)$$

where, for simplicity, we assume a unit sound speed, i.e. the wave number k coincides with the angular frequency. We multiply then the continuity equation with a (conjugated) test function q, the momentum equation with a vector-valued test function v, integrate over an element K, and integrate by parts,

$$\begin{cases} ik\int_K p\bar{q} - \int_K \boldsymbol{u}\cdot\boldsymbol{\nabla}\bar{q} + \int_{\partial K} \hat{u}_n \mathrm{sgn}(\boldsymbol{n})\bar{q} = 0 & q \in H^1(K) \\ ik\int_K \boldsymbol{u}\cdot\bar{\boldsymbol{v}} - \int_K p\,\mathrm{div}\bar{\boldsymbol{v}} + \int_{\partial K} \hat{p}\bar{v}_n = 0, & \boldsymbol{v} \in H(\mathrm{div}, K) \end{cases} \qquad (3.18)$$

where

$$\mathrm{sgn}(\boldsymbol{n}) = \begin{cases} 1 & \text{if } \boldsymbol{n} = \boldsymbol{n}_e \\ -1 & \text{if } \boldsymbol{n} = -\boldsymbol{n}_e \end{cases} \qquad (3.19)$$

The fluxes[4] : $\hat{u}_n, \hat{p}$ representing normal velocity component $u_n = u \cdot n_e$ and pressure p along an edge e, are declared to be *independent unknowns*. This is driven by mathematics: upon the integration by parts, the natural energy setting for *field unknowns* $\boldsymbol{u}$; p is the L^2 space for which the traces are undefined. Notice that the fluxes that live on interelement boundaries (the skeleton) are single-valued, they are responsible for "connecting" solution across the interelement boundaries.

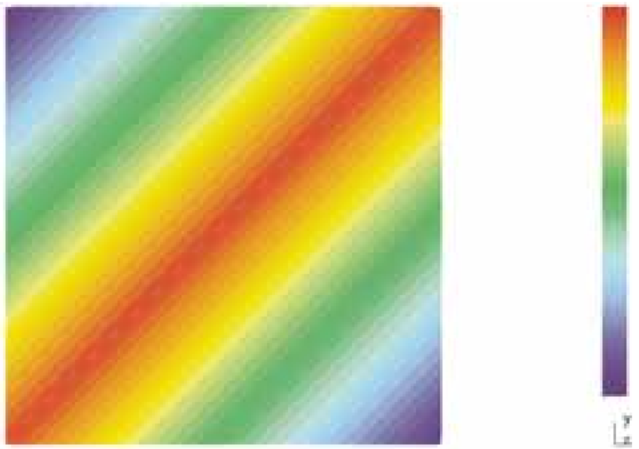
To complete the formulation of the boundary value-problem, we split the boundary of the domain into parts and, on each part of the boundary, use one of three possible boundary conditions:

hard boundary: normal velocity prescribed, $u_n = g$

soft boundary: pressure prescribed, $p = h$

impedance boundary condition: $p = zu_n$ where z is an impedance constant.

In each case, one of the fluxes is eliminated from the list of unknowns and replaced with the known data or expressed in terms of the other flux (impedance BC). In this way, the boundary conditions are built into the



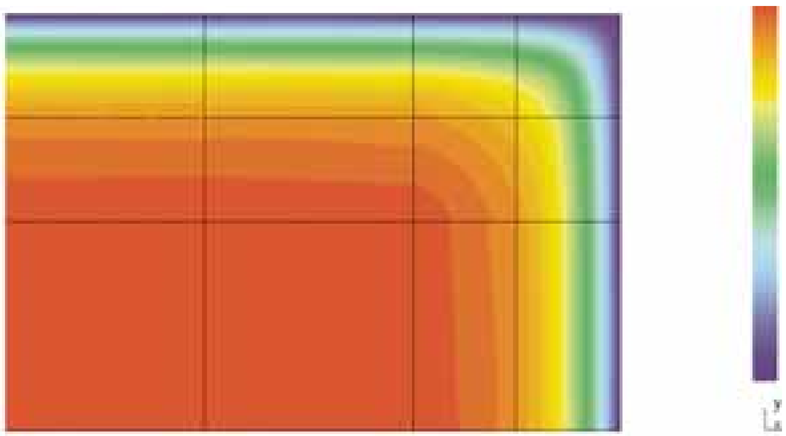


Figure 1 (a) & (b):
Solution of a convection-dominated diffusion problem with advection vector = (1,1) and diffusion parameter ∊ = 10^{-7}.
Solution develops boundary layers along the north and east boundaries.
(a) view on the whole domain
(b) resolution of the boundary layers in the north-east corner (zoom10^6)

[4]Upon studying the functional setting for the fluxes, we learn that $\hat{u}_n, \hat{p}$ have essentially different regularity. For that reason, we frequently call $\hat{p}$ a trace, and $\hat{u}_n$ a flux

formulation. The test functions are globally discontinuous and the “broken” Sobolev spaces provide a natural “mathematician’s test norm”:

$$\|(q, v)\|_V^2 = \sum_K (\|q\|_{H^1(K)}^2 + \|v\|_{H(\text{div},K)}^2) \qquad (3.20)$$

Given the variational formulation, we select trial basis functions for both field variables and the fluxes (hp elements are our choice), and we pursue now the idea of the optimal testing. The critical observation is that, with the discontinuous test functions, inversion of the Riesz operator. i.e. solution of variational problem (2.12) *is done element-wise*. Given an element K and a set of trial shape functions, we solve (2.12) to determine the corresponding optimal test functions, and only then proceed with the evaluation of the element matrices.

Approximate Optimal Test Functions
In practice, solution of the element equivalent of (2.12) is done only approximately using the concept of an enriched *space*. If field variables are discretized using polynomials of order p (which may vary element-wise), we use polynomials of order $p + \Delta p$ to approximate (2.12) (with a Bubnov-Galerkin method). Typically, the global parameter $\Delta p = 2$. With approximate optimal test functions, we cannot claim that the discrete inf-sup constant γ_h matches the exact one but, with increasing Δp, $\gamma_h \to \gamma$. The issue of how much we loose by approximating the optimal test functions, needs to be investigated but, according to our experience, it is a secondary one, see [27, 29, 48, 22] for numerical evidence. Intuitively speaking, it is not the exact reproduction of optimal test functions that matters, but only their action on the trial functions. This “action” is captured very well with small values of Δp.

Relation with classical hybrid methods
Fluxes act as Lagrange multipliers and this resembles the classical hybrid methods, see e.g. [4, 5] or various hybridization approaches including the FETI (Finite Element Tear and Interconnect) method of Farhat, [32]. The main idea of those methods is to break interelement continuities and reimpose them using Lagrange multipliers. The local variables are then eliminated and a global problem in terms of Lagrange multipliers is only solved. This property is shared by the DPG method[5] but, otherwise, the methods are essentially different. The hybridization concepts rely on the Bubnov-Galerkin method (Brezzi’s theory) and, typically, use standard (H^1) energy setting over elements.

Relation with the Concept of Numerical Flux and DG Methods
The DPG method starts with an infinite-dimensional functional setting and we assume (or prove, if we can) that the problem is well-posed, i.e. that inf-sup condition is satisfied. We proceed then with a consistent Petrov-Galerkin discretization of the problem and treat the fluxes as independent unknowns. This is to be contrasted with all discretization schemes using the notion of numerical flux introduced by Peter Lax, including finite volume, DG method of Cockburn and Shu, and other DG methods. In the numerical flux concept, the flux is expressed in terms of field variables on both sides of the edge and is required to be *consistent*, i.e. it reduces to the original, continuous flux in the case of a continuous solution. Numerous numerical fluxes are possible, and the construction of numerical fluxes is an art and is problem-dependent. A proper construction of the numerical flux (e.g. upwinding) is critical for accomplishing the discrete stability. Once the numerical flux is selected, the DG methods follow typically with a Bubnov-Galerkin discretization. One should emphasize that the numerical flux makes sense only on the discrete level (see our motivation for making fluxes independent unknowns), and this makes construction of higher order DG schemes challenging as the construction of fluxes and the corresponding stability analysis depends heavily on polynomial order being used. *This is not the case* for the DPG method. With a fixed grid, the discrete inf-sup constant matches the exact one for any polynomial order. Contrary to the DG methods, stability of the p-version of the FE method is automatic.

Example of a Quasi-Optimal Test Norm
We conclude this discussion with an example of how to use the idea of the optimal test norm discussed so far at the abstract level only. We use the wave problem as an example. Restricting ourselves for simplicity to the impedance boundary condition on the whole boundary of the domain:

[5]From now on, by the DPG method we mean our version with the optimal test functions.

$$u_n = p + g \tag{3.21}$$

we sum up the element contributions and rearrange terms to obtain the formula for the sesquilinear form,

$$\begin{aligned} b((\boldsymbol{u}, p, \hat{u}_n, \hat{p}), (\boldsymbol{v}, q)) &= \sum_K \int_K p\,\overline{[ikq - \operatorname{div}\boldsymbol{v}]} + \sum_K \int_K \boldsymbol{u} \cdot \overline{[ik\boldsymbol{v} - \boldsymbol{\nabla} q]} \\ &+ \sum_K [\int_{\partial K - \partial\Omega} \hat{u}_n \overline{[\operatorname{sgn}(\boldsymbol{n})q]} + \sum_K \int_{\partial K - \partial\Omega} \hat{p}\overline{[v_n]} + \sum_K [\int_{\partial K \cap \partial\Omega} \hat{p}\overline{[q + v_n]} \end{aligned} \tag{3.22}$$

Computation of the optimal norm (2.15) is now straightforward. We get,

$$\begin{aligned} \|((\boldsymbol{v}, q))\|^2 &= \sum_K [|ikq - \operatorname{div}\boldsymbol{v}|^2 + |ik\boldsymbol{v} - \boldsymbol{\nabla} q|^2] + \left(\sup_{\hat{u}_n} \frac{|\sum_K [\int_{\partial K - \partial\Omega} \hat{u}_n \overline{[\operatorname{sgn}(\boldsymbol{n})q]}|}{\|\hat{u}_n\|} \right)^2 \\ &+ \left(\sup_{\hat{p}} \frac{|\sum_K \int_{\partial K - \partial\Omega} \hat{p}\overline{[v_n]}|}{\|\hat{p}\|} \right)^2 + \left(\sup_{\hat{p}} \frac{|\sum_K [\int_{\partial K \cap \partial\Omega} \hat{p}\overline{[q + v_n]}|}{\|\hat{p}\|} \right)^2 \end{aligned} \tag{3.23}$$

With this norm, the DPG method will deliver the best approximation error in the energy norm including the L^2-norm for the velocity and pressure. This is the good news. The bad news is that we cannot work with this norm as it is not *localizable*, i.e. except for the first term, all three remaining terms cannot be represented as a sum of over all elements (*the terms are measures of interelement jumps of q and v_n*). The inversion of the Riesz operator leads to a global problem.

The situation has turned out to be not entirely hopeless. In [48, 28], we introduced a new localizable test norm by replacing the jump terms simply with the L^2-norms of v and q. We have managed to prove that the localizable "quasi-optimal" norm *is equivalent to the optimal one with equivalence constants independent of wave number k*. This in turn implies that we can prove that

FE error $\leq C$ best approximation error

where the norm includes the L^2-norm for p, $\boldsymbol{u}$ and appropriate norms for fluxes, and constant C *is independent of wave number*. The method is thus *robust*. In 1D case, fluxes are just numbers which implies that the best approximation error of fluxes is just zero, i.e. robustness in the DPG norm implies robustness in the L^2-norm (the 1D method is *pollution free* [40]). This is not true in the multidimensional case where the best approximation error for fluxes does not vanish. Hence, there is no conflict with the well known result of Babuška and Sauter [6] which (roughly speaking) states that it is impossible to construct an L^2-robust method in multidimensions.

The real excitement about the quality of the discretization comes from numerical experiments. For an illustration, Fig. 2 presents results of propagating a plane

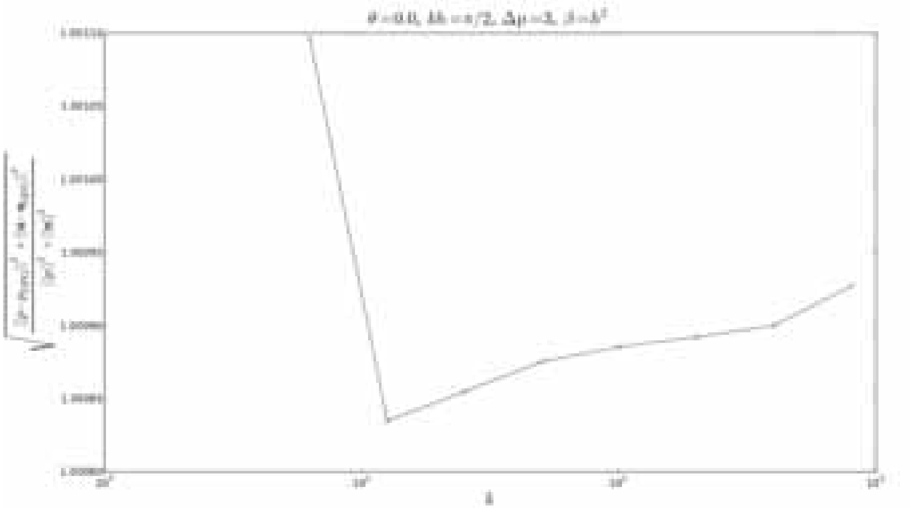


Figure 2:
DPG discretization of 2D linear acoustics with four linear elements per wave length. Ratio of the actual to the best approximation L2 error as a function of wave number.

"…. from the practical point of view, the method delivers the best approximation error in the L^2-norm."

wave through a uniform 2D rectangular grid with *just four linear elements per wave length*. The horizontal axis displays wave number (all the way to 1000), while the vertical axis presents the ratio of the actual FE error to the best approximation error, both measured in the L^2-norm (this includes both pressure and velocity components related to derivatives of the pressure for the standard Helmholtz equation). As the wave number grows, the ratio displays a modest increase to just 1:01 !. This simply means that, from the practical point of view, the method delivers the *best approximation error* in the L^2-norm.

4. A Summary

We have presented a new discretization concept based on the Petrov-Galerkin method and the idea of computing optimal test functions on the fly. The framework of hybrid Discontinuous Petrov Galerkin (DPG) method enables the 6 computation of (approximate) optimal test functions on the element level. The approach can be interpreted as a special least-squares method, the resulting stiffness matrix is always hermitian (symmetric) and positive-definite.

Since the inception of the idea [26, 27], we have applied the method to a number of problems including convection, convection-dominated diffusion [29] (see *Fig. 1* for an illustrative numerical result), thin-walled structures [42], wave propagation [48, 28], linear elasticity [12] and, more recently, Stokes problem [45]. We have managed to prove convergence (mesh independence) for all 1D problems [48, 42] and a number of multi-dimensional problems [25, 28]. With an appropriate choice of test norm, the methodology enables construction of *robust* discretizations for singular perturbation problems including wave propagation discussed here.

The method comes with a built-in residual error calculation which enables a straightforward implementation of adaptivity [29]. As the method delivers the best approximation error in the *computable* energy error, each refinement (even in a very preasymptotic stage) leads to the decrease of the energy error.

Besides the wave propagation problems, our DPG research is focusing on compressible flow, see [22] for the application of DPG to 1D Burgers and compressible Navier-Stokes equations.

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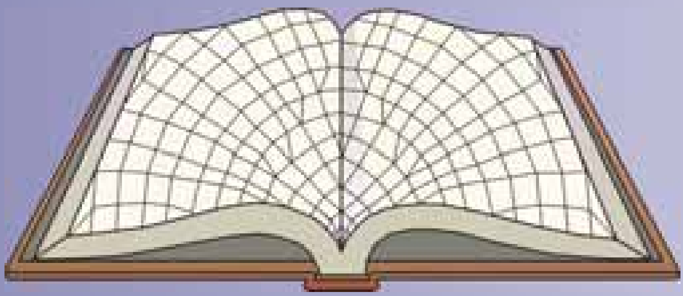

Isogeometric Analysis

Toward Integration of CAD and FEA

J. Austin Cottrell, Thomas J. R. Hughes and Yuri Bazilevs
Wiley, West Sussex, UK, 2009

BOOK REVIEW

SBN: 978-0-470-74873-2, 335 pages, hard cover
US $130 (List Price)
Contents: Preface

When I took this book into my hands for the first time, quickly glancing through its pages, my first impression was that – from a purely external perspective – this is the most beautiful scientific book that I have ever seen. (I am excluding popular science books from this statement; this book matches some of them in its beauty.) The authors, editors and publishers should be congratulated for giving so much attention not just to the content but also to the way the book looks. It is extremely inviting to read.

On top of this, the book is very well-written. This comes with no surprise, since it follows the tradition of the crystal-clear writing of T.J.R. Hughes. The combination of excellent writing, beautiful production and the importance of the subject (as discussed below) makes this book a real gem.

Isogeometric analysis (IGA) is a body of theory and techniques invented originally by T.J.R. Hughes and further developed by his group, including the co-authors J.A. Cottrell and Y. Bazilevs, and others. IGA seeks to unify the fields of Computer-Aided Design (CAD) and Finite Element Analysis (FEA). Although early concepts of CAD-FEA unification have appeared in the pioneering work of Mark S. Shephard and his RPI group, IGA is the first instance in which the unification goes as deep as

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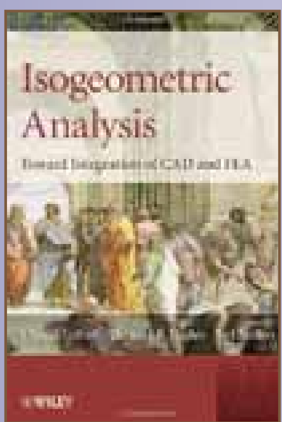
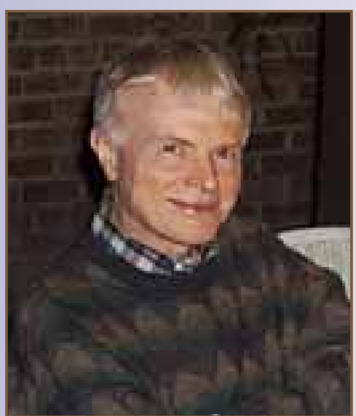




T.J.R. Hughes

the approximation space. The book assumes no knowledge in CAD, but it does assume basic knowledge in FEA. As written in the preface, “a background in FEA at the level of Hughes, 2000 is ideal preparation for understanding this book.” It is ideal preparation also because the notation and general approach employed in the two books are quite similar.

The key idea behind IGA is that the functional basis used to model the geometry (as traditionally employed in CAD) also serves as the basis for the solution space of the numerical scheme. The ‘building blocks’ of this basis are B-splines, which are explained very nicely in the first half of Chapter 2. Many concepts which are new to most FEA community members are introduced here (B-spline functions, knot, knot vector, knot multiplicity, index space, control point, control net, B-spline curve, k-refinement, etc.). A common misconception related to B-splines is explained on pp. 22 and 24: despite the fact that B-splines have a larger support than standard finite element functions for polynomial degree larger than 1, the bandwidth associated with the two types of functions is exactly the same. Section 2.1.4 discusses various ways of refinement (without altering the geometry and parameterization), using (1) knot insertion, (2) order elevation, or (3) k-refinement (which very importantly controls the smoothness), as well as their combination.

Non-Uniform Rational B-Splines (NURBS) are the standard tool in CAD, and under IGA become also integral part of analysis. NURBS are explained in the second half of Chapter 2 using two points of view (geometric and algebraic). The chapter ends with a long illustrative tutorial to generating a NURBS mesh. See *Fig. 1*.

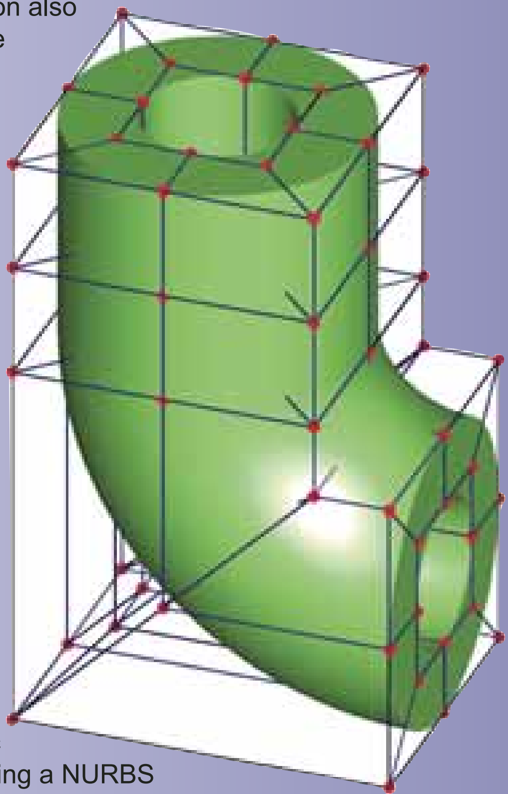
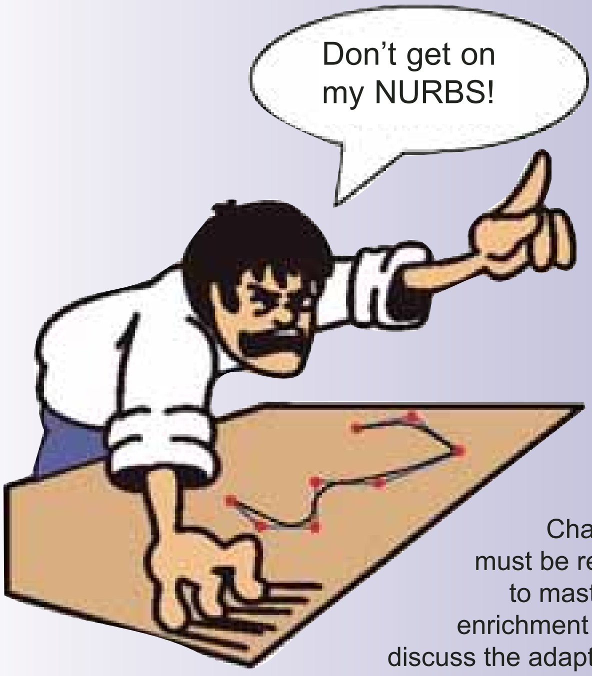


Figure 1: *The control lattice for a NURBS-based pipe model. This is Figure 2.44 taken from the book, p. 64, and is part of the tutorial on NURBS modeling.*

For a person that has worked in FEA for many years, grasping these new concepts may pose a challenge. One may attempt to find analogies between these concepts and the more familiar ones, but as the authors write on p. 27, “we should resist this urge, and understand the B-spline technology for what it is, not merely by analogy with things that are already familiar.”

Chapter 3 explains how NURBS are brought into use in analysis. This chapter discusses a number of classes of methods (Galerkin, collocation, least-squares and meshless methods) where NURBS can be incorporated. Of course, complete books can be written on each of these methods, but the approach here is to provide the reader with the minimum amount of material needed to understand how these methods work with NURBS. Different ways to enforce boundary conditions are also discussed here, as well as work with multiple patches in general geometries.



Chapter 3 ends with a nice and clear comparison of IGA and classical FEA. At this point, the reader already understands the significant benefits entailed in IGA as compared to standard FEA. An additional and very important benefit was pointed out to me by Michel Bercovier: IGA allows one to construct vector basis spaces (like H(div) or H(curl), as done, e.g., by Buffa et al., CMAME, 199, 1143-1152, 2010 for Maxwell’s equations) directly and easily, a feature which was unavailable before. In Michel’s words: “Approximations that were once regarded as exotic have become, owing to IGA, simple and natural.”

Chapters 2 and 3 are the heart of this book. They must be read and understood completely if the reader is to master the material. The other chapters constitute enrichment and extension to this material. Chapters 4-13 discuss the adaptation of IGA to various types of problems, and

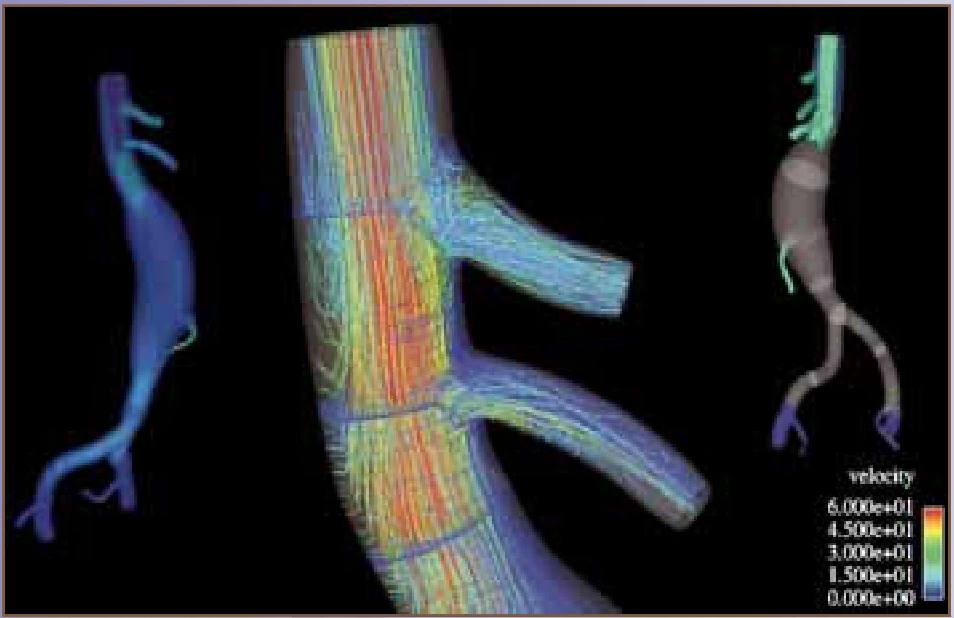


Figure 2:
Blood flow in a vessel as the heart contracts during systole. This is Figure 19.9(a) taken from the book, Chapter 10 (fluid-structure interaction and fluids on moving domains), p. 263

include demonstrations of very impressive applications of IGA. Among them are those shown in *Figs. 2 and 3*.

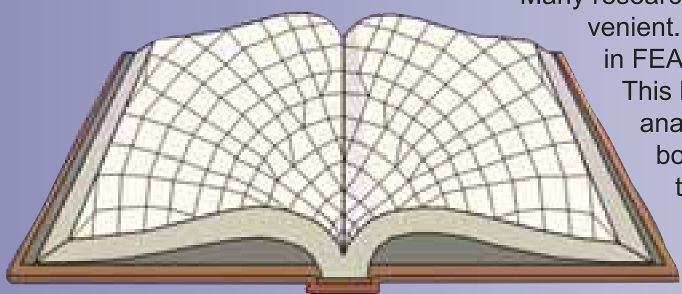
Finally, a bit more on the fine touches which make this book such a delight to read. The book contains many colorful figures, and is extremely pleasing visually. On pp. 9, 10, 13 and 14, a 'picture gallery' of some prominent researchers in FEA and CAD is shown. Along the entire book there are pictures of additional famous scientists who have contributed to what FEA and CAD are today. Many attempts are done throughout the book to help the reader digest the new material easily; for example, on p. 98, two very helpful tables appear which summarize the differences and similarities between IGA and FEA. At the end of each chapter there are numbered Notes that are referred to from the text. The captions of the figures are very detailed and clear, and the illustrations are well crafted. The reader can learn a great deal by merely looking at the figures and reading their captions.

Figure 3:
Two propellers spinning in opposite directions. This is Figure 10.16(b) taken from the book, chapter 10, p. 274

The only thing in this book which I found to be slightly less than perfect is the index. For some reason in many excellent books the importance of a detailed index seems to be underestimated. (An extreme example is the classical book by Strang and Fix on the finite element method; this book is a masterpiece but its index "leaves much to be desired" as the British understatement goes.) Most of the entries in the index are cited only once, even though many of them appear in different places in the text, sometimes in an important way. Some entries are altogether missing. Here are a few examples: 'NURBS coordinates' appears in the index, but 'NURBS' itself (defined in pp. 47-51) and 'NURBS curve' (p. 50) do not appear; 'B-spline curve' appears but 'B-spline basis functions' (p. 21) does not appear; 'multiple patches' are discussed on pp. 87-92 but do not appear under 'patches' in the index, and 'multiple' or 'repeated' do not appear either; 'error estimates' (pp. 103-106) and Bézier element (pp. 91-94) do not appear in the index. Fortunately, the book is so well-structured and the table of contents is so revealing that the reader can easily find her way even without the aid of an index.

For decades, geometric design and mesh generation on one hand and analysis on the other hand have been regarded as quite separate from each other. Many researchers and practitioners may feel that this separation is convenient. For example, many researchers who investigate subjects in FEA consider geometry-related techniques a 'black box'. This book shows us the benefits of the integrative geometry-analysis approach, and establishes a language common to both constituencies. Indeed, as written in the explanation to the painting of Raphael which is on the front cover of this book, legend has it that over the door to Plato's Academy in Athens there was an inscription:

Let no man ignorant of geometry enter here!



The Asian Pacific Association for Computational Mechanics

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APACM News

The Constitution of The International Association of Computational Mechanics (IACM) gives equal emphasis to the three geographical regions of America, Europe-Africa and Australia-Asia. The purpose of the Asia Pacific Association for Computational Mechanics (APACM) is to promote the activities related to computational mechanics in the Asian Pacific region and represent the region's interest in the International Association. It was agreed that one of the ways by which the computational mechanics activities can be promoted in the region is by organizing the Asian Pacific Congress on Computational Mechanics (APCOM) in different countries of the region at an interval of three years.

The first APCOM Congress was held in Sydney, Australia during 2001. The second Congress was held in Beijing, China during 2004 in conjunction with WCCM 6. The third one was held in Kyoto, Japan during November 2007 together with EPMESC XI and the fourth one was held in conjunction with WCCM2010 in Sydney in July 2010.

The WCCM/APCOM 2010 publications consist of a printed book of abstracts given to delegates, along with 247 full length peer reviewed papers published with free access online in IOP Conference Series: Materials Science and Engineering.

The General Council of APACM met at 17-18pm, 21 July, Wednesday, in the Board Room of the conference venue. The General Council was very happy to learn that Genki Yagawa was elected the President of the International Association for Computational Mechanics and was delighted to elect Gui-Rong Liu to succeed him to be the President of the Asia Pacific Association for Computational Mechanics. The Executive Council also met and planned to arrange symposia between two APCOM Congresses to promote rapid advancement of computational mechanics. ●

A.Y.T. Leung
President of the Hong Kong Society of Computational Mechanics
22 November 2010

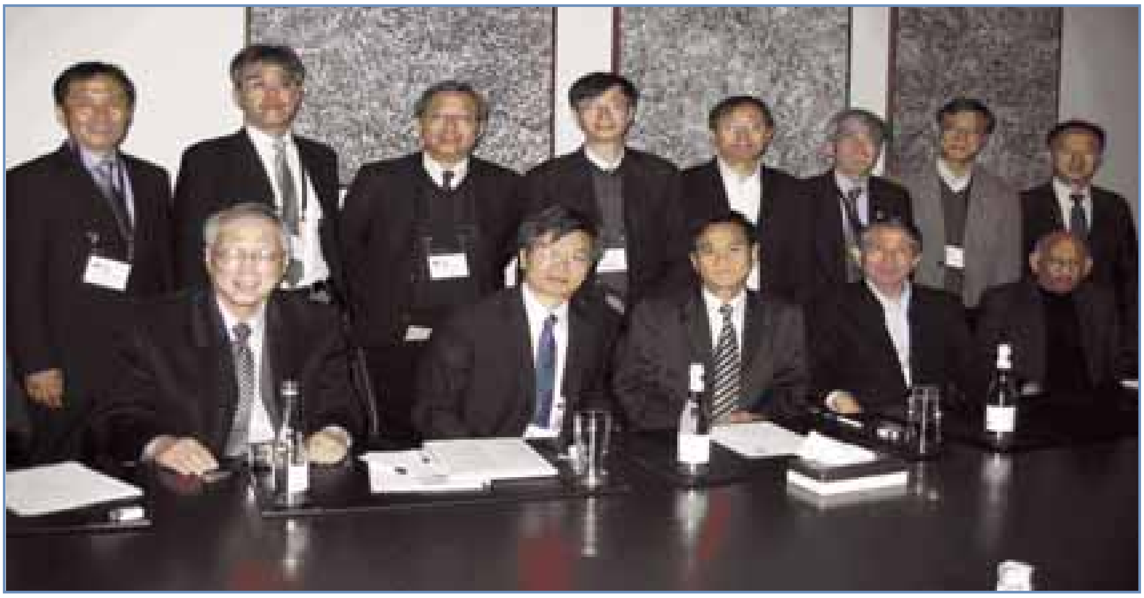

Figure 1:
APACM General Council :
Front row from left: Profs. M.W. Yuan, G.R. Liu, T. Kanok-Nukulchai, G. Yagawa, S. Valliappan
2nd row from left: Profs. S.K. Youn, K. Terada, K. Kashiyama, Z. Yao, H.W. Zhang, N. Miyazaki, T. Yabe, S. Yoshimura

by:
H.W. Zhang
Dalian Univ.of Technology
Q. Zhang
Hohai University
(co-chairs,
CCCM 2010 & SCCM 8)

The 2010 Conference of
Chinese Computational Mechanics
&
the 8th Conference of Southern China Computational Mechanics

The 2010 Conference of Chinese Computational Mechanics & the 8th Conference of Southern China Computational Mechanics were as a single conference combined and held in Mianyang, Sichuan, China between 20th and 23th August 2010. This conference was jointly hosted by the Chinese Association of Computational Mechanics and the Southern China Association of Computational Mechanics. It was co-sponsored by the Institute of Systems Engineering of the China Academy of Engineering Physics and by the School of Civil Engineering and Architecture in Southwest University of Science and Technology. It was also supported by: the Jiangsu Society of Theoretical and Applied Mechanics; the College of Mechanics and Materials in Hohai University; the State Key Laboratory of Structural Analysis of Industrial Equipment in Dalian University of Technology; the School of Aeronautics and Astronautics in Zhejiang University; the School of Mechanics and Engineering in Southwest Jiaotong University and the School of Aerospace in Tsinghua University.

Figure 1: *The opening ceremony of CCCM 2010 & SCCM 8*

On the opening ceremony, Prof. W.X. Zhong, Prof. J.Z. Cui and Prof. Z.L. Xu gave wonderful invited speeches about the past history and current status of Chinese computational mechanics.

IACM

Professor Masataka Tanaka
(1943–2009)

Prof. Masataka Tanaka

Professor Masataka Tanaka has passed away on 9 December 2009 at the age of 66, soon after he retired from Shinshu University, Japan in 2008. We are in deep grief for the lost of one of the leading researchers of computational mechanics community.

He found in the final year at Shinshu University that he had suffered from a desperate disease causing his motor-function disorders. The disease went worse quickly and he had really a very hard time just before his retirement. We are very puzzled by it because he has always been a very active and strong person. Shinshu University is located in Nagano City where a Winter Olympic Game in 1998 was held. There are many places for skiing in the close area of the city, so we used to enjoy skiing together. He could ski even on a steepest slope together with young students of his lab all the day. After skiing, he used to enjoy eating and drinking until late at night. He could sort out all his jobs very quickly. His room has always been clean and in order. He used to reply to the emails he received promptly. He has been such a precise person, but he was cheerful, spirited, frank, and direct, as we all remember.

Professor Tanaka was born in 1943 in Osaka, Japan. He graduated from Osaka University in 1968 and obtained a Doctorate of Engineering in 1973 from Osaka University. From 1968 to 1983, he has been a research associate of Osaka University, during this period from 1975 to 1976, he studied at the University of Stuttgart under the financial support of Alexander von Humboldt Foundation. In 1983, he moved to Shinshu University, Japan, as an Associate Professor, then in 1987, he was promoted to a Professor and retired in 2008.

He specialized in continuum mechanics, solid mechanics, computational mechanics, etc. He was particularly interested in the formulations and applications of the boundary element method to wide areas of engineering problems, such as elastostatics, elastoplastics, elastodynamics, fracture mechanics, heat transfer, acoustics, etc. Inverse problems are also one of his main interests. He used BEM time-harmonic vibration analyses and extended Kalman filter algorithms to identify defects and inclusions in solids. He also interested in identification problems of sound sources and active noise control designs. He used BEM to calculate not only the solutions of the governing equations but also their sensitivities with re-

About three hundreds participants, from 23 provinces of China, England, Netherlands, etc., attended the conference. Over 340 papers were submitted and 220 presentations were delivered. There was a rich scientific program including 5 plenary lectures, plus 66 keynote lectures given in 8 parallel symposiums. The plenary lectures were delivered by the distinguished Chinese researchers: Prof. Y.B. He, Prof. J.H. Lin, Prof. X.G. Deng, Prof. Z. Zhuang and Prof. X. Han. Topics cover a wide spectrum of computational mechanics including: solids and fluids; statics and dynamics; linear and non-linear; continuum and non-continuum; composites; rocks and soils; constitutive equations and micro- and nano-mechanics.

Figure 2:
The award ceremony of the "Qian Lingxi Award for Computational Mechanics"

An award ceremony of the “Qian Lingxi Award for Computational Mechanics”, which was founded in memory of Prof. Lingxi Qian, a veteran Academician of the Chinese Academy of Sciences and the founder of the Chinese Association of Computational Mechanics, was held during the conference. This was the first time this award has been made and it will take place every two years in future. This year’s Award for Achievement was conferred on Prof. Y.L. Xu and Prof. L.D. Zhu, and the Award for Youth to Prof. X. Guo. The recipients presented their honorary lectures respectively.

At the closing ceremony, Prof. M.W. Yuan summarized the scientific activities during the four-days of the conference and looked forward to the prosperous future of Chinese computational mechanics.

Finally, we would like to express our gratitude to the organizers, co-organizers and hosts for their enthusiasm and hard work on the preparations for the conferences. Also, many thanks should be especially addressed to all participants for their strong support and high-standard papers and presentations.

spect to design parameters. Because the boundary element methods are numerical methods based on singular integral equations, he was interested in their numerical treatment based on their regularizations. He has published more than 400 papers related to all of these fields.

In Japan, he has been one of the founders and the head of the Japan Society for Computational Methods in Engineering (JASCOME). Many scientists and engineers working in wide areas joined into JASCOME. Under the leadership of Professor Tanaka, JASCOME organized several series of conferences, symposia, and research forums every year on BEM. He organized many other research groups of BEM and inverse problems also in the Japan Society of Mechanical Engineers (JSME), and organized lots of sessions on related issues every year. In addition to them, he was the organizers of BEM International Conferences in 1986 and 1990; Japan-US, US-Japan BEM Symposia in 1988 and 1990; Japan-China, China-Japan Boundary Element Symposia in 1987, 1988, 1990, 1991, 1993, 1994, 1996, and 1998; International Symposium on Inverse Problems in Engineering Mechanics (ISIP) in 1992, 1994, 1998, 2000, 2001, and 2003; Asia-Pacific International Conference on Computational Methods in Engineering (ICOME) in 2003 and 2006. He was a Fellow of the Japan Society of Mechanical Engineers and was the Chairman of its Computational Mechanics Division of the year 2001. Due to these extensive contributions, he had awards from JSME in 1996, 1997, and 2003, from JSMS in 2005, from JACM in 2005. He was awarded the Wessex Institute Eminent Scientist Medal in 1986, and the Honor Plaque of the Slovak Academy of Sciences named by Aurel Stodola in 2003.

He was such an active and eminent person, and we never thought of this disaster coming to him. But when we remember carefully the moments we stayed together, we notice some symptoms of his disease. The last international conference we attended together was the ICOME2006 that was held in Hefei of China. We visited Yellow Mountains as the conference workshop tour, and we found that he could not walk up the mountain well. So we hired palanquin bearers for him. He looked enjoying with them but that was the last journey with him. He looked very tired in the airplane returning to Japan.

We invited him to attend WCCM’08 & ECCOMAS’08 held in Venice, but he declined because he did not feel well. Since then, he could never attend any meeting. He confessed his difficult state to us in the autumn of 2008. Since then, his disease got worse very rapidly, and at the end of that year, he could not walk by himself without the help of a wheelchair. We had a serious pain to have known that he had such a hard time at the end of his life. We planned a JASCOME Symposium on December 12, 2008, and when we were preparing for the symposium, we were informed from his wife, Mrs. Taeko Tanaka, that he has peacefully passed away at 13:44 on December 9, 2008, at Nagano Red Cross Hospital. The funeral ceremony was on December 12. We held the JASCOME Symposium on December 11, one day before his funeral ceremony. It was really a requiem to him. We all miss him. We pray that his soul may rest in peace.

Toshiro Matsumoto & Masahiro Arai

Report from the

Japan Association for Computational Mechanics

For all JACM news:
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The JACM is a union of researchers and engineers working in the field of computational mechanics in Japan, and is also an umbrella organization covering almost all computational mechanics related societies in Japan. Currently 23 societies send 31 members to the General Council of JACM. Computational Mechanics Division of JSME (The Japan Society of Mechanical Engineers), the number of whose division members is 5,400, is the largest CM community among them, and a number of JACM members also belong to the JSME-CMD. Last year, Professor Eugenio Oñate of Technical University of Catalonia received 2009 Computational Mechanics Award of the division. In September 2010, he was invited to the 2010 Annual Conference of JSME-CMD held in Kitami city of Hokkaido, which is in almost the most northern part of Japan, and gave a special invited lecture on Advances in the Particle Finite Element Method for Multidisciplinary Problems in Engineering. Many JSME-CMD members and JACM members enjoyed his lecture, while he enjoyed technical discussion with the members as well as Okhotsk food and culture. (*Figure 1*).

On the occasion of WCCM/APCOM 2010 held in Sydney, Australia in July 2010, the JACM meeting was held to discuss the prospects of the association and to present the 2010 JACM Awards. More than 50 members attended the meeting. As a part of JACM's recent activity, Professor Noriyuki Miyazaki, JACM President, reported that JACM members organized 13 Mini-symposia for WCCM/APCOM2010, and appreciated their great contribution to the congress. The 2010 JACM Awards ceremony was then followed (*Figures 2, 3*). The JACM Awards for Computational Mechanics were presented to Professors Nobutada Ohno and Kazuhiro Nakahashi (*Figure 4*). The JACM Fellows Awards were presented to Professors Toru Ikeda, Hiroshi Kanayama, Nobuatsu Tanaka and Seiya Hagihara (*Figure 5*). The JACM Awards for Young Investigators in Computational Mechanics were presented to Professors Yosuke Imai, Tomohiro Takaki and Kenichi Tsubota (*Figure 6*). Furthermore, Professors Shoichi Kobayashi, Toshio Kobayashi, Nobuyuki Satofuka, Masaki Shiratori and Genki Yagawa were newly elected as the JACM honorary members (*Figure 7*). ●

Figure 1:
Eugenio Oñate at 2010 Annual Conference of JSME-CMD in Hokkaido

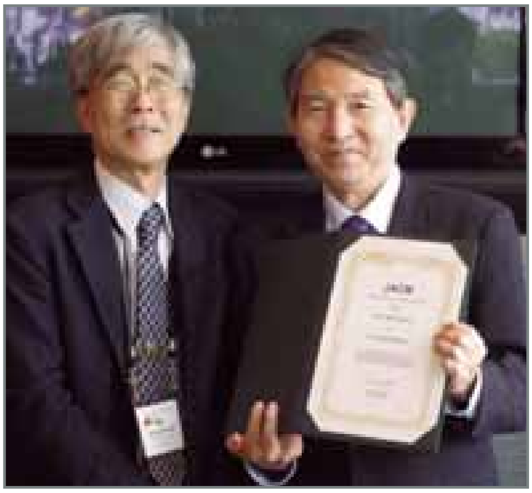

Figure 3:
Genki Yagawa receiving a Certificate of JACM Honorary Member from Noriyuki Miyazaki, JACM President

Figure 2:
JACM meeting in Sydney, Australia

Figure 4:
The JACM Awards for Computational Mechanics :
Nobutada Ohno (far left) and Kazuhiro Nakahashi (left)

Figure 5:
The JACM Fellows Awards :
Toru Ikeda (left), Hiroshi Kanayama (central-left), Nobuatsu Tanaka (central-right), Seiya Hagihara (right)

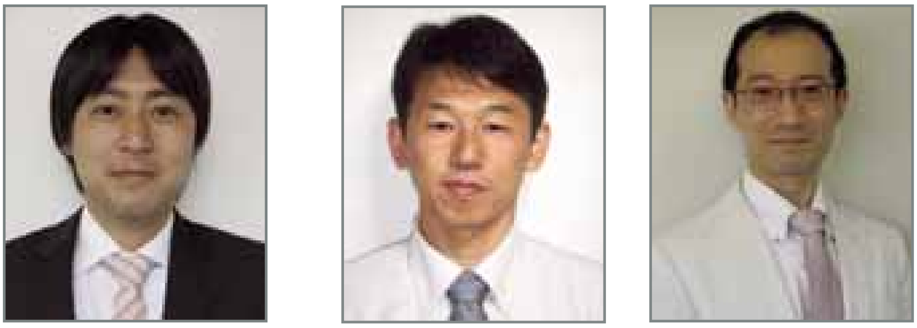

Figure 6:
The JACM Awards for Young Investigators :
Yosuke Imai (left), Tomohiro Takaki (central), Kenichi Tsubota (right)

Figure 7:
JACM Honorary Members :
Shoichi Kobayashi (far left), Toshio Kobayashi (left), Nobuyuki Satofuka (bottomn left), Masaki Shiratori (bottom central), Genki Yagawa (bottom right)

ASOCIACIÓN ARGENTINA DE MECÁNICA COMPUTACIONAL

AMCA

25 AÑOS 1985-2010

MECOM DEL BICENTENARIO

15 – 18 November 2010

For all inclusions under AMCA please contact:

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On May 25th 1810 the first local government was designated in Buenos Aires, substituing the Spanish Viceroy. This May Revolution marked the start of Argentina as a country, although the formal declaration of independence came after all the provinces agreement in 1816. This year 2010 has been declared as the Year of the Bicentenary. In this frame, the Argentine Association of Computational Mechanics (AMCA) and the Brazilian Association for Computational Mechanics (ABMEC) undertook the organization of MECOM DEL BICENTENARIO: CILAMCE 2010 (XXXI Iberian-Latin-American Congress on Computational Methods in Engineering) and MECOM 2010 (IX Argentinean Congress on Computational Mechanics and II South American Congress on Computational Mechanics).

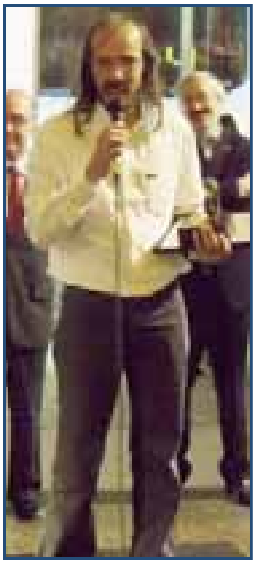
The Congress was organized by the Engineering School of Universidad de Buenos Aires and Sim&Tec S.A. The Organizer Committee, chaired by Marcela Goldschmit, was integrated by José L.D. Alves, Miguel Cavaliere, Philippe R.B. Devloo, Sebastian D´Hers, Paula Folino, Adan Levy, Mario Storti and Rita Toscano. The Scientific Committee was chaired by Eduardo Dvorkin.

Figure 1:
Opening ceremony of MECOM-CILAMCE 2010

During this conference, there were plenary lectures by Klaus-Jürgen Bathe (MIT, USA), Segen Estefen (UFRJ-COPPE, Brazil), Sergio Idelsohn (UPC, Spain and UNL, Argentina), Miguel Ortiz (Caltech, USA), Raul Radovitzky (MIT, USA), and semi-plenary lectures by Perla Balbuena (Texas A&M, USA) , Alberto Cardona (INTEC, UNL, Argentina), Diego Celentano (PUC, Chile), Yomar Gonzalez (UCV, Venezuela), Alberto Cuitiño (Rutgers U., USA), Guillermo Etse (UBA, UNT, Argentina), Marisol Koslowski (Purdue U., USA), Adrian Lew (Stanford U., USA), Xavier Oliver (UPC, Spain), Eugenio Oñate (UPC, Spain), Carlos Prato (U. of Córdoba, Argentina), Sandra Rugonyi (Oregon H&S U., USA).

MECOM del Bicentenario incorporated 15 mini-symposia and 12 Technical Sessions bringing together more than 700 presentations by authors from different countries.

- AMCA Awards 2010 -



AMCA Award 2010 for Young Researcher: Pablo Sanchez

AMCA Award 2010 for Senior Researcher: Eduardo Dvorkin

AMCA Award 2010 for International Researcher: Rainald Lönher

The ceremony of the AMCA Awards 2010 took place during the Congress Banquet of MECOM-CILAMCE 2010

The award for Young Researchers was granted to Pablo Sanchez, from the CIMEC, UNL, CONICET and UTN Regional Faculty of Santa Fe, Argentina.

The award for Scientific, Professional and Teaching Career was given to Eduardo Dvorkin, from Universidad de Buenos Aires, Argentina.

The award to the International Scientific Career, was for Rainald Lohner, from the George Mason University , USA.

The jury for the AMCA Awards 2010 was integrated by: V. Fachinotti, R. Feijoo, S. Idelsohn, G. Marshall, X. Oliver, J. Signorelli and V. Sonzogni. ●

MECOM 2010 - CILAMCE 2010

Buenos Aires, Argentina

It received support from: National Scientific and Technological Promotion Agency of Argentina; Agency for the Promotion of Science and Technology; Fund for the Promotion of the Software Industry; KB Engineering S.R.L., Buenos Aires, Argentina.

Figure 3:
During the congress banquet MECOM-CILAMCE 2010: S. Idelsohn, P. Pimenta, J. Alves, E. Oñate, V. Sonzogni, R. Toscano, M. Golschmit, E. Dvorkin

During MECOM del Bicentenario other events took place. The University of Buenos Aires gave the Honoris Causa Doctoral Degree to Prof. Klaus-Jürgen Bathe. ABMEC and AMCA had their annual meetings. There were courses of SolidWoks, Simulia-Abaqus, and Unified Sistem for Finite Elements. Finally, during the congress banquet, the 2010 AMCA Awards were held.

In the year of the Argentine bicentenary, AMCA is celebrating 25 years since its constitution in 1985. Also, in 1985 the First MECOM place. And one decade ago the AMCA Awards were instituted. This celebration of a quarter century of AMCA counted on the presence of many colleagues from other Associations. Besides the presence of Brazilian researchers attending the CILAMCE Congress, we were able to add delegates from the Chilean Society for Computational Mechanics as well as Spanish Association for Numerical Methods in Engineering.

The experience of joint realizations between ABMEC and AMCA has been highly successful. Rendez-vous: São Paulo, Brazil, 2012: X WCCM. ●

Figure 2:
Some of the lecturers:
K.-J. Bathe, S. Idelsohn, M. Ortiz, A. Cardona, S. Estefen, E. Oñate, X. Oliver, G. Etse.

Call for Papers

ENIEF 2011

XIX Congress on Numerical Methods and their Applications

1 – 4 November 2011

Rosario, Argentina

Organized by the Faculty of Engineering of the National University of Rosario

Deadline for abstract submissions: 15 May 2011

Location: Rosario is one of the most important cities in Argentina. It is located 300 km northwest of Buenos Aires, over the Paraná River.

E-mail: enief2011@fceia.unr.edu.ar
Web: www.enief2011.fceia.unr.edu.ar

The Israel Association for Computational Methods in Mechanics (IACMM) has held two IACMM Symposia since our last report (see IACM Expressions No. 26). In this issue we shall report on them.

The **27th IACMM Symposium** was held in October 2009 at Tel-Aviv University. The local organizers were Rami Haj-Ali and Slava Krylov. The very impressive Opening Lecture was given by Prof. Roland Glowinski from the University of Houston, Texas, and was entitled "Bifurcations and Instabilities in Particulate Flows." See *Figs. 1 and 2.* Prof. Glowinski has chosen to be a full member of IACMM (despite the fact that he resides outside of Israel), a fact which brings a lot of pride to IACMM.

Figure 1: *Prof. Roland Glowinski gives the Opening Lecture in the 27th IACMM Symposium*

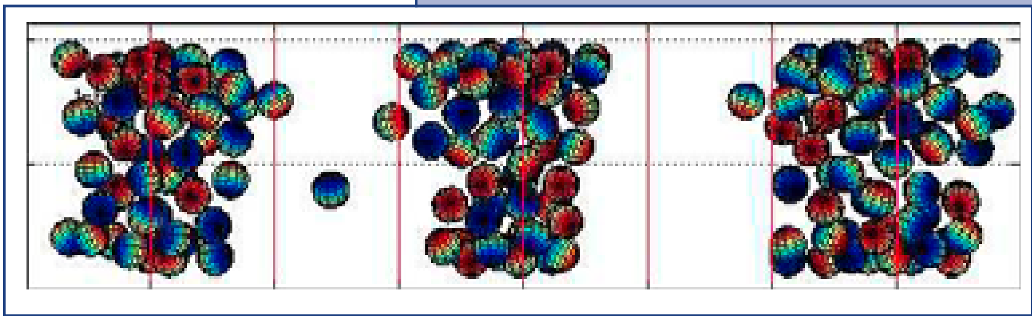


Figure 2: *A plot taken from Prof. Glowinski's talk: the result of a simulation, showing clustering of 160 balls in a rotating cylinder filled with a Newtonian incompressible viscous fluid*

The symposium ended with a very interesting invited Keynote Lecture of Prof. Aharon Ben-Tal, a leader in optimization methods from the Technion, who talked about "Some Remedies for Some Intractable Engineering Optimization Problems."

Eight contributed talks were presented, including a talk by Pavel Trapper, a student from the Technion supervised by Kosta Volokh. See *Fig. 3*. *Fig. 4* is a picture taken after the end of the symposium.

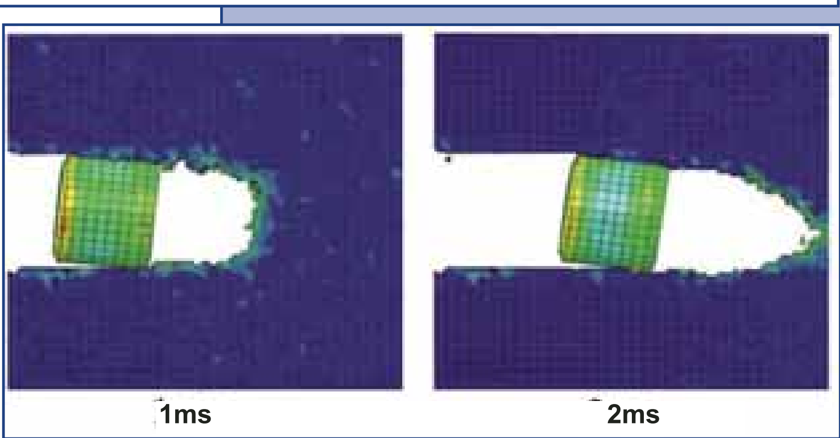


Figure 3: *A plot taken from the lecture of Pavel Trapper and Kosta Volokh: penetration of a cylindrical bullet into a thick plate*

During the symposium, Nir Trabelsi, a student at the Ben-Gurion University of the Negev under the supervision of Zohar Yosibash, received an award as the winner of the IACMM Lecture Competition that was held during the previous two IACMM symposia. See *Fig. 5*.

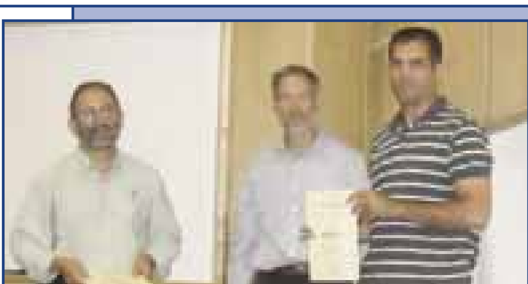


Figure 4: *Nir Trabelsi (right), a student from BGU, receives an award as a winner of the IACMM Lecture Competition from the President (middle, Dan Givoli) and Secretary (left, Amiel Herszage) of IACMM*

Figure 5: *Prof. Glowinski and his wife and Prof. Aharon Ben-Tal with the IACMM Council and the local organizers of the 27th IACMM Symposium*

From left to right: Zohar Yosibash, Rami Haj-Ali, Slava Krylov, Roland Glowinski, Mrs. Glowinski, Michel Bercovier (2nd row), Aharon Ben-Tal, Dan Givoli, Amiel Herszage, Isaac Harari, Pinhas Bar-Yoseph

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IACMM site: http://www.iacmm.org.il

Methods in Mechanics (IACMM)

The **28th IACMM Symposium** was held in April 2010 at the Hebrew University in Jerusalem (HUJI), and was held on the occasion of the 75th birthday of Prof. Shmuel Kaniel, a world-known HUJI researcher in numerical analysis. The audience included many of Prof. Kaniel's former students who are now established computational mechanists in academia and industry. The local organizers were Matania Ben-Artzi, Michel Bercovier and Leo Joskowicz.

The opening Keynote Lecture was given by Prof. Sergio Idelsohn from the Polytechnical University of Catalunya, Barcelona, on "Lagrangian Formulations for Heterogeneous Fluid Flows." This was a fascinating lecture on the computational solution of extremely complicated fluid dynamics problems. See *Fig. 6*.

The closing Keynote Lecture, equally fascinating and on a similar class of problems albeit with another type of techniques, was given by Prof. Helmut Neunzert from Kaiserslauten University in Germany, on "Kinetic Schemes in Fluid Dynamics." See *Figs. 7(a)-(c)*.

Seven additional talks were given during this symposium. *Figs. 8(a) and 8(b)* are photos taken during a special dinner in honor of the guests and of Prof. Kaniel. ●

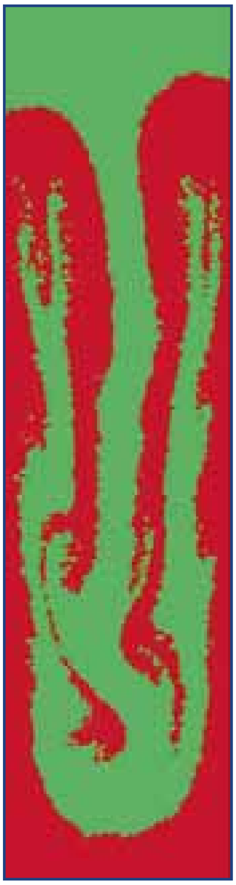
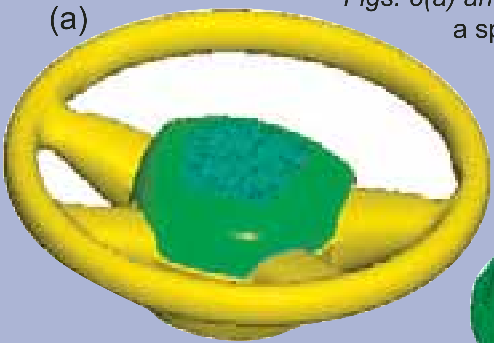
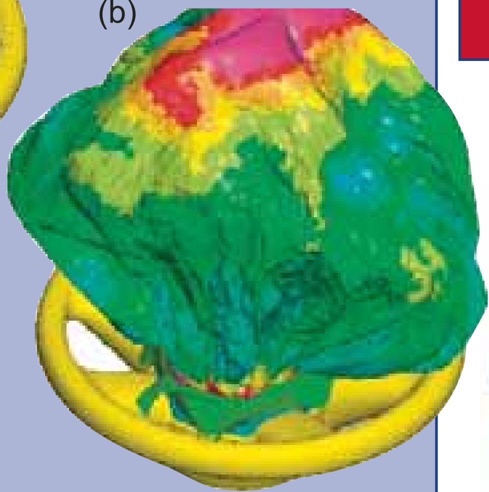


Figure 6:
A plot taken from Sergio Idelsohn's Keynote Lecture: a snapshot from a sloshing simulation

(a)



(b)



(c)

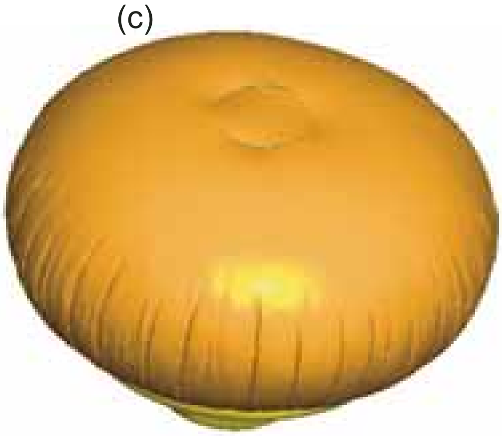


Figure 7:
Plots taken from Helmut Neunzert's Keynote Lecture: snapshots from a simulation of the opening of a car air-bag.

(a)

(b)

Figure 8:
Invited guests, Prof. Kaniel, IACMM Council and local organizers of the 28th IACMM Symposium.
From left to right:
(a) Dan Givoli, Sergio Idelsohn, Amiel Herszage, Isaac Harari.

(b) Mrs. Ben-Artzi, Helmut Neunzert, Matania Ben-Artzi, Shmuel Kaniel and Mrs. Kaniel.

GIMC

The 18th Meeting of (GIMC) took place at Syracuse, Sicily, from September 22 to 24, 2010 in the building of the Faculty of Architecture, which is located inside the beautiful compound of the Maniace Castle, in the Ortygia Island. Syracuse, a 2,700 year-old city, played a key role in ancient times, when it was one of the major powers of the Mediterranean world. It is famous for its rich Greek history, culture, amphitheatres, architecture and, most of all, as the birthplace of Archimedes, one of the greatest mathematicians ever, by many considered as the founder of engineering sciences.

The Italian Group of Computational Mechanics (GIMC) was founded in 1986 as a cultural association under the umbrella of the Italian Association of Theoretical and Applied Mechanics (AIMETA). Main objective of the group is to put together resarchers with different backgrounds who develop and utilise advanced numerical methods for the solution of complex mechanical problems, with special attention to solid, structure, fluid and material mechanics.

The first conference of the association was held at the Politecnico di Milano in 1986. Since then, national meetings have been held on a regular basis every year, at the beginning, and every second year in more recent times. In the past, joint conference have been organized by GIMC with the ibero-latin american associations of computational methods in engineering, and with the frech computational structure mechanics association CSMA.

The meeting in Syracuse has been organized by the University of Catania in the persons of Massimo Cuomo (Conference Chairman), Loredana Contraffatto and Nicola Impollonia. It has been attended by over 100 participants with 75papers presented.

Besides a gorgeous Conference Banquet, the social programme included a visit to the fortress of the Maniace Castle, a military construction built in the first half of the 13th century by Frederick II's architect, Richard of Lentini. Built of sandstone, it owes its name to the Byzantine general who in 1038 defended Ortygia against the Arabs.

Figure 1: *Participants of the XVIII GIMC meeting. In the backgtound the medieval fortress "Castello Maniace"*

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http://www.aimeta.it

Two Plenary Lectures were delivered by distinguished invited researchers:
Prof. Nicolas Moës, Ecole Centrale de Nantes,
 “The thick level set approach to model damage growth and transition to fracture: theoretical background and numerical implementation”;
Prof. Xavier Oliver, Technical University of Catalonia,
 “A contact-interface domain method for large deformation contact mechanics and domain decomposition problems”.

A special session was dedicated to the presentation of the two best PhD theses in computational mechanics that were successfully defended in 2009. Among many other competitors, the prize was awarded to two young researchers, Dr. A. Giampieri and Dr. E. Masoero who were also invited to present their work in the plenary session.

The proceedings of the coneference, as well as those of the two previous ones, are public and available to everybody in the conference site **http://www.lamc.ing.unibo.it/gimc2010/.**

The Conference also hosted the annual meeting of the Association where, among other issues, it was decided that the next GIMC Conference will be organized in Calabria by the University of Cosenza. ●

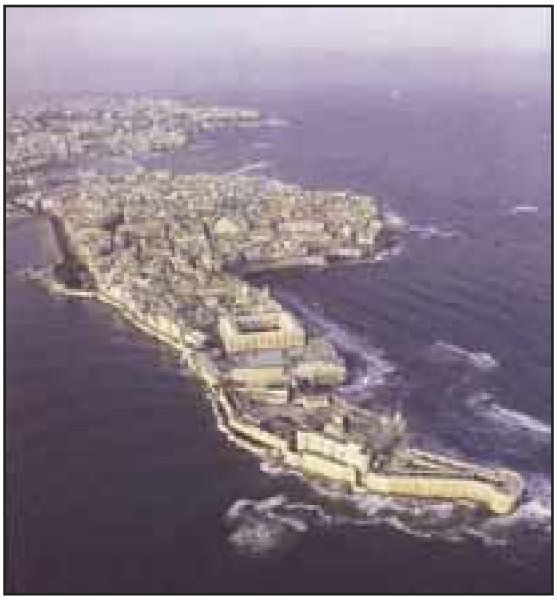
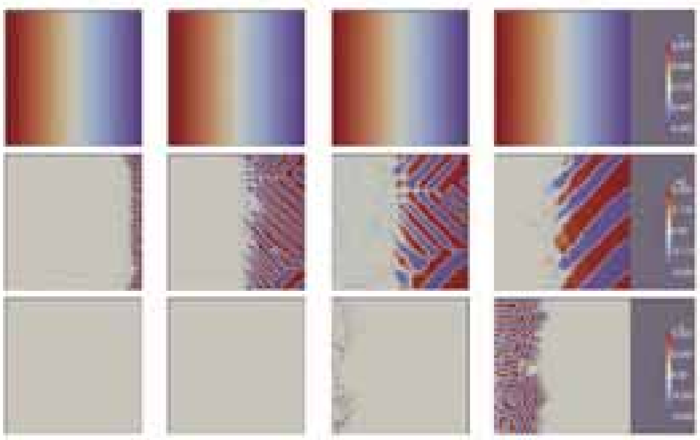


Figure 2:
An aerial view of the city of Siracusa and of the Maniace castle, venue of the conference

Figure 3:
The award ceremony for the best PhD theses. From left, Prof. Ferdinando Auricchio, Prof. Massimo Cuomo, Dr. Andrea Giampieri (award winner), Dr. Enrico Masoero (award winner), Prof. Francesco Ubertini.

Figure 4:
Deformation of an elastic container. Snapshots at different time step.



(a) *t* = 0.002 (b) *t* = 0.006 (c) *t* = 0.012 (d) *t* = 0.024

Figure 5:
Temperature (top row), displacive o.p. (centre row) and diffusive o.p. (bottom row) evolution throughout the domain

JSCES

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IWACOM-II -
The Second International Workshops on Advances in Computational Mechanics

The Second International Workshops on Advances in Computational Mechanics (IWACOM-II) was held on March 29-31, 2010, at Conference Center of PACIFICO Yokohama, Yokohama, Japan. The first IWACOM was held at Hosei University (Tama Campus), Tokyo, Japan in 2004 to mark the 10th anniversary of establishment of the Japan Society for Computational Engineering and Science (JSCES) and the 20th anniversary of establishment of the Computational Mechanics Division of the Japan Society of Mechanical Engineers (JSME CMD).

A unique feature of this conference series is that the meeting consists of individual invited workshops to provide an international forum for recent developments in selected fields of research in computational mechanics by bringing together Asian, European and American researchers. In this conference, 9 workshops which consisted of 147 invited lectures and contributed presentations were organized by prominent researchers in each field of computational mechanics. About 180 delegates from 15 countries attended the event.

Two plenary lectures were presented by the distinguished researchers on the first day of the meeting. One of the speakers was Prof. Charbel Farhat (Stanford University, USA) who gave a talk entitled "A Computational Framework Based on an Embedded Method with Exact Local Riemann Solvers for Highly Nonlinear Multi-Phase Fluid-Structure Problems". The other is Dr. Ryutaro Himeno (RIKEN, Japan) who presented "Japan's Next-Generation Supercomputer R&D Project and Grand Challenges in Life Science." Also, the banquet was arranged on Japanese Old-fashioned Houseboats, called "Yakata-Bune", which served various Japanese cuisines, after enjoying a ceremonial sake barrel.

The financial support received from The Japan Society for Computational Engineering and Science (JSCES), The Computational Mechanics Division of The Japan Society of Mechanical Engineers (JSME CMD), Yokohama National University and other organizations and companies.

All the events in this conference were quite successful thanks to enthusiastic participants as well as outstanding speakers. The Japan Society for Computational Engineering and Science (JSCES) will continue efforts to organize this conference series periodically. ●

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Figure 1: *Plenary lecture by Prof. C. Farhat*

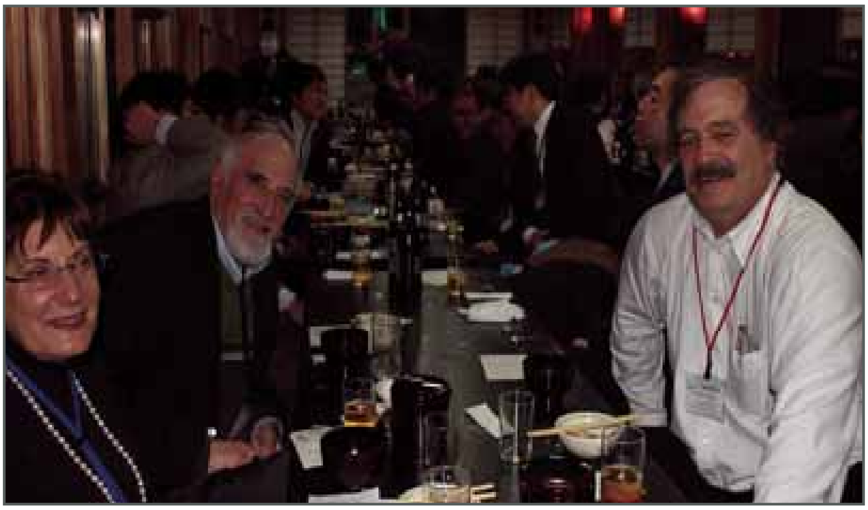

Figure 2: *Conference banquet on Japanese Old-fashioned Houseboats, "Yakatabune," at the port of Yokohama*

JSCES

The JSCES was incorporated in June 2010 under a new regulation about government-affiliated public corporations, while it had been a voluntary association. The first general assembly meeting, as an incorporated organization, was held in June 23, 2010. On the same day, we had the award ceremony, where the JSCES awarded various kinds of JSCES prizes to senior and young researchers, and practitioners. This year's recipients are Profs. T. Taniguchi and K. Fujii (The JSCES Award), Prof. S. Koshizuka (Kawai Medal), Dr. A. Tezuka (Shoji Medal), and Profs. T. Yamada, M. Ogino and S. Yoshimura (Outstanding Paper Award),

Annual Conference:

The Japan Society for Computational Engineering and Science (JSCES) hosted the fifteenth Conference on Computational Engineering and Science, which was held on May 26-28, 2010, at Centennial Hall of Kyushu University School of Medicine (Higashi-ku, Fukuoka, Japan). The conference lasted three days and was attended by about 480 delegates. About 340 papers with full lectures were presented by researchers as well as graduate students and practitioners in the conference composed of 6 tracks and 38 minisymposia. Also, three special sessions are held in the conference. The one collected papers on matching research accomplishments among industry, academia and government, and the other two reported the annual accomplishments of the sectional committees “High Quality Computing (HQC)” and “Computational Engineering for Manufacturing” that have been lead mainly by members from industries.

The plenary lecturer for this year was Prof. D.R.J. Owen (Civil and Computational Engineering Centre, Swansea University, UK) who presented the paper “Multi-Field Coupling Strategies for Large Scale Problems Involving Multi-Fracturing Solids and Particulate Media” written by D.R.J. Owen, Y.T. Feng, K. Han and C.R. Leonardi. On the same day, this year’s “The JSCES Grand Prize” was awarded to him for his outstanding contributions in the field of computational engineering and sciences; see *figure 1* with Prof. N. Takeuchi (President of JSCES of that time, Hosei University) at the presentation ceremony. Right after the lecture, we also had a panel discussion, “Are supercomputers really valuable for manufacturing?”, in which the current and future need and roles of supercomputers especially in industries were intently discussed. The conference was also accompanied with “Best Paper Award” to honor the authors who presented papers with significant achievements, and with “Visualization Contest” to make honorable recognition of attractive figures printed in the conference proceedings. All the events in this conference were quite successful.

Figure 1:
Prof. D.R.J. Owen (recipient of The JSCES Grand Prize) with Prof. N. Takeuchi (president of JSCES) (27th of May, 2010)

The significance of JSCES’s annual conference has been determined as an established setting for the exchange of ideas in the field of computational engineering and science, and for the enlightenment of state of the art in this field. The effort will continue to have the next year’s conference in Chiba, May 2011. ●

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Figure 2:
Group shot of participants in the Third Korea-Japan Workshop (28th of May, 2010)

- General Assembly Meeting -

Prof. M. Tanaka (Young Researcher Award). Also, the JSCES provided the honorary membership to Prof. Yutaka Yoshida. At present, the JSCES (the current president, Dr. Koichi Ootomi) has about 850 members, all of who are registered as international members of the IACM. The JSCES periodically publishes both quarterly magazines (http://www.jsces.org/Issue/Journal/index.php) and internet journals (http://www.jstage.jst.go.jp/browse/jsces).

This year, we organized one international conference and two workshops, whose reports are accompanied with this article. Here, we briefly report the Third Korea-Japan (KJ) Joint Workshop on Computational Engineering with the Computational Structural Engineering Institute of Korea (COSEIK), which was held in conjunction with the JSCES annual conference (*Figure 2*). The opening remark by Prof. N. Takeuchi (President of JSCES, Hosei University) was followed by fourteen talks interchangeably given by Korean and Japanese young scientists (Figure G), including keynote talks by Prof. Sung-Kie Youn (KAIST, Korea) and Prof. H. Kanayama (Kyushu University, Japan). The workshop was closed by the address given by Prof. Jong Se Lee (President of the COSEIK, Hanyang University) and the next one will be held in Korea. Thus, as an IACM affiliated society in Japan, the JSCES is directing various international activities, and supporting IACM activities, such as WCCM’s, APCOM’s and other regional and national congresses. Please visit our website **(http://www.jsces.org/index_e.html)** for the details of our activities. ●

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2nd German-Japanese Workshop on Computational Mechanics

The second German-Japanese(G-J) Workshop on Computational Mechanics, which is a joint two-day meeting between the German Association for Computational Mechanics (GACM) and JSCES, was held on March 28-29, 2010, at Earth Simulator Center, JAMSTEC, Yokohama, Japan, following the first G-J workshop held in Hannover, Germany in 2004.

The aim of the meeting is to intensify the scientific relationship between German and Japanese researchers in the broad field of computational mechanics covering topics such as finite element methods, boundary element methods and meshless methods, computational fluid dynamics, inelastic-solids, acoustics, multi-scale and multi-field problems and innovative engineering applications.

This meeting, which was partially financially supported by the H. Noguchi Fund temporarily established in the JSCES, was started with three opening talks by Prof. N. Takeuchi (President of JSCES at that time, Hosei University), Prof. W. Wall (Vice-President of GACM, Technical University of Munich) and Prof. K. Kashiyama (Current Vice-President of JSCES, Chuo University) and ended with the closing address given by Prof. P. Wriggers (President of GACM, Leibniz Universität Hannover).

The organizing committee invited twelve and eleven papers from Germany and Japan sides, respectively, which include keynote lectures given by Prof. Marek Behr (RWTH Aachen University), Dr. Keiko Takahashi (JAMSTEC), Prof. Naoshi Nishimura (Kyoto University) and Prof. Jörg Schröder (Universität Duisburg-Essen).

We also had a tour of the Earth Simulator 2 (ES2), which is installed in the conference venue. The banquet was held in Rinka-En, an old-fashioned, Japanese traditional restaurant, which was made of wood and was build 600 years ago! The meeting was quite fruitful and deepened exchanges between these two IACM affiliated organizations.

The next G-J workshop will be held in Germany, in 2013. ●

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Figure 1:
Group shot at the Earth Simulator Center, in which all the participants attended.

conference diary planner

23 - 25 March 2011	**16th International Conference on Finite Elements in Flow Problems** *Venue:* Munich, Germany *Contact*: http://www.lnm.mw.tum.de/fef2011/
30 Mar - 1 Apr 2011	**CMBE11 - 2nd International Conference on Computational and Mathematical Biomedical** *Venue:* Washington D.C., USA *Contact*: http://www.compbiomed.net
12 - 15 April 2011	**PARENG 2011 - 2nd Int. Conference on Parallel, Distributed Grid and Cloud Computing for Engineering** *Venue:* Corsica, France *Contact*: http://www.civil-comp.com/conf/pareng2011.htm
27 – 30 April 2011	**IPM2011 - on Inverse Problems in Mechanics of Structures and Materials** *Venue:* Rzeszow/Sieniawa, Poland *Contact*: http://ipm.prz.edu.pl/
26 - 28 May 2011	**COMPDYN 2011 - 3rd. Int. Conference on Computational Methods in Structural Dynamics and Earthquake Engineering** *Venue:* Corfu Island, Greece *Contact*: http://www.compdyn2011.org
6 – 8 June 2011	**CFRAC 2011 - Int. Conference on Computational Modeling of Fracture and Failure of Materials & Structures** *Venue:* Barcelona, Spain *Contact*: cfrac2011sec@cimne.upc.edu
9 - 11 June 2011	**Computational Analysis and Optimization** *Venue:* Jyväskylä, Finland *Contact*: http://www.mit.jyu.fi/CAO2011
20 - 22 June 2011	**Coupled Problems 2011 - 4th. Int. Conference on Coupled Problems in Science and Engineering** *Venue:* Kos Island, Greece *Contact*: http://congress.cimne.com/complas2011
28 - 30 June 2011	**ICCS/16 - 16th International Conference on Composite Structures** *Venue:* Porto, Portugal *Contact*: ferreir@fe.up.pt
25 - 29 July 2011	**USNCCM Congress 11 - US National Congress on Computational Mechanics** *Venue:* Minneapolis, Minnesota *Contact*: http://usnccm.org/
5 - 7 Sept 2011	**2nd International Conference on Computational Methods for Thermal Problems** *Venue:* Dalian, China *Contact*: http://www.thermacomp.com
5 - 8 Sept 2011	**IABEM Symposium 2011 - International Association for Boundary Element Methods** *Venue:* Brescia, Italy *Contact*: http://cesia.ing.unibs.it/iabem2011/index.html
7 - 9 Sept. 2011	**COMPLAS XI - XI Int. Confrerence on Computational Plasticity Fundamentals & Applications** *Venue:* Barcelona, Spain *Contact*: http://congress.cimne.com/complas2011
21 - 23 Sept 2011	**III International Conference on Mechanical Response of Composites** *Venue:* Hannover, Germany *Contact*: www.composite2011.info
28 - 30 Sept 2011	**MARINE 2011 - 4th. Int. Conference on Computational Methods in Marine Engineering** *Venue:* Lisbon, Portugal *Contact*: http://congress.cimne.upc.es/marine2011/
5 - 7 October 2011	**Membranes 2011 - 5th Int.Conference on Textile Composites and Inflatable Structures** *Venue:* Barcelona, Spain *Contact*: http://congress.cimne.com/membranes2011/
26 - 28 October 2011	**PARTICLES 2011 - II Conference on Particle Based Methods, Fundamentals & Applications** *Venue:* Barcelona, Spain *Contact*: http://congress.cimne.com/particles2011
9 - 11 November 2011	**ICCB2011 - V International Congress on Computational Bioengineering** *Venue:* Mazatlán, México *Contact*: www.iccb2011.org
8 - 13 July 2012	**WCCM 2010 - 10th World Congress on Computational Mechanics** *Venue:* Sao Paulo, Brazil *Contact*: www.wccm2012.com

10th World Congress on Computational Mechanics

8-13 July 2012 • São Paulo • Brazil