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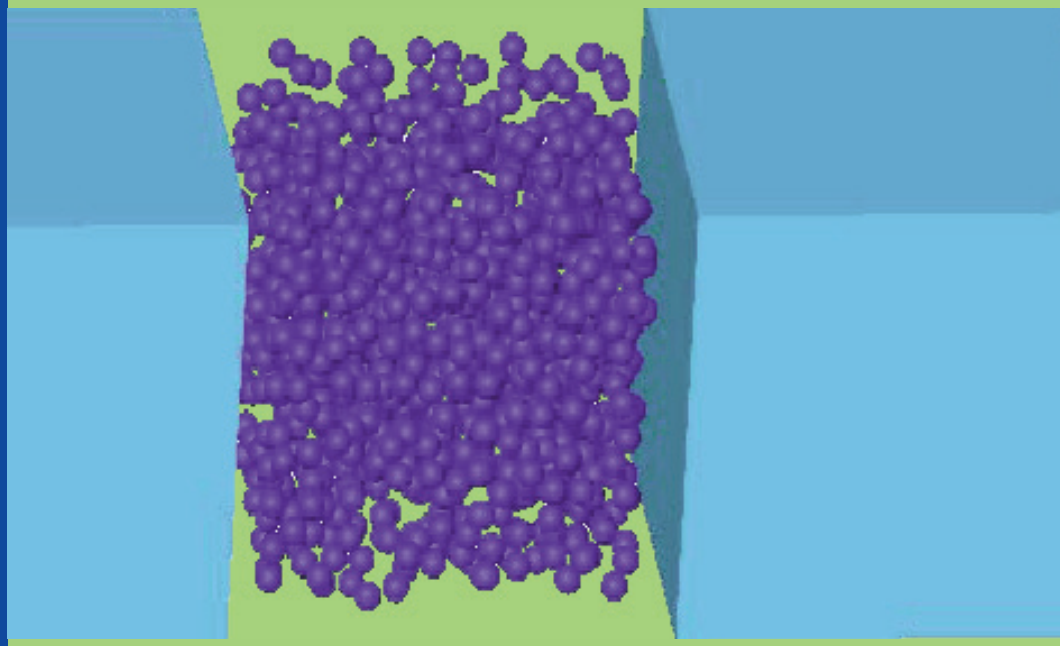

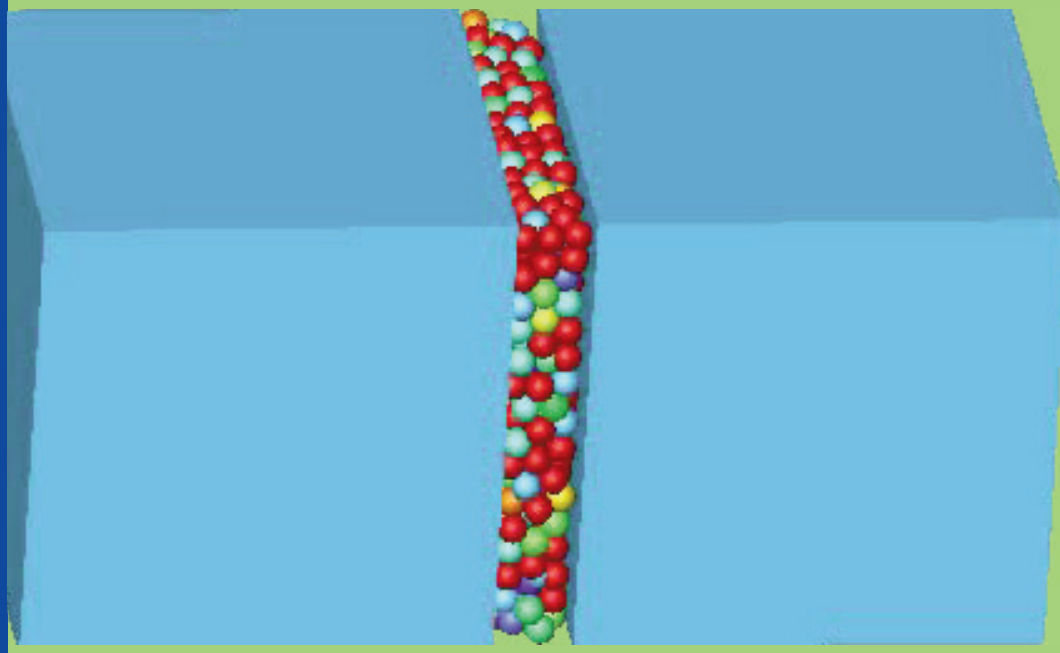

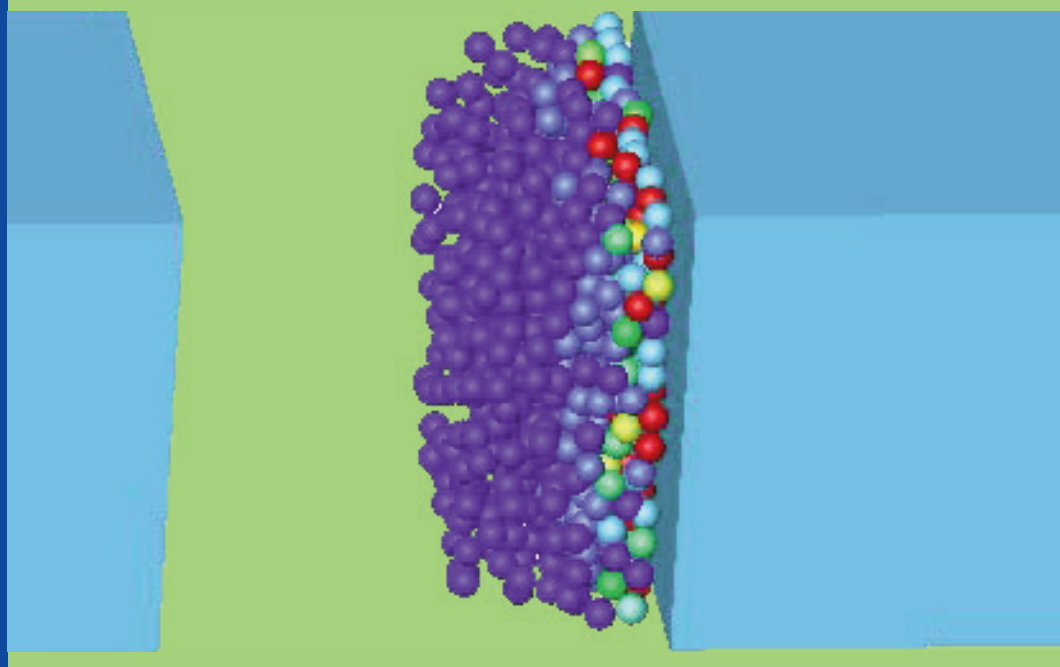

Bulletin for The International Association for Computational Mechanics

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contents

editorial

Particle-based methods (PBMs) encompass a large number of computational procedures that are applicable to the solution of different physical problems.

A number of PBMs refer to the modelling of the mechanics of a discrete collection of objects/units of different size: atoms, granular media, rock masses, etc. In this class of PBMs the particles represent each of the individual objects which motion follow physical laws based on the particle interaction via (frictional) contact laws or more sophisticated equations based, for instance, on the distance between the particles. Among this category of PBMs we find atomistic methods, discrete element methods, lattice methods, cellular automata, etc. An example is the modelling of the interaction between granular particles by solving Newton's second law for each particle.

A second category of PBMs use the particles as a procedure for discretizing a continuum. Hence, as in any discretization method, the accuracy of the numerical solution depends on the number of particles that are used for representing the behaviour of the underlying medium. Here again the mechanics of the particles can be modelled by starting from the force-displacement relationships of cohesive discrete particles, or by using discretized forms of the continuum mechanics equations.

In the latter case we can still distinguish two classes of PBMs. The first one uses the particle information for defining approximations of the mechanics of the continuum (forces, displacements, strains, stresses, etc.) over selected groups (clouds) of particles. Among this type of methods we find the Smooth Particle Hydrodynamics method and many meshless methods that have been proposed in the last twenty years (Reproducing Kernel Particle Method, Element Free Galerkin Method, Finite Point Method, etc.).

In the second class of "continuum" PBMs the particle information is projected forth and back to/from an associated finite element mesh that discretizes the underlying continuum. The solution of the problem is typically done using the standard FEM. Examples of this class of mesh-type PBMs are the Particle Finite Element Method (PFEM) and the Material Point Method.

The above classification is by no means exhaustive, but hopefully will help the non-experienced reader to distinguish between the different PBMs that more and more frequently appear in the computational literature. The articles published in this IACM Expressions bulletin confirm this new and promising trend in computational mechanics.

Finally, I would like to remind you that the 11th World Congress on Computational Mechanics (WCCM) of the IACM will be held on July 20-25, 2014 in Barcelona, Spain, in conjunction with the ECCOMAS conferences on Computational Solid and Fluid Mechanics. The 265 minisymposia organized in the joint event cover most of the classical topics in Computational Mechanics as well as many new areas in Computational Engineering and Applied Sciences.

You are cordially invited to participate in WCCM/ECCOMAS 2014 in Barcelona.

Eugenio Oñate
Editor of IACM Expressions

Surface Condition of Solid in Splash Formation

by
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Osamu Mochizuki
Toyo University, Tokyo
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The Fluid-Structure Interaction (FSI) is one of the most popular topics in the computational mechanics. It covers a wide range of phenomena of scientific and engineering fields such as vehicle, medicine, civil engineering and construction, agriculture, forestry, disaster prevention, music, sports, etc. The vibration of structure caused by the Kármán's vortex street has been studied for many years, which is a locking phenomenon caused by the vortex street behind a spherical cylinder [1]. The FSI study has contributed to the sport engineering: the improvement of the movement form of swimmer [2-3]. Regarding the sound of musical instruments, the vibration of a musical instrument and the circumference air and the pronunciation mechanism of an air lead of pipe organ or flute have been studied [4-6].

The vortex and the exfoliation occur when a solid or structure moves in fluid, which often result in the destruction, the noise, the stall of an airplane or the drag of a vehicle, and the various studies have been performed: the effect by the surface unevenness such as a turbulator, a vortex generator, a tripping-wire, a riblet of wing, and dimples of golf ball [7], the drag reduction of ship by the micro bubble [8], the effect of deformation by an elastic body [9], the relation of vortex and vibration [10], etc.

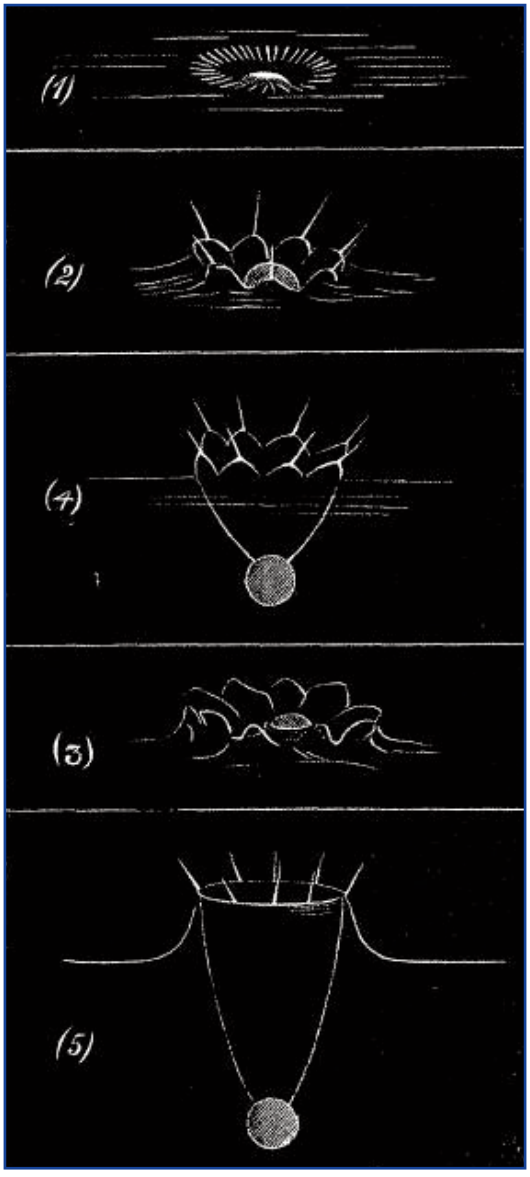


Figure 1:
Observation of the splash by a ball [13]

It is well known that the surface condition, the roughness of surface or the uneven shape of the solid surface gives some influence on the flow fields and the movement of the solid as seen in the case of the dimple of a golf ball [11]. In the most of the FSI studies, however, the wall of the solid or the structures is assumed to be as non-slip condition in numerical simulation. It is not a realistic assumption. For example, creatures living in water such as fish and amphibians have a slimy mucus skin, whose principal ingredient is a hydrogel known as mucin [12]. Furthermore, since the inner wall of the digestive organs or the blood vessel has a slippery surface, it seems important to take the characteristics of such slippery surface into consideration in numerical simulation.

" ... in the dive ... it is important to jump into water pool after a swimmer wipes body well in order to get the high score."

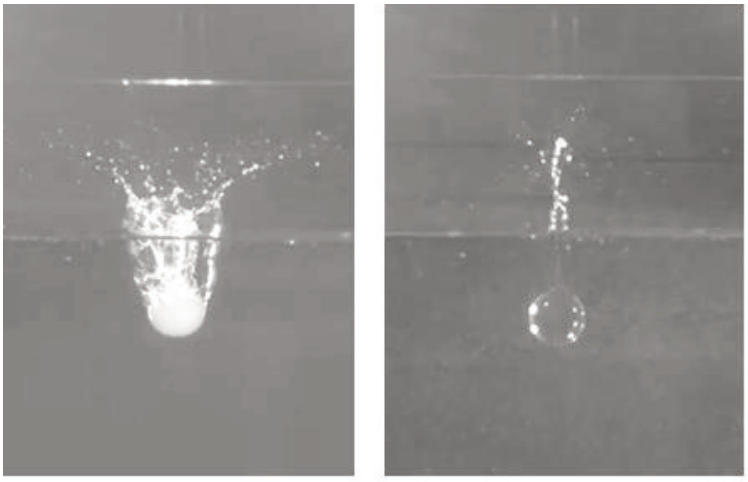
Experimental observation of the splash of a ball, which plunged into water was performed by Worthington [13], *Figure1*. He studied the influence of the state of the surface of a ball on the splash. With the dry smooth ball, the size of the splash became small. With the ball made coarse with the sandpaper or the wet ball, it became a big crown-like splash. It shows that, in the dive game of swimming, since splash will become large if a swimmer jumps into water pool without wiping the body well or with swimming suit wet, the

score becomes disadvantageous. Thus, it is important to jump into water pool after a swimmer wipes body well in order to get the high score.

The experimental results by a high-speed camera of a splash formed by a sphere impinging on water surface are shown in Fig. 2 [14], comparing the primary splash formed by a hydrogel sphere (Fig. 2A) with that by an acrylic sphere (Fig. 2B), where the primary splash means the splash, which rises right after an object plunging. The primary splash formed by the hydrogel sphere is a kind of the crown-type. On the other hand, the acrylic sphere creates the column type primary splash. The splashes are considered to be formed by the dynamics of the film-flow [14], which is a thin water flow around a sphere surface and generated immediately after the sphere impacts the water surface. The difference between the formation processes of *Figures 2A & 2B* is due to the existence of the film on the sphere surface. When the film is little seen on the surface, a crown-type splash is formed. The above difference of film separation is presumably caused by the increase in the film velocity according to the hydrophilic property of the solid wall and the attractive or repulsive force such as the electrostatic force between the solid wall and the water. This experimental observation suggests that the numerical simulation should take into consideration the various surface conditions or the interaction between the solid object and the water.

Let us discuss here how we can introduce the influence of the slippery wall seen, for example, in the case of the skin of a frog into the calculation in a heuristic manner. We take a diving sphere made of agar as the hydrophilic material, which consists of cross-linked structure by polymer called agarose and plenty of water molecule between the polymer structures, which makes the solid surface slippery. *Figure 3* shows schematically the velocity distributions of water flow near the surface of the acrylic-resin versus that of the agar-gel, where δ is the height of the water flow and u the velocity of the water. The slip ratio α is defined as follows,

$$\alpha = \tau' / \tau \qquad (1)$$



(A) Hydrogel (Agar) (B) Acrylic resin

Figure 2: *Comparison of splash patterns between hydrogel and acrylic resin (radius of sphere=10mm, impact velocity=2.21m/sec)*

where τ is the wall shear stress under the no-slip condition and τ' that under the slippery condition. The wall shear stresses are obtained experimentally from the flow velocity near the wall as

$$\tau = \mu \frac{du}{dy}\Big|_{y=0} \qquad (2)$$

where μ is the kinematic viscosity and u the flow velocity. *Figure 4* shows the experimental relations between the swelling ratio S and the slip ratio α for the agar-gel and the carrageenan-gel, respectively, where the swelling ratio S is defined as follows [15],

$$S = (m_{water} + m_{gel}) / m_{gel} \qquad (3)$$

where m_{water} is the mass of the water and m_{gel} that of the solid-gel. S increases with the amount of the water contained in the solid-gel.

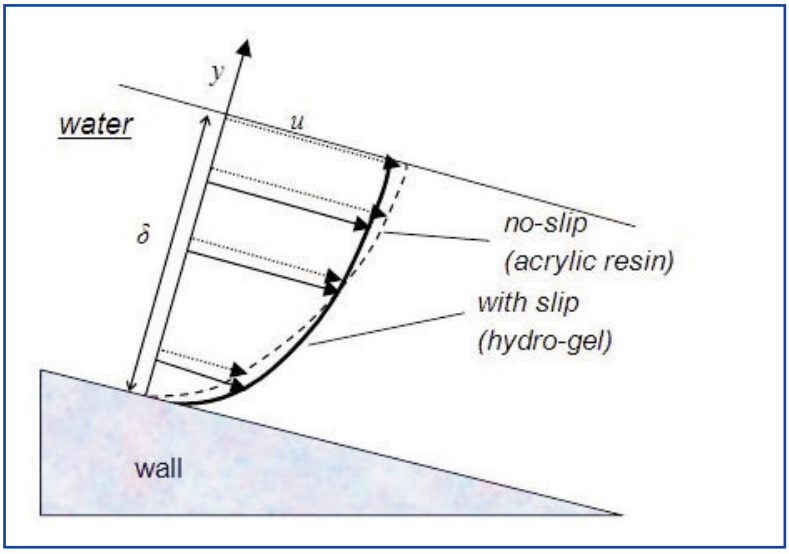


Figure 3: *Schematic view of flow profiles near no-slip wall (acrylic resin) and slippery wall (hydrogel)*

Agar employed in this study is a kind of hydrogel. *Figure 4* suggests that α can be expressed as

$$\alpha = 1 - \beta S \tag{4}$$

where β is a constant value estimated to be 1.2×10-3 in the case of the agar. It is summarized that larger S naturally gives more slip on the surface.

The above relation is taken into consideration in the vicinity of the solid wall in the viscous term of the Navier-Stokes equation in a heuristic manner.

Since the shear force acting between the wall and the fluid is presumed to be directly related with the viscosity term of the Navier-Stokes equation, we modify the discretized form of the viscosity term [16] as follows,

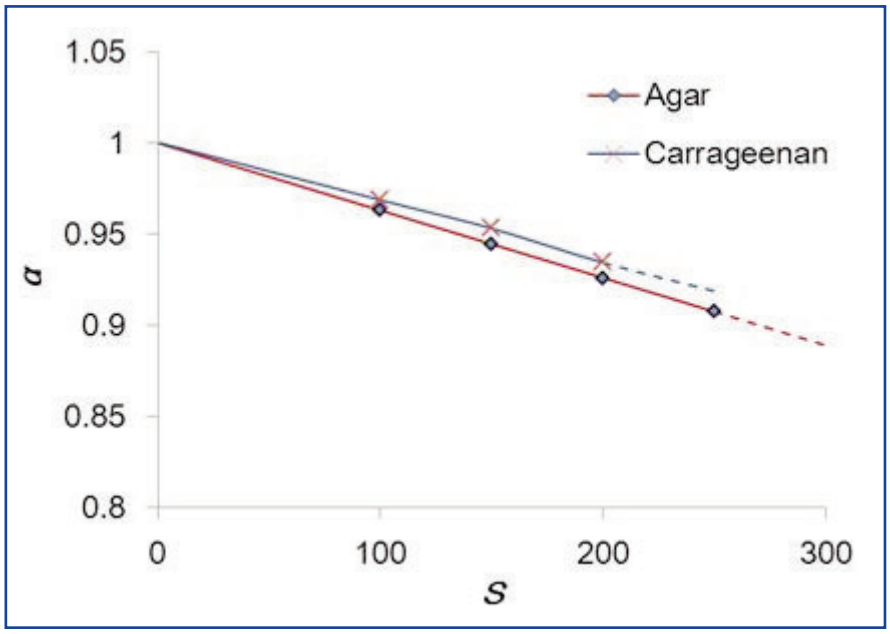
$$\nabla^2 u = \frac{2d}{\lambda n^0} \sum_{i \neq j} \left[(u_j - u_i) \kappa_H (| \vec{r}_j - \vec{r}_i |) \right] \tag{5}$$

with

$$\kappa_H(r) = \alpha \kappa(r) \tag{6}$$

where *i* denotes the water particles near the hydro-gel wall and *j* the surface particles of the hydro-gel wall. Namely, α is set effective only near the hydrogel wall, because the effect of the slip is important only near this area.

Figure 4:
Experimental relationship between swelling degree S of hydrogels and slip ratio α



The comparison of the MPS simulation result with *S* = 100 and the experimental one is shown in *Figure 5*, where the radius of the sphere *R* is 10 mm and the sphere is dropped from the height *h* =50*R* in the both simulation and experiment. The left hand side of *Figure 5* show the simulation result (top) and the snap-shot of the experiment (bottom) at *t* = 0.02 second after the sphere touches the surface of the water, respectively.

On the other hand, the figurers in the right hand side are those at *t* = 0.03 second.

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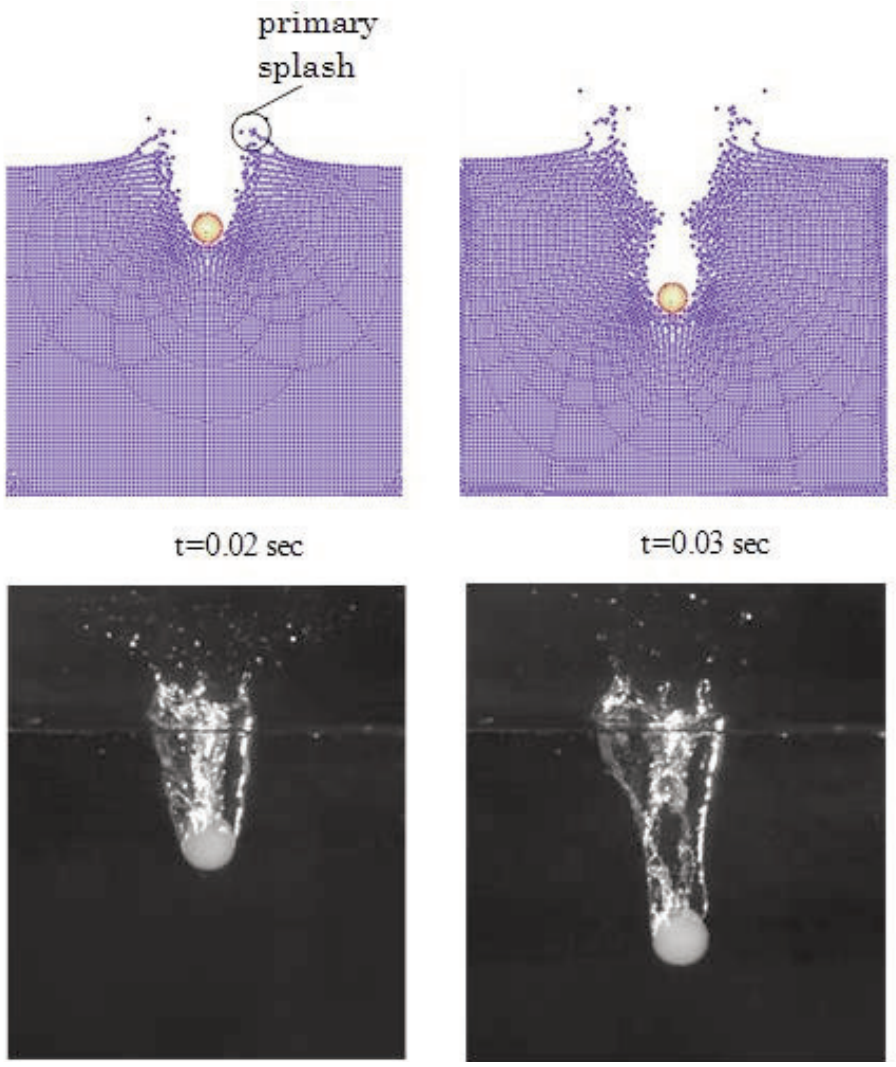

Figure 5:
Crown-type-splash of hydrogel (S = 100) by experiment and simulation, showing primary splash (t=0.02 sec) and air cavity (t=0.03 sec), respectively

The first splash, which is observed just after the hydro-gel sphere is dropped into water is called the primary splash. It is noted that the patterns of the crown-type splash and the air cavity by the present simulation are very similar to the experimental ones and that the above crown-type form and the occurrence of the air cavity are not seen in the case of the acrylic resin sphere. ●

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Manufacturing and Processing of New Particulate-Based Materials: Multiphysics, Modeling and Simulation

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Particle-based mechanics and numerical methods have become wide-spread in the natural sciences, industrial applications, engineering, biology, applied mathematics and many other areas. The term "particle mechanics/methods" has now come to imply several different areas of research in the 21st century, for example: (1) Particles as a physical unit in granular media, particulate flows, plasmas, swarms, etc., (2) Particles representing material phases in continua at the meso-, micro- and nanoscale and (3) Particles as a discretization unit in continua and discontinua in numerical methods.

The application areas of particle-based methods are quite wide-ranging, for example: (1) Particulate and granular flow problems, motivated by high-tech industrial processes such as those stemming from spray, deposition and printing processes; (2) Fluid-structure interaction problems accounting for free surface flow effects on civil and marine engineering (water jets, wave loads, ship hydrodynamics and sea keeping situations, debris flows, etc.); (3) Coupled multiphysical phenomena involving solid, fluid, thermal, electromagnetic and optical systems; (4) Material design/functionalization using particles to modify base materials; (5)Manufacturing processes involving forming, cutting, compaction, material processing; (6) Biomedical engineering, involving cell mechanics, molecular dynamics and scale-bridging; (7) Fracture and fragmentation of materials and structures under impact and blast loads; and (8) Excavation and drilling problems in the oil/gas industry and tunneling processes.

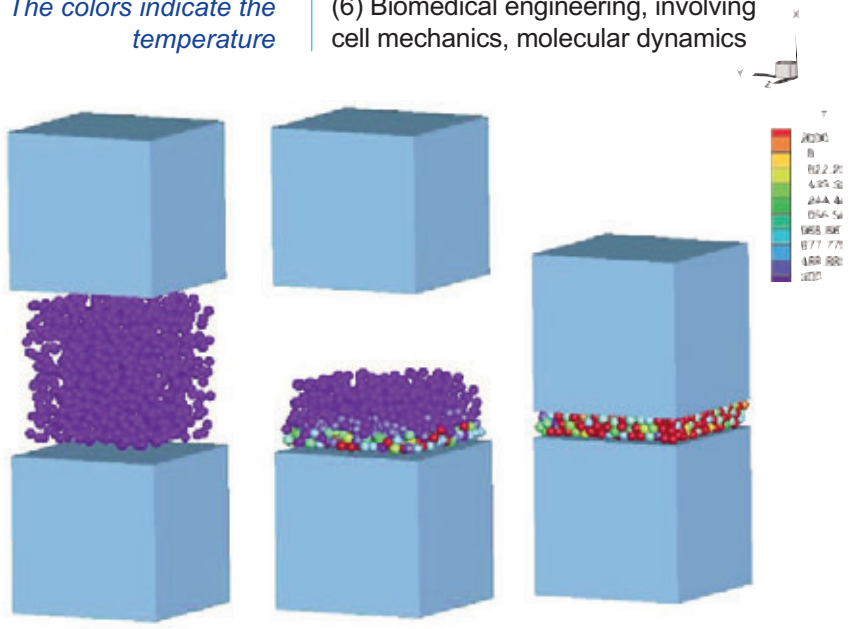

Figure 1: *A series of frames for compaction (side walls not shown) Left to right: (1) Pouring of the particles (2) Contact with the lower electrified wall and (3) Contact with the upper and lower electrified wall [55] The colors indicate the temperature*

Over fifty percent of the raw materials handled in industry appear in powdered form during the various stages of processing. Recently, several manufacturing applications have arisen that involve the multiphysical response of particulate systems in the presence of strongly coupled electromagnetic, optical and thermal fields. In many cases, there is significant multifield coupling, which requires methods that can capture the unique and essential physics of these systems. In this article, the modeling and simulation of three interrelated manufacturing applications, involving particle-based materials, are discussed:

- *Rapid compaction and electrically-aided sintering of materials comprised of heterogeneous powders:* Such processes utilize the material's inherent resistance to flowing current, resulting in Joule-heating to sinter the powder. The process has great promise, since it produces desired materials without much post-processing. Furthermore, it has advantages over other methods, such as high purity of processed materials, in particular since there are few steps during the approach (*Figure 1*).
- *Charged particulate jet sprays and droplets:* Such processes are motivated by microtechnology (electrostatic copiers, inkjet printers, powder coating machines and a variety of small-scale manufacturing processes), where a successful analysis requires the simulation of flowing particulate media involving simultaneous near-field interaction between charged particles and momentum exchange through thermo-mechanical contact (*Figure 2*).
- *Selective laser-assisted processing:* Such processes involve harnessing optical energy which, due to the monochromatic and collimated nature of lasers, provide an attractive way to postprocess (anneal, bond, drill, cut, etc.) powdered materials. Simulation of this process requires algorithms for tracking

the propagation of optical energy through the material microstructure, its conversion into heat and subsequent phase transformations (*Figure 3*).

The article is structured in way that the applications are laid out, and the needed computational methods are broadly outlined. More detailed information is provided in the references.

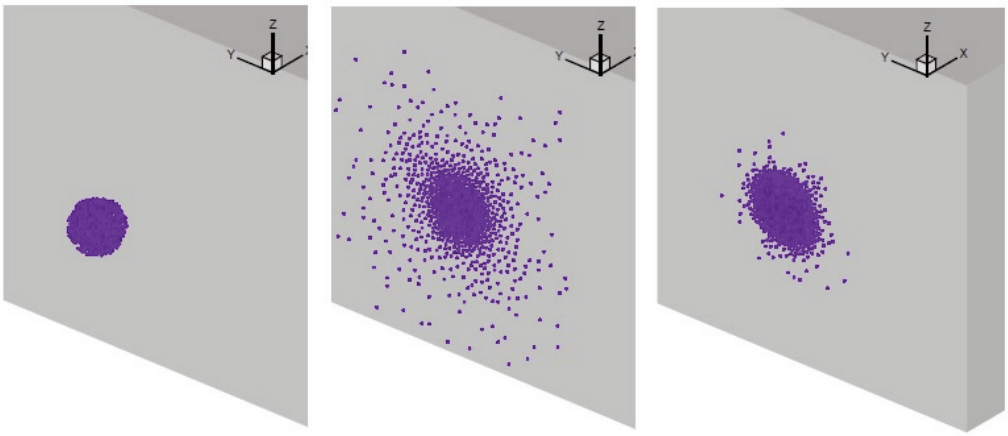

Figure 2:
Starting configuration (left frame) and post impact droplets [53]. For moderate (middle frame) and strong (right frame) electric fields on the substrate surface

Rapid compaction and electrically-aided sintering

Physical process: One commonly used approach used in processing powdered materials is sintering. Generally, sintering refers to processing a powdered material, comprised of fine-scale particles, by compacting it in a press (*Figure 1*) and utilizing heat to bind the material. Sintering has distinct advantages over other methods, for example (1) high purity of processed materials, (2) relatively few steps in fabrication (thus retaining the purity) and (3) the production of near net-shape of the desired product. Most importantly it is a method that can be utilized to produce products with complex shapes that cannot be easily made with other methods. Innovative methods for processing compacted microscale powders are rapidly being developed in industry in order to meet the specifications demanded by new products. The delivery of heat can be achieved in a variety of ways, for example, by heating the walls of the press, with the heat transfer taking place primarily by thermal conduction. In an effort to enhance the heat transfer process, in particular within the interior of the material to be processed, electrically-aided heat generation, drawing upon the material's inherent resistance, via Joule-heating, is one method, that appears to be quite promising.[1]

Computational needs: In order to simulate such a process in a rapid manner, one approach is to develop direct particle-based models which capture three main physical events:

- *particle motion/dynamics*, which primarily entails: (a) the movement of the particles induced by contact with the compressing walls and (b) particle-to-particle contact forces,
- *particle electrical current flow*, which primarily entails: (a) current flow through the particles and (b) current exchange between the particles and walls,
- *particle thermodynamics*, which primarily entails: (a) heat generation via Joule-heating, (b) heat transfer between particles in contact by conduction and (c) thermal softening of the particles.

This is a strongly-coupled multiphysical system, since the dynamics controls which particles are in mechanical contact, thus dictating the electrical contacts, which in turn controls the Joule-heating and the induced thermal fields, thus softening and binding the material. For example, the approach taken by the author is to construct a submodel for each primary physical process mentioned above. These submodels are coupled to one another.
One approach to resolve the coupling would be a recursive multiphysical staggering scheme as follows (at a given time increment): (1) each field equation is solved individually, "freezing" the other (coupled) fields in the system, allowing only the primary field to be active and (2) after the solution of each field equation, the primary field variable is updated, and the next field equation is treated in a similar manner.
As the physics changes, the field that is most sensitive (exhibiting the largest amount of relative nondimensional change) dictates the time-step size. This approach can be classified as an implicit, staggered, time-stepping scheme, in conjunction with an iterative solution method that

[1] *Consistent, high-quality, particles can be produced in a variety of ways, for example (1) melting and vaporizing of metals and other materials, and harvesting the subsequent particles, (2) atomization of liquid streams into droplets by breaking jets of metal, (3) reduction of metal oxides and comminution/pulverizing of bulk material. The particles are usually passed through a series of sieves to separate particles of various sizes.*

automatically adapts the time-step sizes to control the rates of convergence within a time-step. If the process does not converge (below an error tolerance) within a preset number of iterations, the time-step is adapted (reduced) by utilizing an estimate of the spectral radius of the coupled system. The modular approach allows for easy replacement of submodels, if needed. Some results are depicted in *Figure 1* [55].

The approach outlined here can be thought of as a middle ground between semi-analytical approaches, which provide qualitative information [51], and computationally-expensive "brute-force" continuum approaches [48, 50], which attempt to resolve the evolution of finescale thermal gradients, transient electromagnetic fields, stress fields and chemical/damage fields by solving a coupled system of PDE's associated with (1) Maxwell's equations, (2) the first law of thermodynamics, (3) the balance of linear momentum and (4) reaction-diffusion laws. For the mentioned "brute-force" continuum approach to accurately resolve the coupled time-transient spatial electromagnetic, thermal, mechanical and chemical fields, [48] developed a staggered, temporally-adaptive, FDTD (Finite Difference Time Domain) method.

This is a computationally intensive approach, owing to the fact that one needs literally millions of numerical unknowns, due to the fine mesh sizes needed. However, it is obvious that for a deeper understanding of the deformation within a particle, it must be treated as a deformable continuum, which would require a highly-resolved spatial discretization, for example using the Finite Element Method for the contacting bodies. For the state of the art in Finite Element Methods, see [37].

Charged particulate jet sprays and droplets

Physical process: In many modern large-scale printing and spray processes, the deposition of particulate-laden fluids are of primary importance. The behavior of an impacting cluster-droplet is of particular interest, and has wide-ranging applications to inkjets and industrial coatings, etc. In many cases, the deposited material is guided to the surface by electric fields. A central issue is the determination of the electrical field strength on the surface, which leads to a coherent droplet deposition, versus a droplet that will break apart, motivated by coating technologies (for example epitaxy and electrostatic painting) that ionize particulates and electrify surfaces to capture the particles, in order to enhance the quality of coating. Relative to a charge-free and electric-field-free system, the resulting coatings can be more accurately controlled, provided the system parameters are appropriately set. The particles are endowed with charges through a variety of possible methods, such as: (1) Post atomization charging - whereby the particles come into contact with an electrostatic field (produced by electrostatic induction or by electrodes) downstream of the outlet nozzle; (2) Direct charging - whereby an electrode is immersed in the coating supply; and (3) Tribological charging - whereby the friction in the nozzle induces an electrostatic charge on the particles as they rub the surface see [28, 29]. Improper handling of these clusters can lead to manufacturing inconsistencies/variability which can strongly affect the overall product quality, in particular if the manufactured devices have small dimensions.

Computational needs: In order to simulate such a process in a rapid manner, one approach is to develop a direct particle-based model for the simulation of the dynamics of collections of charged particles, initially in the form of "cluster-droplets", and the resulting impact behavior of such clusters on electrified surfaces. An overall model, amenable to numerical simulation, is constructed by assembling submodels of the multistage physical events in order to form a system that is solved numerically, in a staggered manner. Specifically, the author has developed a numerical strategy whereby the dynamics of charged particles, accounting for their collisions, inter-particle near-fields and interaction with external electromagnetic fields are all computed implicitly in an iterative, modular, manner. The numerical approach was based on an implicit, staggered, time-stepping scheme that separates the impulsive and continuous forces between particles, in conjunction with an iterative solution method that automatically adapts the time step sizes to control the rates of convergence within the time step. Some results are depicted in *Figure 2*.

Selective laser-assisted processing

Physical process: In order to meet the specifications demanded by new products, novel additive manufacturing techniques, which involve processing of high-density particle-laden materials are being developed. Examples include particulate spray coatings, particle-laden ink deposition

The journal Computational ParticleMechanics (CPM), has been launched with the goal of publishing original articles addressing the modeling and simulation of systems involving particles and particle methods and to enhance communication among researchers in the applied sciences.
(http://www.springer.com/materials/mechanics/journal/40571)
T. I. Zohdi, E. Onate & P. Wriggers; Editors-in-Chief

of printed electronics and compacted particulate powders.[2] Many of these techniques involve laser driven thermal processing, such as sintering, annealing, melting, drilling, polishing and ablation, which is achieved by melting and vaporization of the discrete particulate materials when they are packed together. Because of the monochromatic and collimated nature of lasers, they are an attractive way to post-process (anneal, bond, drill, cut, etc.) powdered materials, in particular with pulsing, via continuous beam chopping or modulation of the voltage.[3] The upper bound for the power of a typical industrial laser is approximately 6000 Watts. Typically, the initial beam produced is in the form of collumated (parallel) rays that are 1-2 mm apart, which are then focussed with a lens onto a small focal point (approximately 50 mm away) of no more than about 0.00001 m in diameter. As the material changes phase from solid to liquid, its absorptivity increases, thus increasing the depth of the cut/hole. While this is the primary way a laser is used in cutting materials, variants include reactive cutting where the laser is used as an ignition source for a flame or thermal stress cracking whereby large thermal gradients are induced causing thermal expansion, stresses and fracture. It is important to note that pulsing the laser (as opposed to a continuous beam) to control the heat affected zone is important when heating the whole piece is undesirable. In summary, because of the extremely tight profit margins and short turn-around times in manufacturing of new materials, there is an industrial need for numerical simulation of laser post-processing of particulate based-materials, in order to reduce time-consuming experiments.

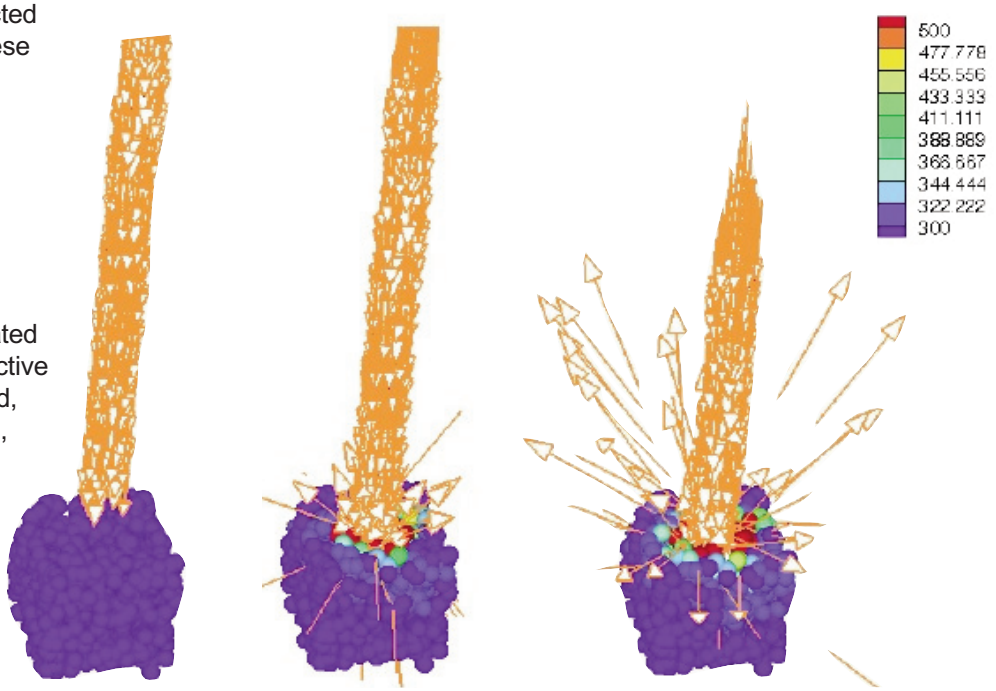

Figure 3: *Contact and propagation of a laser beam with compacted powder [54]. The colors indicate the temperatures.*

Computational needs: In order to simulate such a process in a rapid manner, the approach pursued by the author is to develop a computational tool by assembling relatively simple, physically meaningful, models at the small scale, for many interacting particles, in order to allow much more refined estimates of the resulting overall system temperature and, ultimately, its change of phase from a solid, to a liquid to a gas. Specifically, the author has developed a reduced-order computational model and corresponding solution algorithm for the rapid simulation of the laser processing and targeted localized heating of materials composed of discrete particles that are packed together [54]. Such materials possess a complex microstructure which contains gaps and interfaces. This type of process is extremely difficult to simulate using continuum-based methods, such as the Finite Difference Time Domain Method or the Finite Element Method. The reduced-order model captures the main physical effects. The features of the reduced-order computational model are (1) a discretization of a concentrated laser beam into rays; (2) a discrete element representation of the particulate material microstructure; and (3) a discrete element transient heat transfer model that accounts for optical (laser) energy propagation (reflection and absorption), its conversion into heat, the subsequent conduction of heat and phase transformations involving melting and vaporization. In [54], a discrete ray-tracking algorithm was developed, along with an embedded, staggered, iterative solution scheme, in order to calculate the optical-to-thermal conversion, particle-to-particle conduction and phase-transformations, implicitly (Figure 3). ●

[2] *There are a large variety of deposition techniques, and we refer the reader to the surveys of the state of the art found in [28, 29].*
[3] *For example, Carbon Dioxide (CO2) and Yttrium Aluminum Garnett (Y AG) lasers are commonly used.*

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The Role of Quadrature in Meshfree Methods:
Variational Consistency in Galerkin Weak Form and Collocation in Strong Form

by
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Quadrature Issues in Galerkin Meshfree Methods: Loss of Galerkin Orthogonality Leading to Suboptimal Convergence

Meshfree methods introduce new approximations for solving PDEs without using conventional meshing topology, as shown in *figure 1*. This reduces the strong tie between the quality of the discretization and the quality of the approximation, and can ultimately ease the difficulty of mesh distortion problems. The functions used in meshfree methods such as moving least-squares (MLS) and reproducing kernel (RK) approximations can be constructed with arbitrary order of completeness and continuity. These unique properties provide the opportunity to solve problems that are difficult or impossible to be solved by conventional finite element methods, and *it admits the development of paradigms for solving PDEs without being restricted to Galerkin type procedures.*

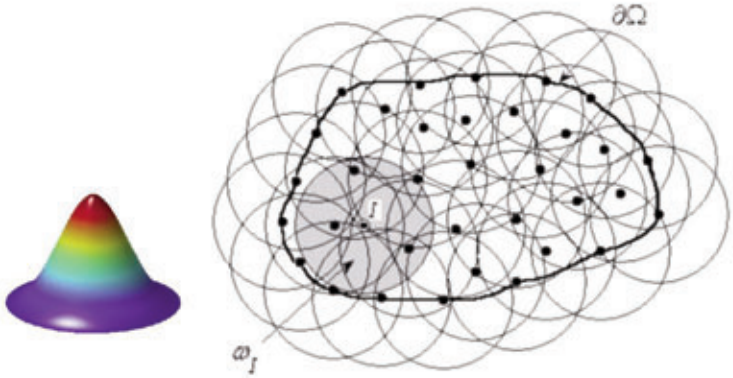


Figure 1:
Meshfree approximation function and domain discretization by points

A critical issue in Galerkin meshfree methods is domain integration, typically carried out by Gauss integration (GI) or direct nodal integration (DNI). The MLS and RK approximations shown in *figure 1* are typically *rational functions with overlapping supports*. These approximations are capable of reproducing monomials of arbitrary order in arbitrary discretizations; however, this completeness property does not guarantee optimal rates of convergence in the Galerkin solution of PDEs if the domain integration is not sufficiently accurate. The quadrature error in the Galerkin equation also leads to the *loss of Galerkin orthogonality* as shown in *figure 2*, where u^h and u^{hh} are the solutions of the Galerkin equation without and with quadrature error, respectively. *Violation of Galerkin orthogonality leads to the loss of the best approximation property of the Galerkin solution* according to Strang's first Lemma [1]. This can be demonstrated by solving a PDE with a linear solution given in *figure 3*, where RK approximation with linear basis is introduced, and the exact linear solution is not obtained. Errors in this linear problem are also reflected in sub-optimal convergence when solving the problem with a higher order solution shown in *figure 4*, where optimal convergence rates (2 in the L^2 norm and 1 in the semi-H^1 norm) are not obtained, even with 5x5 GI.

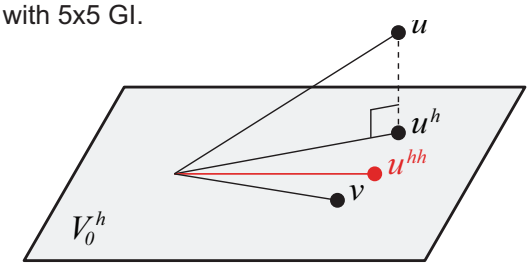
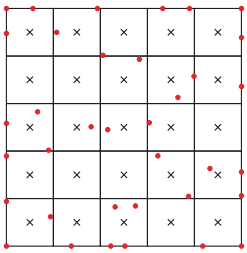


Figure 2:
Projection of true solution u into finite dimensional space: Galerkin solution u^h without quadrature error and u^{hh} with quadrature error

$\nabla^2 u = 0$ in Ω
$u = x + 2y$ on $\partial\Omega$
$\Omega = (-1, 1) \times (-1, 1)$
MLS/RK: linear basis



L2 error norm

DNI	0.0321744
Gauss, 1x1	0.0068057
Gauss, 2x2	0.0016625
Gauss, 3x3	0.0005414
Gauss, 4x4	0.0002542
Gauss, 5x5	0.0000913

Figure 3:
Linear exactness test of meshfree methods with linear basis using various domain integration methods (red solid dots: discretization points, cross symbols: Gauss quadrature points in GI)

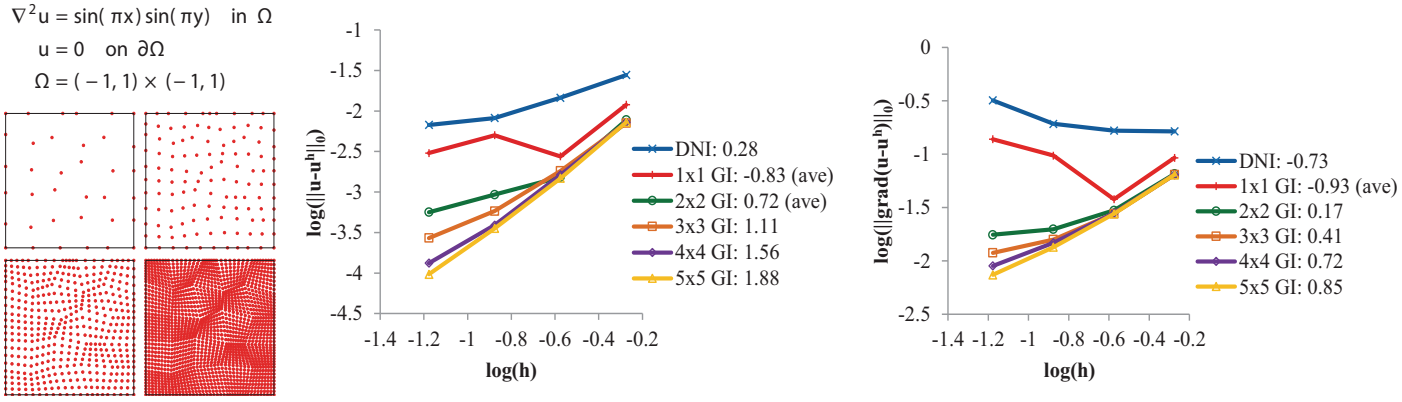


Figure 4: *Convergence of the Galerkin meshfree method with various integration methods for a Poisson problem with a higher order solution*

Recovery of Galerkin Orthogonality by Variational Consistency

One of the early attempts to recover Galerkin orthogonality in meshfree methods was the development of stabilized conforming nodal integration (SCNI) [2, 3], where the Galerkin orthogonality is approximated by imposing the following first order integration constraint to achieve *first order Galerkin exactness:*

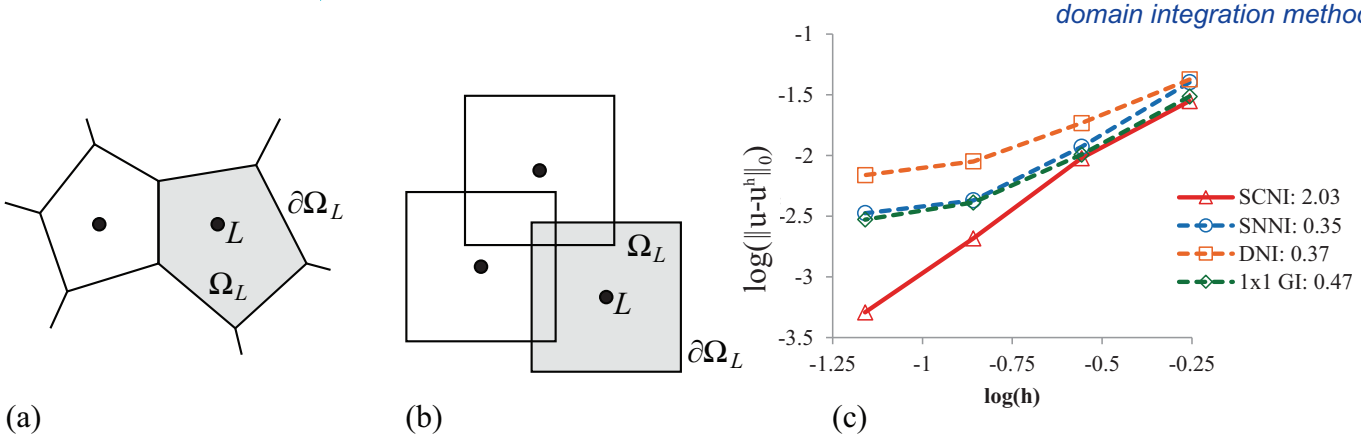
$$\hat{\int_{\Omega}} \nabla \Psi_I(\mathbf{x})\, d\Omega = \hat{\int_{\partial\Omega}} \Psi_I(\mathbf{x})\mathbf{n}\, d\Gamma \quad \forall I \tag{1}$$

Here, the superposed "^" denotes the numerical integration, $\Psi_I(\boldsymbol{x})$ is the meshfree approximation function associated with point I, and $\mathbf{n}$ is the unit outward surface normal. *A quadrature rule that satisfies the divergence condition in (1) recovers first order Galerkin orthogonality.* In SCNI [2], gradient smoothing under an assumed strain framework has been introduced to meet the integration constraint (1):

$$\overline{\nabla} u^h(\mathbf{x}_L) = \frac{1}{A_L}\int_{\Omega_L} \nabla u^h(\mathbf{x})\, d\Omega = \frac{1}{A_L}\int_{\partial\Omega_L} u^h(\mathbf{x})\mathbf{n}(\mathbf{x})\, d\Gamma \tag{2}$$

where $A_L = \int_{\Omega_L} d\Omega$ and Ω_L is the conforming representative domain of point L as shown in *figure 5(a)*. It can be shown that SCNI recovers quadratic rate of convergence in the L^2 norm when a linear basis is used as shown in *figure 5(c)*. When SCNI is simplified to stabilized nonconforming nodal integration (SNNI) [4] with nonconforming smoothing domains as shown in *figure 5(b)*, Galerkin orthogonality is lost and poor convergence is again encountered similar to that in GI and DNI as shown in *figure 5(c)*. *The recovery of Galerkin orthogonality in SCNI can be viewed as introducing a corrected finite dimensional space for the gradient as shown in figure 6, to recover the solutions u^h from u^{hh}.* The SCNI method has been enhanced with additional stabilization [5,6], and has also been applied to meshfree methods for plates and shells [7, 8, 9] and other meshfree methods such as the natural element method [10].

Figure 5: *(a) Conforming Voronoi smoothing domains for SCNI, (b) nonconforming smoothing domains for SNNI, (c) convergence in the L^2 norm for various domain integration methods*



A general framework for achieving n^{th} order Galerkin exactness (thus recovering n^{th} order Galerkin orthogonality) is the recent work in [11] which introduces the concept of *variational consistency (VC)*. VC dictates that for achieving n^{th} order Galerkin exactness, the following general n^{th} order integration constraints must be satisfied in addition to using n^{th} order completeness of trial functions:

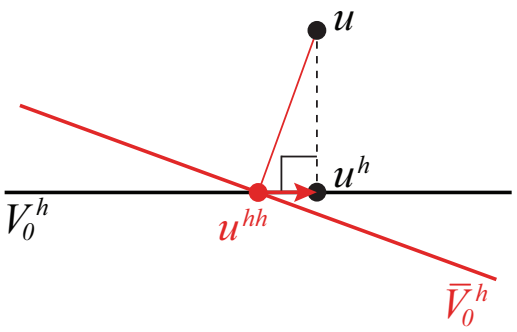


Figure 6: *Recovery of Galerkin orthogonality by a correction of finite dimensional space*

$$a\langle \hat{\Psi}_I, \mathbf{x}^\alpha \rangle_\Omega = -\langle \hat{\Psi}_I, L\mathbf{x}^\alpha \rangle_\Omega + \langle \hat{\Psi}_I, B\mathbf{x}^\alpha \rangle_{\partial\Omega} \; \forall I, \; |\alpha| = 0,1,\cdots,n \tag{3}$$

where $a\langle \cdot,\cdot \rangle_\Omega$ is the quadrature version of the bilinear form, $\langle \cdot,\cdot \rangle_\Omega$ and $\langle \cdot,\cdot \rangle_{\partial\Omega}$ are the quadrature versions of inner products of two functions in the domain and on the boundary, respectively, L and B are the differential operator and the Neumann boundary operator of a boundary value problem, respectively, $\mathbf{x}^\alpha$ is the multi-dimensional representation of a monomial with degree α, $|\alpha|$ denotes the norm of multi-dimensional index, and $\hat{\Psi}_I$ is the test function. The equation in (3) states that a numerical integration by parts condition should hold for the inner product between test functions and the differential operator acting on n^{th} order monomials. *It can be shown that SCNI possesses first order variational consistency while GI, DNI, and SNNI are in general not variationally consistent with the meshfree approximation functions [11,12].*

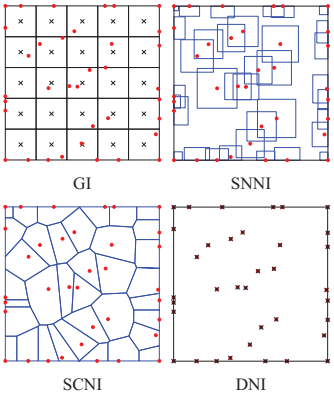
Variational Consistency for Recovery of Optimal Convergence

VC provides a paradigm for formulating quadrature rules and test functions to achieve optimal convergence for a given PDE, and it can also be used to correct methods that are variationally inconsistent via modification of test functions to recover Galerkin orthogonality as shown in *figure 6*. The construction of the test function gradients proposed in [11] for achieving the n^{th} order integration constraint in (3) is performed by introducing a corrected test function gradient

$\nabla\hat{\Psi}_I = \nabla\Psi_I + \sum_{|\beta|\le n} \xi_{\beta I} \nabla\hat{\Psi}_I^\beta$, where $\{\Psi_I, \hat{\Psi}_I^\beta\}_{|\beta|=1}^n$ are linearly independent, and the coefficients $\xi_{\beta I}$ are solved from the following equation:

$$\sum_{|\beta|=1}^{n} A_{\alpha\beta I}\xi_{\beta I} = r_{\alpha I} \; \forall I, \; |\alpha| = 0,1,\cdots,n \tag{4}$$

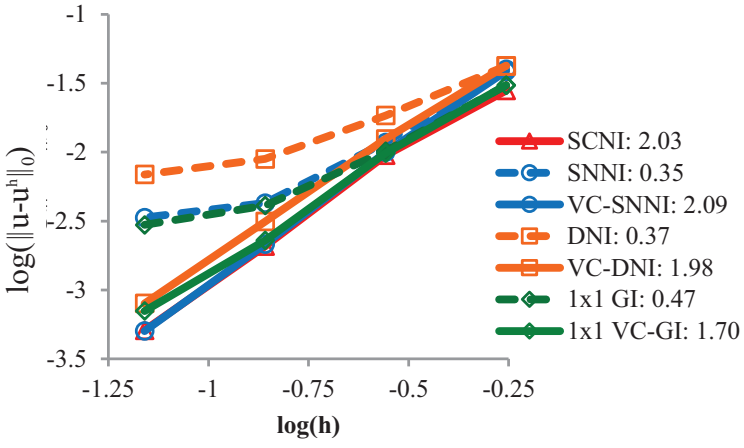
$\nabla^2 u = 0 \quad \text{in } \Omega$
$u = x + 2y \quad \text{on } \partial\Omega$
$\Omega = (-1,1) \times (-1,1)$



(a)

Method	L2 error
DNI	0.593025
SNNI	0.282710
SCNI	2.46E-14
1x1 GI	0.123775
2x2 GI	0.048582
3x3 GI	0.021067
4x4 GI	0.007910
5x5 GI	0.003436
VC-DNI	2.70E-14
VC-SNNI	1.67E-14
1x1 VC-GI	1.57E-14
2x2 VC-GI	2.71E-14
3x3 VC-GI	1.32E-14
4x4 VC-GI	1.77E-14
5x5 VC-GI	2.90E-14

(b)



(c)

Figure 7:
(a) Two dimensional linear exactness test,
(b) L^2 errors in various domain integration methods and their VC corrected counterparts,
(c) L^2 convergence rates

where $A_{\alpha\beta I}$ and $r_{\alpha I}$ are the components of the linear system matrix and the residual vector, respectively, obtained from substituting $\nabla\hat{\Psi}_I = \nabla\Psi_I + \sum_{|\beta|\le n} \xi_{\beta I} \nabla\hat{\Psi}_I^\beta$ into (3). The residual term $r_{\alpha I}$ represents the violation of integration constraint in (3). Here it is worth noting that with proper selection of $\nabla\hat{\Psi}_I^\beta$, $A_{\alpha\beta I}$ can be diagonalized for fast computation. Since the type of numerical integration to be corrected is arbitrary in (4), several variationally consistent methods have been derived under a unified framework [11].

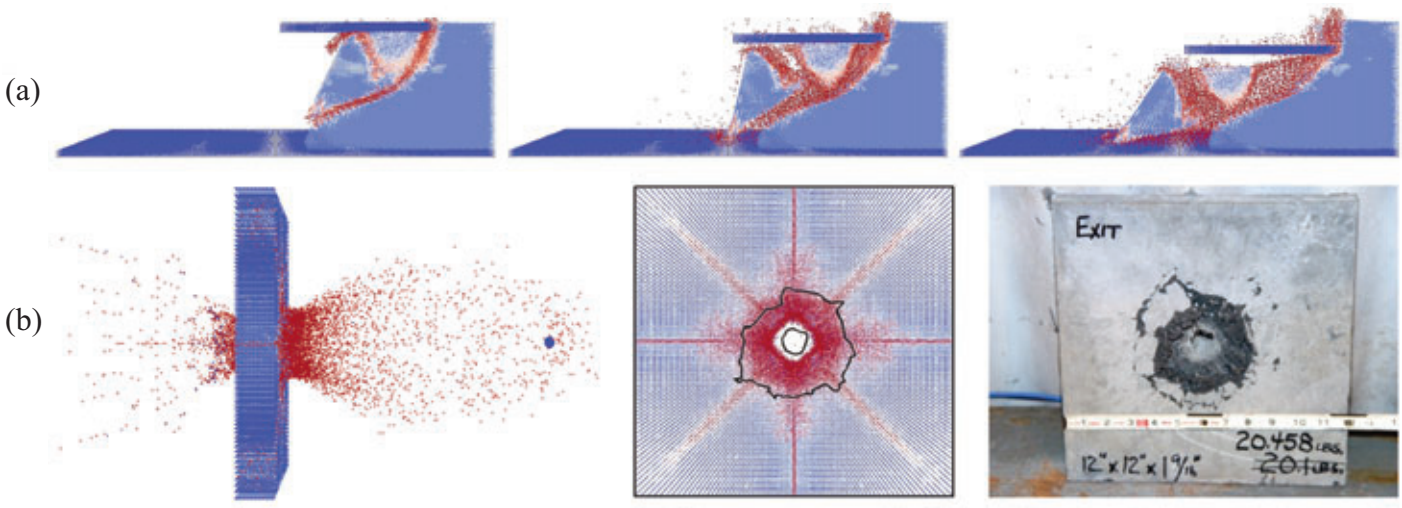


Figure 8: *Meshfree modeling of (a) slope instability, and (b) bullet penetration through a concrete plate*

Using the integration schemes shown in *figure 7(a)*, a PDE with a linear solution shown in *figure 7(b)* is solved using the RK with linear basis. The results given in *figure 7(b)* demonstrate VC integration methods achieve the exact linear solution, and the results in *figure 7(c)* demonstrate the recovery of optimal convergence rates for domain integration methods corrected by VC for problems with higher order solution. VC recovery of higher order convergence for solving PDEs with higher order basis is also reported in [11]. *Figure 8* demonstrates the application of the Galerkin meshfree method to problems involving large deformations, failure and fragmentation processes [4, 13].

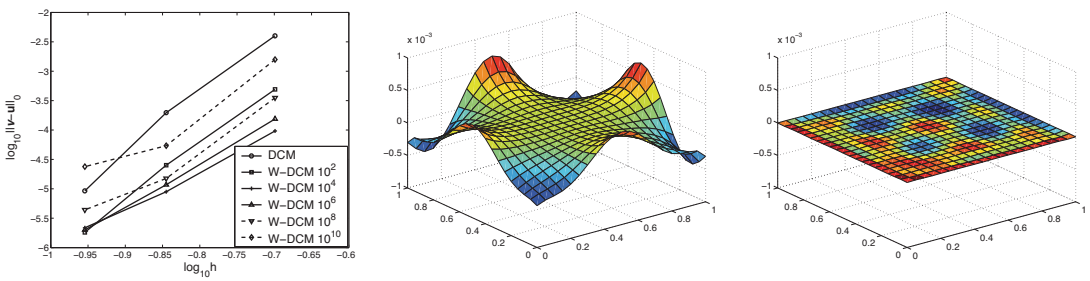
Strong Form Collocation Methods

Using the arbitrary smoothness of the meshfree approximation functions, collocation on the strong form has been proposed for meshfree methods, such as the finite point method [14], radial basis collocation methods (RBCM) [15, 16, 17, 18, 19, 20], and the reproducing kernel collocation method (RKCM) [21, 22].

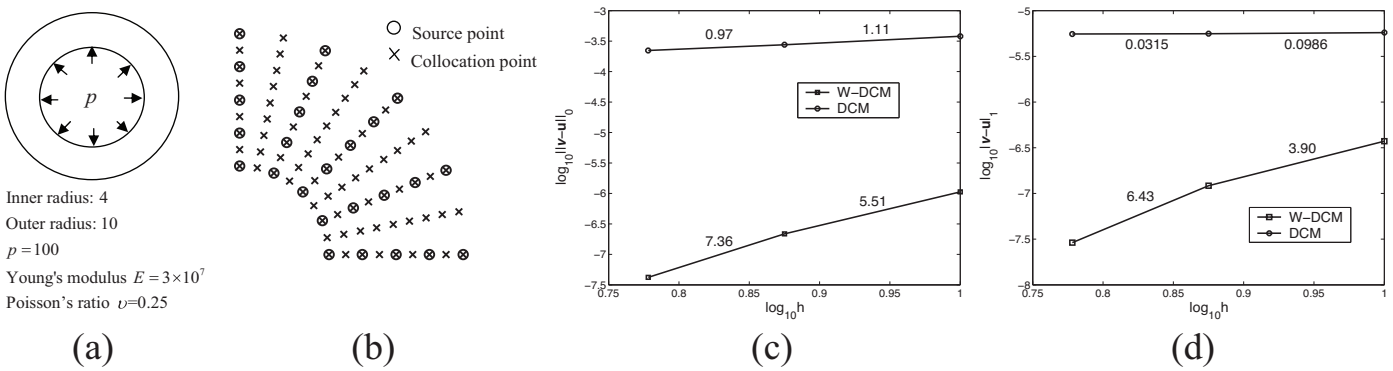
These methods directly circumvent the quadrature issues associated with the Galerkin methods. From the standpoint of convergence, the compactly supported RK approximations with monomial reproducibility render algebraic convergence in RKCM, and the nonlocal radial basis functions (RBFs) with certain regularity offer exponential convergence in RBCM. However, two major disadvantages have been identified in the strong form collocation method: (1) the unbalanced errors from the domain and boundary collocation equations lead to reduced accuracy and convergence rates, and (2) the linear system of RBCM is typically more ill-conditioned compared to those based on compactly supported approximations.

Figure 9: *(a) Convergence in the L^2 error norm (numbers associated with W-DCM denote the weights for the Dirichlet boundary collocation equations), (b) error distribution of DCM, (c) error distribution of W-DCM*

$$\Delta u = (x^2 + y^2)\, e^{xy} \text{ in } \Omega$$
$$u = e^{xy} \text{ on } \partial\Omega$$
$$\Omega = (0,1) \times (0,1)$$



(a) (b) (c)



(a) (b) (c) (d)

Figure 10:
(a) Problem statement of an infinite tube subjected to an internal pressure, (b) discretization of the quarter model, (c) convergence in the L^2 norm, (d) convergence in the H^1 semi-norm

Convergence and Conditioning of Collocation Methods

The issue of unbalanced errors of the domain and boundary collocation equations in the strong form with direct collocation method (DCM) was first investigated in [20]. This work first showed that the *employment of least-squares functionals with quadrature rules constitutes an approximation of the strong form collocation method*. Based on error analysis of a least-squares functional, a strong form solution procedure using a weighted direct collocation method (W-DCM) was then proposed for enhanced accuracy and convergence [20]. The analysis given in [20] concludes that the *weight* $\sqrt{\alpha}$ *for the Dirichlet boundary collocation equations should be in the order of* $\alpha = (\kappa N_p)^2$ *for optimal convergence*, where κ is the maximum coefficient involved in the differential operator and the boundary operator, and N_p is the number of discrete points used in the discretization. Consider a Poisson problem shown in *figure 9* solved by the strong form collocation method using multiquadrics radial basis functions, where the domain is discretized by 6x6, 8x8, and 10x10 discrete points. It is seen in *figure 9(a)* that the proposed W-DCM with properly selected weights for the Dirichlet boundary on the order of $\alpha = (\kappa N_p)^2 \approx 10^4$ yields the best solution accuracy and convergence rate, and it is a significant enhancement over the DCM solution as seen in *figures 9(b) and 9(c)*. The superior performance of W-DCM over DCM can also be seen in the tube inflation problem shown in *figure 10*.

Standard RBF offers exponential convergence; however the RBCM method suffers from large condition numbers due to its "nonlocal" approximation. The work in [23] constructed a localized RBF using a partition of unity function, such as the RK function, as a localizing function to yield a local approximation with significantly enhanced conditioning while maintaining the exponential convergence of RBF. In two-dimensional elasticity, the stability analysis in [23] shows that *the conditioning number of the RBCM of the order of* $O(h^{-8})$ *is reduced to* $O(h^{-3})$ *in the collocation method using RK localized RBF*. The RK localized RBF approach combined with the subdomain collocation method has been applied to problems with local features, such as problems with heterogeneity [24] and cracks [25]. It has also been shown that the collocation method with radial basis function (RBCM) can achieve very small dispersion error (<1%) compared to linear and quadratic finite elements [26]. Further, since the discrete system of the strong form collocation method is typically overdetermined and is solved by a least-squares method, mixed approximations can be introduced for constraint problems (such as incompressible problems) without suffering from instability due to violation of the LBB condition [27].

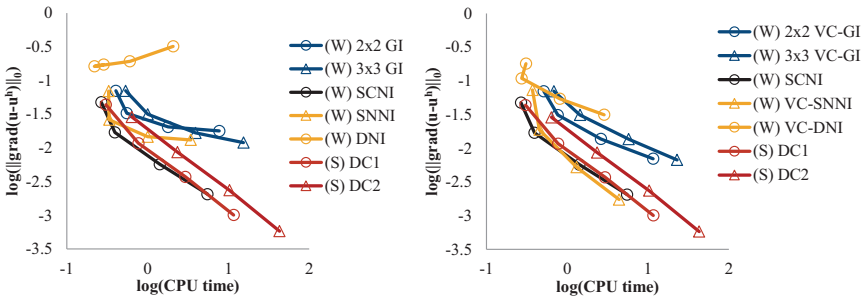


Figure 11:
Effectiveness comparison of meshfree methods based on weak and strong formulations

Comparison of Meshfree Methods based on Weak and Strong Formulations

The requirement of VC for integration in the weak formulation to recover Galerkin orthogonality originates from the introduction of integration by parts in the construction of the Galerkin weak equation. The strong form collocation method, on the other hand, does not invoke integration

by parts and is thus not subjected to the VC condition for optimal convergence. A comparison of the effectiveness of meshfree methods based on the Galerkin weak form approach (denoted with (W)) and collocation in the strong form (denoted with (S)) is shown in *figure 11*. In this study, RK approximations with linear bases are employed for the Galerkin weak form approach, and quadratic bases are used for the collocated strong form approach as necessary for convergence [22]. For the strong form collocation approach, the discrete points used as collocation points is denoted as DC1, and background collocation with half the spacing of the nodes is denoted as DC2. The results for the H^1 error norm show that the weak formulation using VC-SNNI and SCNI, and strong formulation using DC1 are the most effective methods for obtaining an accurate solution. It is interesting and informative to note that similar approaches ((S) DC2 and (W) 2x2 GI, and (S) DC1 and (W) DNI) can give drastically different results; without VC integration Galerkin methods can hardly compare in terms of efficiency. However with VC, Galerkin methods compare well to strong form collocation, particularly SCNI and VC-SNNI. A comparison of meshfree methods formulated based on weak and strong formulations is summarized in *table 1*. ●

Table 1:
Advantages and disadvantages of meshfree methods based on weak and strong formulations

Feature	Meshfree with Galerkin Weak Form	Meshfree with Strong Form Collocation
Overall effectiveness	Standard Galerkin methods with integration such as GI or DNI are not effective unless a VC method or a VC corrected integration is used. Out of all the methods, SCNI and VC-SNNI are the most effective.	Methods are effective as long as the number of collocation points is not too large. In particular, DC1 and DC2 are most effective.
Integration/collocation points	Too few integration points lead to sub-optimal convergence for the standard Galerkin method. For VC integration methods, nodal integration methods are sufficient for convergence.	Maintains reasonable convergence even with few collocation points as long as boundary collocation equations are properly weighted.
Nonuniform point distributions	Leads to sub-optimal convergence in the standard Galerkin method without higher order quadrature or VC correction. VC corrected integration methods yield good convergence and the solution is insensitive to the nonuniformity of the nodal distribution.	Solution accuracy and convergence is more sensitive to nonuniform point distributions than the Galerkin method.
Implementation	Similar to FEM.	Easier than FEM, except for nonlinear problems.
Additional advantages /disadvantages	• Easy coupling with FEM and has similar coding structure. • Compactly supported approximation functions used in weak form yields well-conditioned discrete system. • Very effective for large deformations, fracture problems, and h-adaptive refinements.	• RBCM yields exponential convergence and nearly zero dispersion error, but the discrete systems have high condition numbers. • RKCM is well-conditioned, but requires at least 2nd order basis in the RK functions. • No LBB instability in the mixed formulation and thus is attractive for constrained problems. • Requires 3rd derivatives in linearized equation of nonlinear 2nd order PDE.

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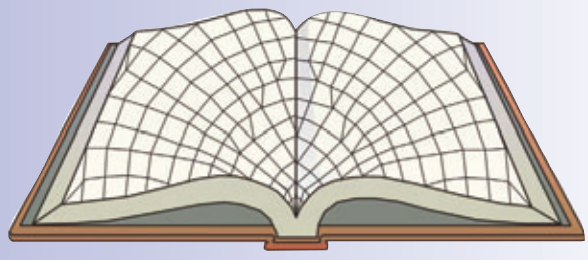
MODELING MATERIALS: CONTINUUM, ATOMISTIC & MULTISCALE TECHNIQUES



Ellad B. Tadmor and Ronald E. Miller
Cambridge University Press, UK, 2011

BOOK REVIEW

ISBN: 978-0521856980
786 pages, hard cover, $85 (List Price).
Contents: 1. Introduction; 2. Essential continuum mechanics and thermodynamics; 3. Lattices and crystal structures; 4. Quantum mechanics of materials; 5. Empirical atomistic models of materials; 6. Molecular statics; 7. Classical equilibrium statistical mechanics; 8. Microscopic expressions for continuum fields; 9. Molecular dynamics; 1 0. What is multiscale modeling?; 11. Atomistic constitutive relations for multilattice crystals; 12. Atomistic/continuum coupling: static methods; 13. Atomistic/continuum coupling: finite temperature and dynamics; Appendix; References; Index..

First, we have to describe the scope of this book, since its main title ("Modeling Materials") may give the wrong impression. The book does not offer a wide treatment of material modeling of various kinds, as this title may suggest. You will not find here, for example, much about the modeling of human-made composite materials, or rubber-like materials, or shape-memory alloys, or viscoelastic materials, or electro-active materials, or any fluids. A more descriptive main title would have been "Multiscale Modeling of Crystalline Materials," since this exactly defines the book's true scope. The secondary headline hints in this direction.

The subject, no doubt, is of extreme importance. There are various crucial processes and phenomena in solid mechanics that cannot be modeled in a robust way using the continuum level only. Examples include the behavior near a crack tip or a dislocation, and the formation of a shear band. In such processes, the various scales – from the atomistic scale to the macroscale – all play a role, and moreover the behavior in each scale affects that on the higher scale. This is described delightfully in Chapter 1 of this book, using pictures taken from an electron microscope, and tables for illustration. The challenge fronting modelers in this context is to describe the behavior on the macroscale while taking the effects of the smaller scales, up to the atomistic scale, into account. The two authors have done excellent research work in this area, which has been published as journal articles and presented in conferences and seminar talks. In this book they summarize this work, while supplying the reader with a lot of additional background material.

Given that the scope of the book as is indicated above, this is an exceptional book on the subject, and for more than one reason. First, it is extremely well written. The authors are very clearly talented writers. The text is thought provoking, original and crystal clear (no pun is intended). Second, the book is quite attractive to the eye. It is full with pictures and illustrations, and their captions are very detailed. Only from looking at the figures and reading the captions one can learn a great deal. The important equations appear in a "shaded" box. The whole appearance of the book is very inviting to read.

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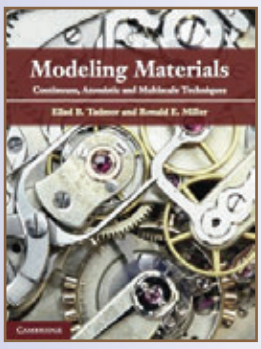
Ellad Tadmor


Ronald Miller



Third, there is a kind of attention to little stylistic details that is quite rare. The notation throughout the book is uniform – the authors have made a special effort to this effect despite the various scales involved, associated with different jargons in the literature. A helpful comprehensive table of notations is included at the beginning. Each chapter ends with a section entitled Further Reading, including a list of references with helpful comments on them, as well as a number of nice exercises. (A solution manual is available to course instructors on the book website.) Throughout the book there are interesting footnotes on historical and other matters. Finally, there is, of course, the fascinating theme of the book, namely multiscale analysis for bridging the atomistic and macro scales. For many of us who have lived most of our CM career in the macroscale world (continuum mechanics), the book is eye and mind opening.

The book is intended to be stand-alone, and requires only basic mathematical and physical knowledge. Most of the book serves as background material toward its climax which consists of the last two chapters (statics and dynamics). In the latter, the authors show how to solve the multiscale problems in the crystal. The wide background material is needed since the book offers a new view on the subject which involves many disciplines: atomistic structures, quantum mechanics, statistical mechanics, thermodynamics, etc. It should be pointed out that most of this background material is more associated with physics than with engineering or numerics. In fact, the book's content is on the interface between physics, materials engineering and CM. The advantage in this is the opportunity to bring concepts and ideas from physics to the CM world. However, the reader belonging to the CM community should be aware of the big investment required here.

What makes this investment even more demanding is the fact that the authors do not indicate anywhere to what extent the various chapters or sections depend on each other. For example, is reading the long discussion on thermodynamics essential in order to understand the last two chapters? It seems that some of the models neglect the effect of temperature (the authors relate to this as analysis with temperature 0K). Another example is quantum mechanics. Is careful reading of the whole of Chapter 4 on this subject essential? It seems that the atomistic models employed in the last two chapters are simplified models and not quantum-mechanical models in their full glory. It is true that in order to understand the way to derive the simplified models and their limitations, one has to understand quantum mechanics. But have the authors taken into account that they might lose those readers that are willing to accept the simplified models as established models and do not wish to go much deeper than that?

If the authors are ever to publish a second edition of this book, I strongly recommend that they relate in the Preface to this matter, by guiding the reader as to the dependencies of the various parts of the book, and by indicating how the reader may reach the last two chapters in shortened ways, if the reader so wishes. Perhaps this would require also to write parts of this book in a more modular way.

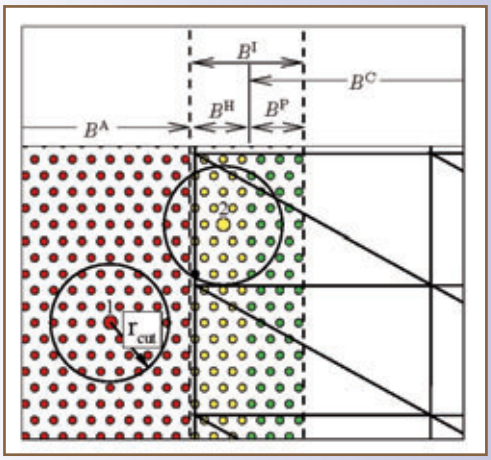


Figure 1:
Illustration of the idea of micro-macro coupling. A b&w version of this figure appears in the book as Fig. 12.3(a).

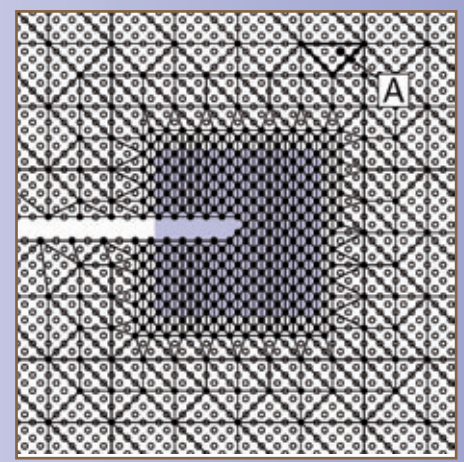


Figure 2:
A typical atomistic-continuum mesh used at the vicinity of a crack-tip. A b&w version of this figure appears in the book as Fig. 12.4.

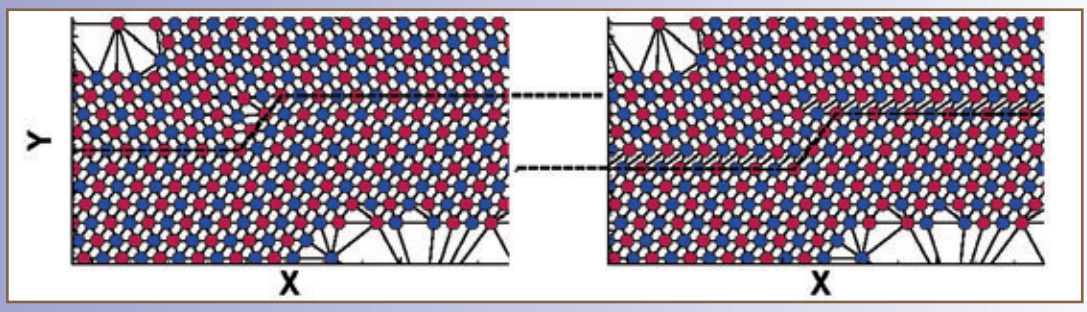


Figure 3. *Atomistic-continuum mesh used for the analysis of a twin dislocation. A b&w version of this figure appears in the book as Fig. 12.14*

Chapter 2 is a crash course on continuum mechanics and thermodynamics. Only material essential to the understanding of the remainder of the book is covered here. Chapters 3-9 cover many important topics on behavior at the atomistic and molecular levels. Chapter 10 is a review of multiscale methods in the context of crystalline materials. Chapter 11 shows how one can pass from the micro to the macro scale in the constitutive model, namely how a macroscale material law may be obtained from the microscopic relations. This passage makes use of statistical mechanics (chapter 7) and follows the work of Penrose and Lebowitz from 1971 and the kinematics of Cauchy-Born. The expressions obtained for the macro stresses and for the elasticity tensor are complicated, and hence the authors approximate them using the assumption that the motion of atoms from their mean location is small. They further simplify the expressions by assuming no temperature effects (0K). As a result the free energy reduces to the potential energy, and the simple expressions obtained are then used in the next chapters for the coupling of the scales.

Chapter 12 is perhaps the most important chapter in the book, and shows how to perform the atomistic-continuum coupling, for static problems. The FEM is introduced briefly here, since it is used at the continuum level. See Fig. 1. Next the authors survey a few energy-based and force-based coupling methods. Then the authors concentrate on their own method, QC (a 2D version of which is freely accessible as open source), and discuss its implementation. They compare the various methods via numerical examples. Table 12.1 summarizes the different methods very nicely. Application to solids with cracks and dislocations are discussed. See Figs. 2 and 3.

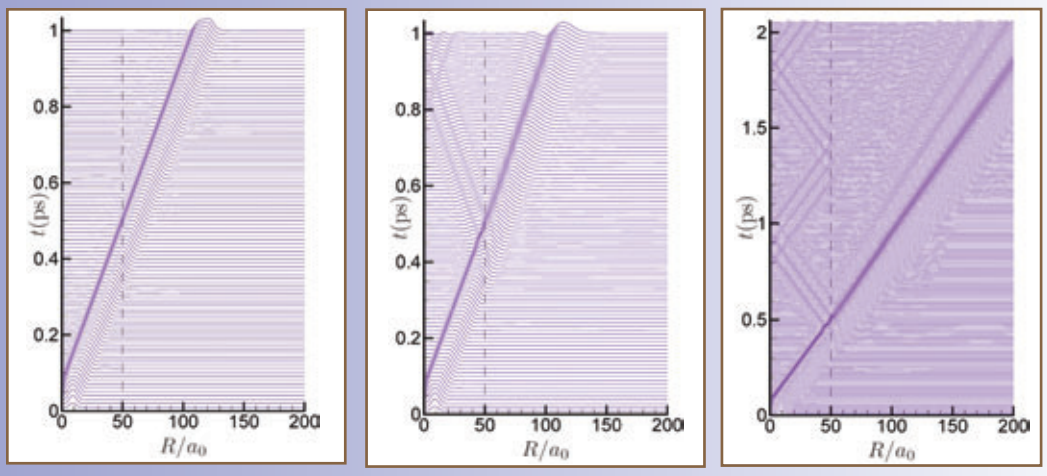


Figure 4: *Analysis of wave propagation in a crystal. A b&w version of this figure appears in the book as Fig. 13.4.*

Chapter 13 shows how to generalize the technique discussed in the previous chapter to dynamics, and how to take into account thermal effects. See Fig. 4, that shows the result of an analysis of wave propagation in a crystal. The time evolution is obtained via time stepping. The latter is done by using the "VV method" that has been introduced in Chapter 9 for molecular dynamics, and was invented in 1982 to analyze chemical processes. A closer look shows that this is nothing but the Newmark explicit method (central differences), that was invented in the context of structural dynamics as early as in 1959. The reader from the CM community may not appreciate the "foreign" jargon employed here for a standard CM method like Newmark, but I have not found other such occurrences in the book.

In summary, this is an excellent book that is highly recommended to CM researchers who are interested in the modeling of atomistic effects in continuum mechanics, and are willing to make the necessary investment required in reading the extensive physics-oriented parts of the book. As a final remark, the book is very heavy (physically), and should not be carried around if you are suffering from back problems. ●

Professor J. Tinsley Oden
awarded
The Honda Prize

Dr. J. Tinsley Oden, the director of the Institute for Computational Engineering and Sciences (ICES) and the associate vice president for research at The University of Texas at Austin, was awarded the Honda Prize 2013 for his role in establishing the field of computational mechanics.

The Honda Foundation, a public-interest foundation established by the Honda Motor Company's founder Soichrio Honda and his brother Benjiro Honda, created the Honda Prize in 1980 to acknowledge the efforts of an individual or group who contributes new ideas in ecotechnology, a field that works to advance human achievement while concurrently preserving the natural environment. The prize is awarded annually.

Dr. Oden, who was a founding member and second president of the IACM, and the first president of the United States Association for Computational Mechanics (USACM), is the 34th Honda Prize laureate. An award ceremony was held in his honor at the Imperial Hotel in Tokyo on Nov. 18, 2013. He is world renowned for his contributions in establishing and developing the field of computational mechanics and is credited with a wide range of contributions to the field embodied in hundreds of scientific papers and 27 books on the subject.

He has received many awards in recognition of his scientific contributions, including being knighted by the French government and receiving the Computational Mechanics Medal from the Japanese Society of Mechanical Engineers. He has been awarded six honorary doctorates from institutions in Europe and the United States.

In addition, Dr. Oden has received the Theodore von Karman Medal from the American Society for Civil Engineering in Engineering Mechanics in 1992, the John von Neumann Medal from USACM in 1993, the Newton-Gauss Congress Medal of the IACM in 1994, and the Stephen P. Timoshenko Medal from the American Society of Mechanical Engineers in 1996, among other awards.

by
Genki Yagawa & Noboru Kikuchi

Figure 2:
J.Tinsley Oden and H. Ishida, President of the Honda Foundation

Figures 3 (above) and 4 (below):
Barbara and Tinsley with Colleagues

IACM and ECCOMAS
are pleased to announce the
joint organization of

11th. World Congress on
Computational Mechanics
(WCCM XI)

and

5th. European Conference on
Computational Mechanics
(ECCM V)

6th. European Conference on
Computational Fluid Dynamics
(ECFD VI)

20 - 25 July 2014 - Barcelona, Spain

www.wccm-eccm-ecfd2014.org

ACCM2013

1st Australasian Conference on Computational Mechanics

Sydney, Australia 3-4 October 2013

by
Professors *Grant Steven*
and
Qing Li

On October 3rd and 4th of 2013 a special event in the history of Australian Computational Mechanics (CM) took place. We had our first official Australian Association for Computational Mechanics (AACM) conference at the University of Sydney and it was a great success. The prime goals were to:

- Bring the Australia and surrounding community together. This allows the members of this community to meet each other and make new friends and potential colleagues. Such new connections would be good for promoting research networks and enhancing funding opportunities.
- To enable younger researchers to meet senior members and local heroes and thereby seek out employment opportunities and career prospects in relevant areas.
- To promote the membership of the Australian Association for Computational Mechanics (AACM) and International Association for Computational Mechanics (IACM) in the region. Every registration included a two year membership fee for both AACM and IACM, thereby increasing significantly the number of Australians in IACM (totalling 181 members)
- Through the AACM website we are encouraging more Australians to participation in international events such as Asian Pacific Congress on Computational Mechanics (APCOM) and World Congress on Computational Mechanics (WCCM).
- To ensure the best quality of review of conference proceedings, thereby enabling the accepted papers to be published in a Scopus and Thomson Reuters cited journal, this helps all members, in particular postgraduate students and early career researchers, of Australian CM community in many different ways relating to career progression.

The conference was opened by the AACM Director, Professor Grant Steven, with remarks about the origins of CM in Australia and the reason this conference was timely and that it addressed many of the above points. The first of the two guest speakers was introduced. Professor Roger Tanner is a world renowned rheologist with many professional accolades, including being a Fellow of the Royal Society of London, he told the delegates about his first encounters with CM at Manchester University in the 1960s and how he was still fascinated by what CM could do to solve useful physical problems. The next keynote speaker was Dr Andrew Sims from Resmed, a major success story for Australia in the medical device area, and the role of CM in producing the next generation of devices that will keep Resmed at the global forefront in their field.

For more information about the conference and the programme see **http://web.aeromech.usyd.edu.au/ACCM2013/**

There were 169 registered delegates and the meeting then split into four parallel sessions in all the many aspects of Computational Mechanics. An interesting aspect of the range of topics was the high proportion of papers in biomedical, materials and civil/geotechnical engineering. We set up the best paper awards for categories of undergraduate, postgraduate, early career researchers (five years since PhD) and open. Many presented paper were of very high quality and drawn considerable attention.

At the closing session after thanks to all the organizers there was a group decision to seek a name change the first A in AACM from Australian to Australasian. Australasia is a region of Oceania comprising Australia, New Zealand, the island of New Guinea, Fuji, and neighbouring islands in the Pacific Ocean. This was initiated by a few delegates from New Zealand who did not feel there were sufficient CM practitioners in New Zealand and that being grouped with Australia would be a good thing. Another group decision was to hold conferences of a similar form every two years to keep our community active in the region. ●

Figure 1:
Prof. Jan Hesthaven explains a delicate point at the end of his talk, in ISCM-33. On the left: Prof. Dalia Fishelov, chair of the session

The Israel Association for Computational Methods in Mechanics (IACMM) has held two IACMM Symposia since our last report (see IACM Expressions No. 32). In this issue we shall report on them.

The 33rd IACMM Symposium was held in October 2012 at the Technion in Haifa. The local organizers were Mahmood Jabareen and Oded Amir from the Civil and Environmental Engineering Department. The very interesting Opening Lecture was given by Prof. Jan Hesthaven from Brown University, USA (that since has moved to EPFL in Switzerland), and was entitled "Reduced Models You Can Believe In". *Fig. 1*. shows Prof. Hesthaven lecturing, and *Fig. 2* shows him with the organizers and some of the IACMM Council members.

The Symposium also included 11 other lectures, presented by practitioners and researchers from industry and academia. These included a Keynote Lecture on the analysis of turbulent flows by Dr. Amiel Herszage from the Israel Electric Industry. *Fig. 3* shows an illustration from the lecture of the student Aviad Sasson from Tel Aviv University on micro-meso material modeling of multi-layered soft composites.

Figure 2:
Organizers and some of IACMM Council members with Prof. Jan Hesthaven, at the end of ISCM-33. From left: Mahmood Jabareen (local organizer), Oded Amir (local organizer), JH, Dan Givoli (President), Pinhas Bar-Yoseph, Amiel Herszage (Secretary/Treasurer) and Emanuel Ore

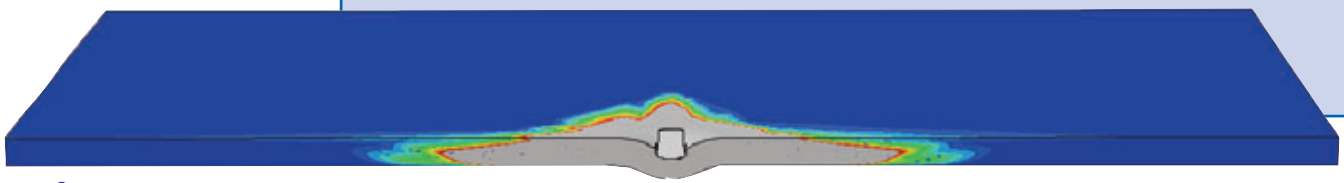


Figure 3:
Illustration from Aviad Sasson's lecture at ISCM-33, showing analysis of multi-layered soft composite plate

Figure 4:
IACMM Council with Prof. Antonio Huerta and other speakers of ISCM-34. From left: Emanuel Ore, Michel Bercovier, Jonathan Tal, Pinhas Bar-Yoseph, Dan Givoli, AH, Timo Saksala, Isaac Harari, Amiel Herszage, Zohar Yosibash and Rami Haj-Ali

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Figure 5:
Prof. Antonio Huerta during his Opening Lecture in ISCM-34

The 34th IACMM Symposium was held in April 2013 at Tel Aviv University. The local organizers were Rami Haj-Ali and Slava Krylov. A very impressive Opening Lecture was given by Prof. Antonio Huerta from the Polytechnic University of Catalunya, on "Improving Numerical Efficiency with Model Reduction and High-Order Adaptive Discontinuous Galerkin." *Fig. 5* shows Prof. Huerta in his lecture, and *Fig. 4*. shows him with the IACMM Council.

The afternoon Keynote Lecture was given by Prof. Rami Haj-Ali from Tel-Aviv University, on a new modeling approach for piezo-resistive fiber-reinforced composites. See *Fig. 6*, which is taken from his interesting talk.

ISCM-34 included 8 additional contributed talks. One of them was given by Prof. Timo Saksala form Tampere University of Technology, Finland, on "Numerical Modeling of Dynamic Indentation of Rock." *Fig. 7* shows Dr. Saksala lecturing. Another talk was given by Elad Priel from Ben-Gurion University of the Negev on modeling of necking, fracture and fragmentation. *Fig. 8* is an illustration from his talk. ●

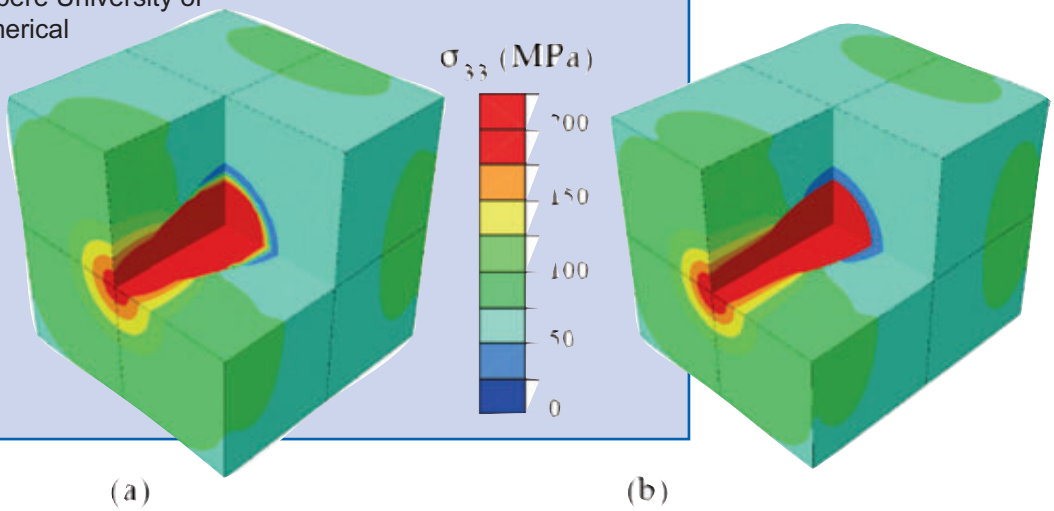

Figure 6:
Figure taken from the Keynote Lecture of Prof. Rami Haj-Ali at ISCM-34, showing comparison between a newly proposed method for analysis of a composite solid and a standard analysis which requires a much larger number of elements

Figure 7:
Prof. Timo Saksala from Finland delivering a lecture at ISCM-34

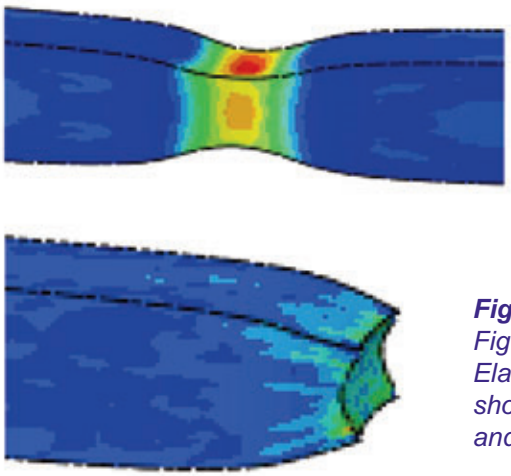

Figure 8:
Figure taken from the talk of Elad Priel in ISCM-34, showing the result of a necking and fracture analysis of a ring

Chilean Society for Computational Mechanics

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During this year 2013, the annual scientific meeting of the Chilean Society for Computational Mechanics (CSCM) was warmly hosted by Universidad de Santiago de Chile (USACH) at Santiago de Chile city. The XII Workshop on Computational Mechanics (JMC 2013, acronym in Spanish), organized by USACH and the CSCM during October 3th and 4th, has been strongly supported by USACH authorities also presented at the Opening Ceremony: Prof. Pablo Vera Head of the Department for Scientific and Technological Research (DICYT) also on behalf of Prof. Oscar Bustos Vice-President of Research, Technology and Innovation (VRIDEI); Prof. Patricio Navarro, Vice-Dean of Scientific and Technological Research at Faculty of Engineering (FING); and Prof. Enzo Schachter, Head of the Mechanical Engineering Department (DIMEC). Prof. Franco Perazzo, President of the CSCM and Prof. Marcela Cruchaga representing the Organizing Committee, have welcomed the participants: faculty members and students coming from different universities located along Chile.

The two-days Workshop encompassed four exceptional Plenary Lectures. Prof. Peter Minev from Alberta University, Canada, talks on "A fast parallel algorithm for direct simulation of particulate flows using conforming grids". The conference "Solving incompressible flow on gpu's with the finite volume method and fft preconditioning" was delivery by Prof. Mario Storti from Universidad Nacional del Litoral – CIMEC, Argentina. Prof. Gustavo Guinea from Universidad Politécnica de Madrid, España, has presented "Modelo constitutivo para materiales biológicos de base colágeno". Prof. Luis Quiroz from Universidad de Concepción, Chile, talks on "Aplicaciones de la mecánica computacional a la gestión de la integridad de activos". All these works reveals important aspects and new developments on topics of interest and novel applications of Computational Mechanics. The Technical Parallel Sessions summarizing 60 works from several areas of computational mechanics. Moreover, a collection of 17 full written papers were reported in the journal of the CSCM "Cuadernos de Mecánica Computacional", Vol. 11 (2013).

Figure 1:
Patricio Navarro, Franco Perazzo, Pablo Vera, Enzo Schachter & Marcela Cruchaga during the Open Ceremony

Prof. Claudio García and Prof. Cesar Rosas, as Organizing Committee members, work to satisfactorily accomplish the JMC 2013. The Organizers and the CSCM thanks the valuable help to the meeting given by Prof. Diego Vasco and Prof. Roberto Ortega; professionals working in VRIDEI: Mrs. María Isabel Rivera, Mrs. Jeannette Zamorano and Ms. Francisco Rodríguez; and Miss. Geraldine Farías and Ms. Matías Pacheco among a great number of students.

Figure 2:
Plenary Lectures: Luis Quiroz, Gustavo Guinea, Peter Minev and Mario Storti

In particular, the CSCM friendly thanks the participation of authors and speakers and, specially acknowledges the active participation of under and post graduate students. All of you built the success of this meeting.

Finally, the CSCM cordially invites to participate in the next version of the Workshop (JMC 2014), further information on the next meeting could be found visiting the web page of the CSCM www.scmc.cl or contacting the President F. Perazzo or the Secretariat M. Cruchaga of the CSCM at franco.perazzo@usm.cl or marcela.cruchaga@usach.cl. ●

Figure 3:
Participants to the XII Workshop on Computational Mechanics JMC 2013 at Universidad de Santiago de Chile

Jubilee 20th International Conference on Computer Methods in Mechanics (CMM2013)

40 years of tradition

by
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The Jubilee 20th International Conference on Computer Methods in Mechanics (CMM2013) was organised by Poznan University of Technology (PUT) and held in Poznań, POLAND during August 27-31, 2013 under the auspices of Section of Mechanics of Structures and Materials, Committee on Civil Engineering and Hydro-engineering, Polish Academy of Science (PAS), Section of Computational Methods and Optimization, Committee on Mechanics, PAS, Committee on Mechanics, PAS and Polish Association for Computational Mechanics which is affiliated at IACM.

The first International Conference on Computer Methods in Mechanics (CMM) was held in Poznań in 1973. This very successful conference initiated a series of subsequent conferences organized every two years by different Polish Universities. The 20th CMM Conference continues a 40-years tradition and had taken place again in Poznan University of Technology (PUT). Till 2009 these meetings have been organized under the honourable patronage of late Professor Olgierd Zienkiewicz. These conferences succeeded in gathering together both the world known experts in the field as well as younger researchers starting their professional carriers. The common general objective of CMM Conferences is to provide a forum for presentation and discussion of new ideas referring to the theoretical background as well as practical applications of computational mechanics. The program of each conference reflects current extensive research in this field of science.

Figure 1:
Poznań Town Hall

Topics of interest included, but were not only limited to:
adaptive materials systems, structures and smart materials ● artificial intelligence methods ● biomechanics ● contact mechanics ● computational intelligence ● concrete and ceramic materials ● coupled field problems ● dynamics of multibody systems ● experimental mechanics ● fluid mechanics, including modeling of blood flow ● geophysics ● growth phenomena and evolution of microstructures ● heat transfer ● industrial applications ● inverse problems and optimization ● mechanics of multiphase and porous materials ● mechanics of plates and shells ● meshless and related methods ● multiscale problems and nanomechanics ● numerical analysis of the initial and boundary value problems in mechanics ● parallel computing ● response of structures to extreme actions ● soft computing ● solid, structural and composite mechanics.

The Conference was enriched by about 190 contributions, including 9 plenary lectures, and 14 keynote lectures. There were 15 Mini-symposia and 9 Thematic sessions. The participants from 34 countries attended the Conference. Professor Peter Wriggers from Leibniz Universität Hannover was awarded by the title of the Honoris Causa Doctorate of PUT. ●

Figure 2:
From left: Prof. A.Garstecki (Reviewer), Prof. P.Wriggers, Prof. T.Łodygowski (Rector of PUT)

Figure 3:
Poznan University of Technology Educational Centre

Figure 4:
CMM2013 participants

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Zhou Pei-Yuan Mechanics Award 2013

On August 19-21th 2013, the Chinese Congress of Theoretical & Applied Mechanics (CCTAM'2013) took place in Xi'An, organized by the Chinese Society of Theoretical & Applied Mechanics (CSTAM). During the congress, the China Association for Mechanics was pleased to announce the Zhou Pei-Yuan Mechanics Award 2013 (given every 2 years), to Prof. Cheng Gengdong from Dalian University of Technology for his outstanding and sustained contributions to the research on structural and multidisciplinary optimization (SMO) and teaching in mechanics.

In words of the jury, "Professor Cheng Gengdong is a very active member of CSTAM, and his research activities spread over a range of multidisciplinary fields. He has contributed relevant theories and methods of scientific and industrial relevance, which significantly advance the understanding and application of theories and methods of SMO. His investigations on solid elastic plates with Prof. Niels Olhoff have been regarded as the pioneering work of modern structural topology optimization. Here, he has discovered that the essence of singular optimal solution in truss topology optimization subject to stress constraints is the discontinuity of the constraint function and coming up with a correct shape of feasible domain". Professor Cheng was elected member of the Chinese Academy of Sciences (CAS) in 1995, and member of the Russian Academy of Sciences (RAS) in 2102.

International Workshop on CO-DESIGN
面向百亿亿级计算的协同设计国际研讨会

In the PC/single core times, we usually assume that flops are expensive. As such, the "best" practice being followed up to now is to trade frequent memory access for saved flops; the philosophy of code/algorithm optimization is to reduce the number of flops. However, following the current trend of multi/many-core hardware change, flops are becoming the next round of "free lunch", whereas data movement becomes the new bottleneck. So, from the viewpoint of hardware efficiency and energy effectiveness, the more flops per unit data movement, the merrier. For the future's extreme-scale simulation, the S&E application should adopt a numerical algorithm that can maximize the number of flops per unit data movement to take advantage of the "free flops". This is in perfect contrast with the programming habit and the way of thinking in the past. The algorithm that was deemed to be expensive in the PC/single core time might be reversely a good candidate on the emerging computer architecture; highly possibly tomorrow would see a paradigm shift in defining a "good" numerical algorithm.

As the power of modern supercomputing systems continues to advance at an exciting pace to extreme scales, it is quite clear that the associated numerical software development challenges are also increasingly formidable. On the emerging architectures, memory and data movement present increasingly serious bottlenecks as the low-power consumption requirements lead to systems with significant restrictions on available memory and communications bandwidth. Consider the current trend of hardware change, if no change is made to the key numerical algorithm, the waste of floating point capability seems unavoidable. So, computational science experts in multiple application domains will need to re-visit key application algorithms and solvers – with the likelihood that new capabilities be demanded in order to keep up with the dramatic architectural changes that accompany the impressive increases in compute power.

Co-design, in the most basic sense, engages the necessary collaborations between hardware designers, computer scientists, applied mathematicians, and computational science experts in multiple application domains to carry out the essential interdisciplinary research that will enable harvesting in a timely way the scientific and technological benefits as HPC hardware moves forward to extreme scales.

In 2010, the HPC Technical Committee of Chinese Computer Foundation and the CACM started an annual international workshop on "COllaborative DEvelopment of SImulation software of next GeNeration (in short CO-DESIGN)". This workshop is mainly based in China; Beijing - 2010 & 2012 & Guilin - 2013. CoDesign 2013 will be co-locating with HPC China 2013 Conference in Oct 29-31. The primary motivation is interdisciplinary discussions with focus on stimulating progress in domain applications that engage extreme-scale computing. By gathering insights in petascale simulation applications, it is hoped that this workshop will help optimize a converged co-design path toward computing at the extreme scale and associated big data challenges.

The executive committee members are Rong Tian (local chairman, China), Minwu Yuan (co-chairman, China), Genki Yagawa (co-chairman, Japan) and William Tang (co-chairman, USA). The workshop is by invitation only.

*by **Rong Tian, Mingwu Yuan***
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CM13
International Conference on Computational Mechanics

Jointly organised by
The School of Engineering and Computing Sciences
at Durham University
and
The UK Associaton of Compuational Mechanics in Engineering
(ACME)

The International Conference on Computational Mechanics (CM13) was held in Durham, UK, between 25-27 March 2013 and was jointly organized by Durham University and the UK Association of Computational Mechanics in Engineering (ACME). Durham University is one of the oldest universities in the UK. The university is an integral part of Durham City, a treasure house of culture and heritage.

ACME was formed in March 1992 to promote research in computational mechanics within the UK, and to establish formal links with similar organisations in Europe and worldwide. The principal activity of ACME involves the organisation of annual national conferences. The first such conference took at the University College of Wales Swansea in 1993.

Durham University

CM13 is the first international conference has been held under the auspices of ACME. 120 delegates from 13 countries were attended the conference and the conference proceedings contain more than 80 papers, each of which was critically assessed by two reviewers and presented in one of 23 sessions during the conference. Two keynote lectures were given by Professor Rene de Borst of the University of Glasgow and Professor Javier Bonet of Swansea University. Two papers written by young researchers at PhD and postdoctoral levels were awarded prizes: Ean Tan of the University of Newcastle, Australia, was awarded Mike Crisfield prize for best paper written by a postdoctoral researcher and Ross MacKenzie of the Glasgow University UK was awarded the ACME prize for best paper written by a PhD student.

12th U.S. National Congress
Raleigh - North Carolina
July 22-25, 2013

The 12th U.S. National Congress on Computational Mechanics took place in Raleigh, North Carolina, July 22-25, 2013. The three and a half-day congress, co-organized by Professors John Dolbow (Duke U.) and Murthy Guddati (North Carolina State U.) featured approximately 900 talks in 75 minisymposia. There were thirteen broad topics including Biological Systems; Flow Problems; Multiscale Problems; Damage, Fracture, and Failure; Optimization, Inverse Problems, and Imaging; Enabling Technologies; Nano and Quantum Mechanics; Numerical Methods; Contact and Fluid-Structure Interaction; Energy Systems; UQ, Error Estimation, and Probabilistic Approaches; and Materials. Honorary minisymposia were organized in honor of Professor Thomas J. Hughes' 75th Birthday and in honor of Professor Leszek Demkowicz's 60th Birthday.
In addition, a special minisymposium was organized concerning centers on Predictive Science in Computational Mechanics.

Figure 1:
USNCCM12 participants at Raleigh Convention Center

USACM Announces 2013
Honors and Awards

USACM is pleased to announce the 2013 Awardees. They are as follows:

John von Neumann Medal: ***Professor Mary F. Wheeler***, University of Texas at Austin
The Belytschko Medal: ***Professor Subrata Mukherjee***, Cornell University
Thomas J.R. Hughes Medal: ***Professor Anthony Patera***, Massachusetts Institute of Technology
J. Tinsley Oden Medal: ***Professor George Em Karniadakis***, Brown University
Richard Gallagher Young Investigator Award:
Assoc. Professor Yongjie (Jessica) Zhang, Carnegie Mellon University

The following were named USACM Fellows:
Jacobo Bielak (Carnegie Mellon U.)
T. Laursen (Duke U./Khalifa)
Shaofan Li (U. California-Berkeley).
Karl K. Maute (U. Colorado)

Announcement and presentation of the awards was made at the 12th U.S National Congress in Raleigh, NC.

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Plenary talks were given by Professors Omar Ghattas (University of Texas at Austin), Jacob Fish (Columbia University), and Gebrand Ceder (MIT). Semi-Plenary talks were presented by Professors George Karniadakis (Brown U.), Barbara Wohlmuth (TUM), Yuri Bazilevs, (U. California – San Diego), Markus Buehler (MIT), Bernardo Cockburn (U. Minnesota), and David Keyes (KAUST).

There was a special Panel Discussion on Careers in Computational Mechanics led by Professor J. Tinsley Oden (University of Texas at Austin), Tod Laursen (Khalifa), and James Stewart (Sandia National Laboratories).

In addition, almost 100 posters were presented by graduate students and post-doctoral fellows in a special poster session, sponsored by the Army High Performance Computing Research Center. Six awards, sponsored by Elsevier, were made for outstanding posters. The awardees were Fannie Besem (Duke U.), Arun Gain (U. Illinois at Urbana-Champaign), Shu Guo (Johns Hopkins U.), Jiaoyan Li (George Washington U.), David Sondak (Rensselaer Polytechnic Institute), and Timothy Truster (U. Illinois at Urbana-Champaign; Computers and Mathematics with Applications awardee).

Photos of the congress may be found at 12.usnccm.org/. ●

Figure 2:
Panelists: T. Laursen, J. Stewart, J.T. Oden

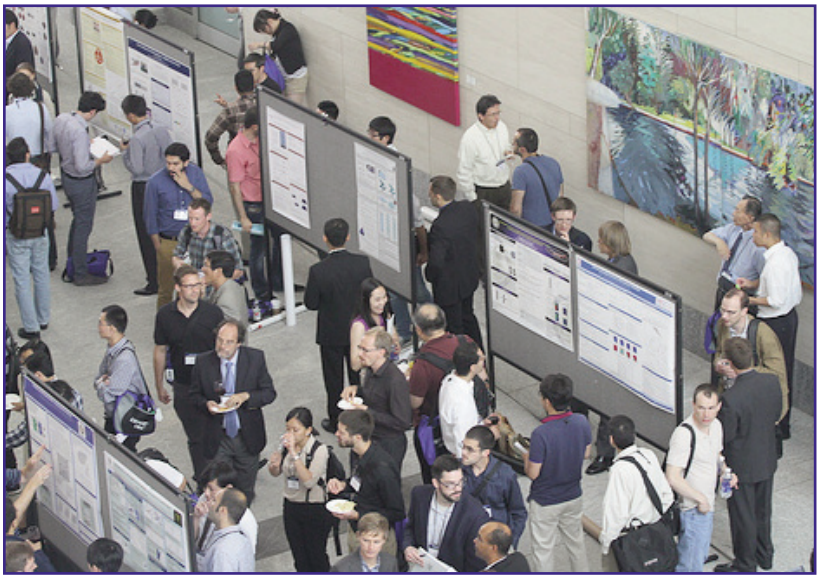

Figure 3:
Participants at the USNCCM12 Poster Session

USACM Upcoming Events

- **IGA 2014: Isogeometric Methods: Integrating Design and Analysis**
  January 8-10, 2014, Austin, Texas; http://iga2014.usacm.org/
- **Multiscale Methods and Validation in Medicine and Biology II: Biomechanics and Mechanobiology**
  February 13-14, 2014, Berkeley, California; California; http://mmvmb2.usacm.org/
- **USACM/IUTAM Symposium on Connecting Multiscale Mechanics to Complex Material Design**
  May 13-24, 2014, Evanston, Illinois; https://sites.google.com/site/iutamsymposium2014/
- **13th U.S. National Congress on Computational Mechanics**
  July 26-30, 2015, San Diego, California; http://13.usnccm.org/

Joint SEMNI & APMTAC Conference In Bilbao, Spain

SEMNI celebrated its eleventh national conference last June 25-28th. Since 2002, SEMNI has celebrated its biannual congresses in conjunction with its sister Portuguese association, APMTAC. Joint Spanish-Portuguese conferences have been celebrated in Madrid (2002), Lisbon (2004), Granada (2005), Porto (2007), Barcelona (2009) and Coimbra (2011). On this occasion, Bilbao was the city chosen as venue. In particular, its magnificent Bizkaia Aretoa building, a masterpiece by the renowned Portuguese architect Alvaro Siza, welcomed the nearly 350 participants from all over the Iberian Peninsula and Latin America.

During the conference, we had the opportunity to attend three different plenary lectures, by prof. Pedro P. Camanho, from Univerisity of Porto, Portugal, by Prof. J. García de Jalón, from the Polytechnic University of Madrid, and by Prof. J. Gopalakrishnan, from Portland State University, U.S.A. In addition, a conference tribute to the work of Alvaro Siza was given by Profs. R. Losada and E. Rojí, from the Basque Country University, who had the opportunity to work with this Pritzker prize awardee architect.

This conference also served as the starting point of the celebration of the 25th anniversary of the foundation of SEMNI. The celebration of this jubilee year will end at the 11th World Congress on Computational Mechanics, to be held in Barcelona the next July 20-25th, together with the 5th European Conference on Computational Mechanics (ECCM V) and the 6th European Conference on Compiutational Fluid Dynamics (ECCFD VI).

SEMNI Sociedad Española de Métodos Numéricos en Ingeniería 25 años

Prof. Tom Hughes awarded Doctor Honoris Causa at University of A Coruña

Our colleague and friend prof. Tom J. R. Hughes has been recently awarded Doctor Honoris Causa by the University of A Coruña. This award recognizes the fruitful collaboration throughout the years with the group of numerical methods of the School of Civil Engineering of this university. SEMNI is proud of having supported his candidature to this prize.

Figure 1:
Prof. Hughes receiving the medal accrediting his Honoris Causa doctorate

Figure 2:
A "family" picture soon after the ceremony

Figure 3:
A view of the gala dinner of the conference

Figure 4:
A view of the closing ceremony

The SEMNI awards granted during the banquet of CMN 2013

During their General Meeting in 1999, The Spanish Society of Numerical Methods in Engineering (SEMNI) introduced its two annual prizes. The Juan C. Simó prize is conferred upon young researchers under the age of 35 whose research and achievement in any field related to numerical methods have been particularly outstanding. The second annual prize is awarded to the best Ph.D. dissertation in the field of numerical methods in engineering.

Figure 5 - 9 : (right)
Receiving their awards from Prof. X. Oliver, SEMNI President.

Dr. M.J. Gómez
2012 J.C. Simó award

Dr. H. Gómez
2013 J.C. Simó award
(ex aequo)

Dr. R. Rossi
2013 J.C. Simó award
(ex aequo)

Dr. J. Baiges
2012 Best Thesis award

Dr. R. Palma
2013 Best Thesis award
(ex aequo)

The SEMNI award is the highest prize given by the Spanish Society in recognition to a leading researcher who has developed an outstanding career with close interactions with the numerical methods community in Spain. On this occasion, the 2013 SEMNI award was granted to Prof. Jaume Peraire from MIT, in recognition to his scientific and professional achievements.

Figure 10:
Prof. J. Peraire receiving the 2013 SEMNI award from its president Prof. X. Oliver

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Victorio Sonzogni
sonzogni@intec.unl.edu.ar
http://www.amcaonline.org.ar

ENIEF 2013
XX Congress on Numerical Methods and their Applications
Mendoza, Argentina
18 - 22 November 2013

The XX Congress on Numerical Methods and their Applications (ENIEF 2013) took place from November 19th to November 22nd, 2013 in the city of Mendoza, Argentina. It was organized by the Mendoza Regional Faculty of the National Technological University of Argentina.

Figure 1:
ENIEF 2013 opening ceremony

The organizing committee was chaired by Miguel Tornello, and integrated by Miguel Coussirat, Graciela Maldonado, Ernesto Gandolfo, Pablo Arenas, Jorge D'Elia, Gustavo Palazzo, Pablo Martín, and Carlos Frau. The Scientific Committee was chaired by Carlos Garcia Garino and co-chaired by Anibal Mirasso.

The Congress counted with invited lectures: Sergio Oller (CIMNE-UPC, Spain); Rainald Löhner (George Mason University, USA); Guillermo Paniagua (von Kàrmàn Institute, Belgium); Xavier Oliver (CIMNE-UPC, Spain); Jean-Philippe Ponthot (LTAS, Univ. Liege, Belgium); Arnaud Deraemaeker (Université Libre de Bruxelles, Belgium); Ricardo Herrera Mardones (Lehigh University, USA) and Roberto Aguiar Falconí (Polytechnique School of the Army, Ecuador).

More than 250 persons attended the Congress. Full length papers were submitted to a review process prior to publication. From them, 236 papers were accepted and included in the XXXII Volume of the AMCA Series "Mecánica Computacional", edited by C. Garcia Garino, A. Mirasso, M. Storti and M. Tornello. The papers at "Mecánica Computacional" are publicly available at the website: http://goo.gl/rXsjHS.

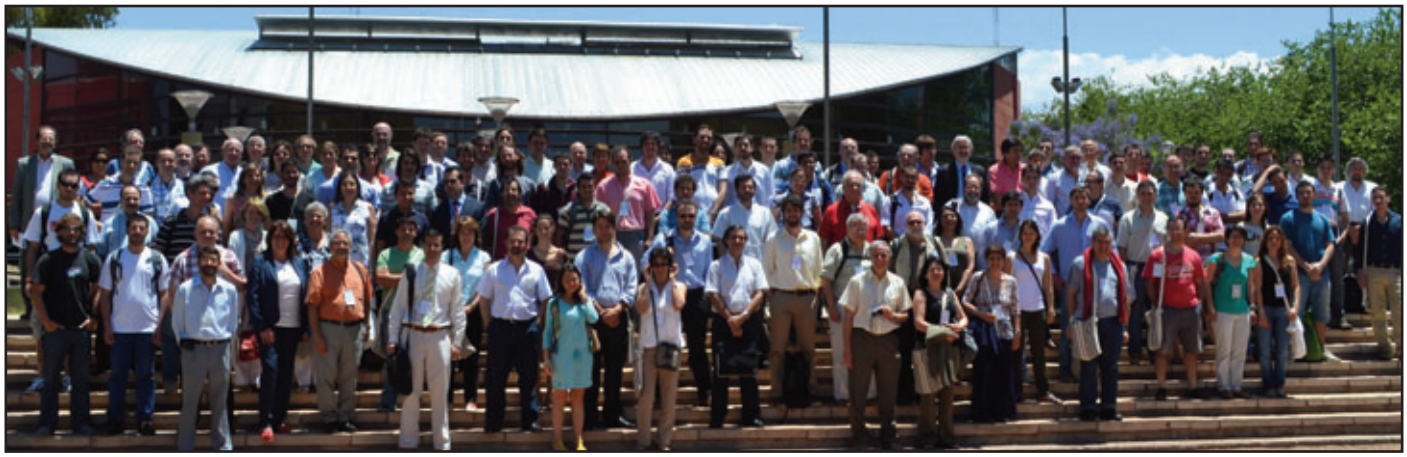

Figure 2:
Participants ENIEF 2013

A special session was devoted to undergraduate students, with awards for the best posters. The award was given for the works of Sebastian Carenzo, Ignacio Peralta and Bruno Storti from the National Technological University, Santa Fe Regional Faculty; and Luciano Gervasoni and Emmanuel Maggiori from the National University of the Center of the Buenos Aires Province.

Figure 3:
Sergio Oller, lecturer at ENIEF 2013

Figure 4:
A break during ENIEF 2013

Call for Papers - ENIEF 2014
XXI Congress on Numerical Methods and their Applications

Bariloche, Argentina, 23- 26 September 2014

The Argentine Association for Computational Mechanics (AMCA) announces the XXI Congress on Numerical Methods and their Applications, which will be held in Bariloche, Argentina, organized by the Bariloche Atomic Center.

Bariloche is one of the most important touristic centres of Argentina. It is a beautiful city in northern Patagonia, located in the majestic Andes mountains, on the southern shore of Nahuel Huapi Lake and at 770 meters above sea level.

Email: enief2014@cab.cnea.gov.ar
Web: http://mecom.cnea.gov.ar/enief2014

ENIEF 2014

Annual Conference

The **18th JSCES's Annual Conference** on Computational Engineering and Science, chaired by Prof. H. Okada (Tokyo University of Science), was held on June 19-21, 2013, at Institute of Industrial Science, The University of Tokyo (Japan). It was composed of 8 tracks and 32 minisymposia, including a plenary lecture and four special symposia. About 350 papers were presented, and 584 participants composed of researchers, graduate students and practitioners gathered, of which 30 percent were affiliated with non-academic organizations. Some of the successful events are reported below.

Figure 1:
Prof. N. Kikuchi

The **plenary talk** entitled "Expectations for Computational Mechanics and CAE" was given by Dr. Noboru Kikuchi, Roger L. McCarthy Professor of The University of Michigan, USA *(Figure 1)* and the Vice-President of the Toyota Central R&D Labs., Inc. He re-defined "Computational Mechanics" by illustrating the feels of some terminologies such as "technology", "engineering", "simulations", "analysis" and "Computer-Aided-Engineering (CAE)". He also showed some landmark textbooks on applied mechanics, continuum mechanics and finite element methods that are related to computational mechanics and CAE, and pointed out that most of the contents were incorporated in general-purpose CAE software. He also emphasized the significance of "common difference" in design processes to be taken into account in addition to verification and validation, and the versatility and capability of fixed mesh methods implicated by Prof. Brezis. His talk was closed with the recommendation that the JSCES be a unique organization that bridges sophisticated CAE software, users, vendors and researchers. He is also the recipient of "The JSCES Grand Prize 2013" for his outstanding contributions in the field of computational engineering and sciences.

Thirty-two diverse **minisymposia** were organized by Japanese most active researchers. Some covered standard and fundamental topics such as "Developments and Evaluation/Verification of Finite Elements" and "Computational Solid Mechanics", while "V&V", "Training of Technical Expert in Computational Engineering and Science" and "User-vendor Collaborations and Communications" were related to the application of computational engineering and science to the industrial world. Two well-attended minisymposia were "Meshfree/Particle Methods", in which the fundamentals in theory and the technical aspects were discussed and "Parallelization Techniques for Many-core Computing", also an active area of research in terms of the number of attendance.

The conference organizing committee organized the following **four special symposia**: (1) Necessity of 1D-CAE Research: Towards government-industry-academia collaboration. Speakers: Dr. A. Tezuka (AIST) from government side, Prof. S. Koshizuka (U Tokyo) & Prof. K. Motoyama (CAVS, MSU) from academia side, Dr. R. Sawada (Toyota Mortor Co.) & Dr. H. Kure (IHI) from industry side. (2) Towards Exa-scale Computations. Speakers: Dr. K. Ono (RIKEN), Dr. R. Takagi (JAXA), Prof. H. Kawai (Suwa Tokyo U Science), Prof. K. Kashiyama (Chuo U), Prof. T. Katagiri & Prof. A. Yoshikawa. (3) Approaches by Community-based CAE：Recent Trends of Applications of CAE in Publicly-run Experimental Laboratories. Speakers: Dr. N. Sasaki (Hitachi,Ltd), Dr. M. Tsuchimura (Kumamoto Industrial Research Institute), Dr. T. Tanaka (Industrial Technology Center of Saga), Dr. M Koganemaru (Fukuoka IST), Dr. T. Nishiwaki (Nagoya Municipal Industrial Research Institute) & Dr. T. Kosugi (Nagano Prefecture General Industrial Technology Center). (4) Recent Trends of Post-Processing of Big-data. Speakers: Prof. S. Sirayama, Prof. H. Masuda (U of Electro-Communications), Prof. F. Araki (JAMSTEC) & Prof. H. Watanabe (Tokyo Metropolitan U).

Figure 2:
Lunch-on seminars provided by sponsoring software venders and distributers

As a **special extra**, the JSCES provided a room for "Course Lectures for Creating Future Vision of Young Scientists and Engineers in the Ph.D Increase Program", which aimed at increasing Ph.D students in Computational Engineering and Science. Prof. D. Ishobe (U of Tsukuba) served as a chairman of this meeting and showered various questions on the JSCES's President (Prof. K. Kashiyama) and

Vice-Presidents (Prof. S. Koshizuka and Dr. K. Yamamura) with the intention of motivating students to take Ph.D. degrees. The Q&A discussions with friendly atmosphere were worth following.

The JSCES awarded "**Best Paper Award**" to speakers with respectable presentations and papers, and "**Visualization Award**" to speakers with illustrative figures placed in their papers. These award was an occasion to promote young researchers. Also, eight sponsoring software venders and distributers provided separate "Lunch-on Seminars", in which their activities were presented to the audience being served lunch boxes. The exhibitors were G-DEP/NVIDIA/ELSA, LMS Japan, Cybernet Systems, TechnoStar, Keisoku Engineering System and MSC Software *(Figure 2)*. Furthermore, Fujitsu, Advanced Technology, HPC Tech, G-DEP, Real Computing, Cybernet Systems and Keisoku Engineering System exhibited their products in the exhibit space *(Figure 3)*.

All these events were very successful. 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 with next year's conference in Hiroshima, June 2014. ●

Figure 3:
Exhibition by sponsors

Figure 4:
Banquet at the reception hall of the venue on 2013/6/20

Summer Short Course

Nonlinear Finite Element Methods for Elastic-Plastic Materials

"Summer School for Nonlinear Finite Element Methods for Elastic-Plastic Materials" was hosted by the JSCES, held on August 22-23, 2013, at Korakuen Campus of Chuo University in Tokyo, Japan *(Figure 5)*, and was attended by about 100 students.

The summer school covered both fundamental and advanced topics on finite element methods for elastic-plastic problems and was composed of the following chapters: (1) Nonlinear Finite Element Methods: overall picture of elastic-plastic materials and guidance, (2) Mechanics of small deformations, (3) Solution methods for global equilibrium, (4) Basic theory in plasticity, (5) Time integration algorithms for elastic-plastic constitutive equations, (6) Implementation into program codes , (7) Viscoplastic and damage models, (8) Finite deformation with hyperelasticity and plasticity. The textbook employed in this short course was "Computational Methods for Plasticity: Theory and Applications, Wiley, 2008 (Authors: E.A. de Souza Neto, D. Perić, D.R.J. Owen)". But the Japanese Translation (Morikita Publishing Co., Ltd.), where Prof. K. Terada served as a translation supervisor, was used as study guide, and the course materials (PowerPoint Slides) were prepared and handed out to the students (*Figure 6*).

Figure 5:
Appearance of "Summer School for Nonlinear Finite Element Methods for Elastic-Plastic Materials"

The opening address by the JSCES's President, K. Kashiyama, was followed by separate lecturers provided by Profs. K. Terada (Tohoku U), T. Ishii (Kisarazu National College of Technology), M. Kurumatani (Ibaraki U), Y. Yamakawa (Tohoku U), I. Saiki (Tohoku U), K. Matsui (Yokohama National U) and M Asai (Kyushu U). Each lecture was followed by questions and answers, which were exchanged among participants.

The short course was very successful and the organizing committee, on behalf of the JSCES, would like to thank the lecturers for their efforts in preparing their contributions. ●

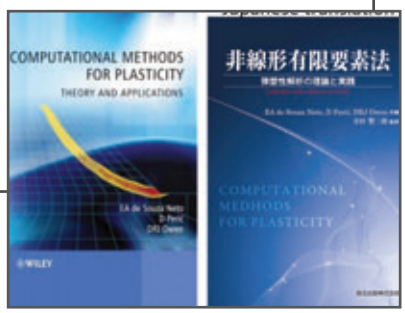

Figure 6:
Computational Methods for Plasticity: Theory and Applications (E.A. de Souza Neto, D. Perić, D.R.J. Owen) and its Japanese translation for study guide

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The Ibero Latin American Congress on Computational Methods in Engineering
XXXV CILAMCE

The Ibero Latin American Congress on Computational Methods in Engineering (CILAMCE) XXXV CILAMCE is a series of annual meetings, promoted by the Brazilian Association of Computational Methods in Engineering (ABMEC), intended to provide an international opportunity for communicating recent developments in various areas of numerical methods.

Since 1977, the CILAMCE has provided a forum for engineers, students, researchers and other professionals active in the field of numerical methods, coming from Brazil and other countries, to discuss and to explore the state-of-the-art of recent applications of computational methods in several engineering branches. The framework of CILAMCE is multidisciplinary and scientists from all over the world are encouraged to contribute to the conference. The technical program includes plenary speakers and mini-symposia sessions on pre-defined topics with contributing papers on this scientific field.

After 34 successful meetings, the 35th Ibero-Latin American Congress on Computational Methods in Engineering will be held from 9 to 12 November 2014, in Fortaleza, and is hosted by the Graduate Program in Structures and Civil Construction of the Federal University of Ceará (UFC). Fortaleza is the state capital of Ceará, located in Northeastern Brazil. Fortaleza is the 5th largest city in Brazil and a major tourist destination. The city will be one of the host cities of the 2014 FIFA World Cup. Its beautiful beaches, sunny days, refreshing breeze, vibrant nightlife and exquisite local cuisine have made the city a favorite travel destination.

On behalf of the organizing committee of CILAMCE 2014, it is a great pleasure to invite you to the XXXV Ibero-Latin American Congress on Computational Methods in Engineering. We look forward to welcoming you in Fortaleza.

Figure 1: *Mucuripe Beach, Fortaleza, Brazil*

XXXIV CILAMCE
NOVEMBER 10-13, 2013. PIRENÓPOLIS-GO.

30º CILAMCE
Congresso Ibero-Latino-Americano de Métodos Computacionais em Engenharia
Armação dos Búzios - Brasil 2009

XXXII CILAMCE
Congresso Ibero Latino Americano de Métodos Computacionais em Engenharia
13 a 16 de Novembro de 2011 - Ouro Preto - MG

International Journal of Modeling and Simulation for the Petroleum Industry

The Brazilian Association for Computer Methods in Engineering and Computational Modeling and Simulation for the Petroleum Industry network (RPCMod-FINEP) have started to co-sponsor The Journal of Modeling and Simulation for the Petroleum Industry (IJMSPI) in 2013. This journal publishes refereed papers describing significant developments in computational modeling and simulation that are applicable to scientific and engineering problems in the Oil Industry, encompassing different areas such as Engineering, Geosciences, Applied Mathematics, Computer Science and Risk Analysis. In addition to regular issues of contributed papers, the journal also publishes special issues including selected conference articles and/or covering specific topics of current interest. 2013 also represents a landmark for IJMSPI Journal with the re-organization of the Journal structure, including Associate Editors on specific sub-areas; the customization of a journal management and publishing system, allowing for the submission and reviewing process to be performed fully online.

Journal Structure:
Paulo R. M. Lyra (UFPE), Brazil - Editor-in-Chief.

Sub-areas of the journal include:
Production and Operations: covering, inshore and offshore systems and structures (pipeline, risers, etc.), multi-phase flow in ducts and related subjects.
Here our associated editors are Philippe R.B. Devloo (Unicamp) Brazil and Kazuo Nishimoto (USP-SP) Brazil.
Reservoir Characterization, Evaluation and Engineering: covering reservoir characterization, geology and geophysics, reservoir management, enhanced oil recovery (EOR), history matching, reservoir simulation and related subjects.
Here our associate editors are Denis J. Schiozer (UNICAMP), Brazil and Virgínio H. Neumann (UFPE) Brazil.
Management: covering uncertainty and risk assessment, optimization, logistic, benchmarking and performance indicators, decision making and related topics.
Here our associate editors are Silvana M.A. Da Silva (UFPE), Brazil, Andre T. Beck (USP-SC), Brazil and Pol Spanos (RICE), USA.
Fundamental Research: covering novel solutions spanning all scientific and technical disciplines (new methodologies and formulations, etc.), numerical analysis and related areas applied to the oil industry problems.
Here our associate editors are Abimael F.D. Loula (LNCC), Brazil and Fernando A. Rochinha (COPPE-UFRJ), Brazil.
Computational Science and Visualization: covering applications of high performance computing, scientific visualization, e-science, computer graphics, software engineering, databases and soft computing (genetic algorithms, neutral networks, data mining, etc.) and related areas to the oil industry.
Here our associate editors are Álvaro L.G.A. Coutinho(COPPE-UFRJ), Brazil,Judith Kelner (UFPE), Brazil, José Ma. Cela (BSC-CNS), Spain and Omar Ghattas (ICES-UT), USA. ●

For further information about the IJMSPI, please refer to the Journal´s new homepage ***http://www.ijmspi.org/***

RPCMOD
REDE DE PESQUISA COOPERATIVA EM MODELAGEM COMPUTACIONAL

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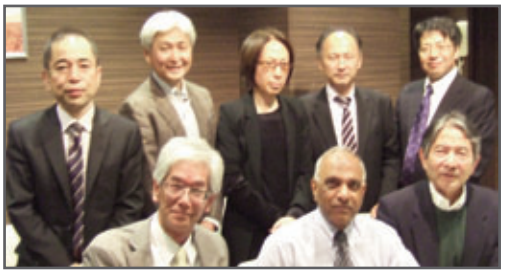
On November 3rd, 2013, Professor J. N. Reddy of Texas A&M University delivered a special plenary lecture at the 26th Computational Mechanics Division (CMD) Conference of the Japan Society of Mechanical Engineers (JSME). Professor Reddy is the recipient of 2012 CMD Award, which is the highest award given by JSME-CMD.



Figures 1&2:
Professor J. N. Reddy delivering the special plenary lecture "Computational Mechanics: The Third Pillar of Engineering and Technology" and attending a party with Japanese colleagues

On December 13th, the 2013 JACM award ceremony was held at its annual meeting on the occasion of the joint conference APCOM & ISCM 2013 in Singapore. At the annual meeting, the JACM discussed the current state of the JACM and future plans.

The 2013 JACM award recipients are listed below.
The JACM 2013 Computational Mechanics Awards winners:
***Professors Muneo Hori** (The University of Tokyo), **Tayfun E. Tezduyar** (Rice University, Houston) and **Feng Xiao** (Tokyo Institute of Technology).*
The JACM 2013 Fellows Awards winners:
***Dr. Hiroshi Akiba** (Allied Engineering Corporation), **Professors Tomonari Furukawa** (Virginia Polytechnic Institute and State University) and **Ryuji Shioya** (Toyo University).*
The JACM 2013 Young Investigators Award winners:
***Professors Hitoshi Matsubara** (University of Ryukyus), **Dai Okumura** (Nagoya University) and **Koichi Yonezawa** (Osaka University)*

by
Hiroshi Okada,
Tokyo University of Science hokada@rs.noda.tus.ac.jp

Figures 3:
The JACM 2013 Computational Mechanics Awards winners:
Professors Muneo Hori (The University of Tokyo) (left), Tayfun E. Tezduyar (Rice University, Houston) (center) and Feng Xiao (Tokyo Institute of Technology) (right)

Figures 4:
The JACM 2013 Fellows Awards winners:
Dr. Hiroshi Akiba (Allied Engineering Corporation) (left), Professors Tomonari Furukawa (Virginia Polytechnic Institute and State University) (center) and Ryuji Shioya (Toyo University) (right)

Figures 5:
The JACM 2013 Young Investigators Award winners:
Professors Hitoshi Matsubara (University of Ryukyus) (left), Dai Okumura (Nagoya University) (center) and Koichi Yonezawa (Osaka University) (right)

conference diary planner

13 - 14 Feb 2014	**Multiscale Methods & Validation in Medicine and Biology II: Biomechanics & Mechanobiology**		
	Venue: Berkeley, California	*Contact:*	http://mmvmb2.usacm.org
20 - 21 March 2014	**Advances in Computational Fluid–Structure Interaction & Flow Simulation**		
	Venue: Tokyo, Japan	*Contact:*	http://www.tafsm.org/TET60/
24 - 28 March 2014	**PACAM XIV: Pan American Congress on Applied Mechanics**		
	Venue: Santiago, Chile	*Contact:*	http://pacamxiv.org/
13 - 16 April 2014	**COMPSAFE 2014: Computational Engineering & Science for Safety & Environmental Problems**		
	Venue: Sendai, Japan	*Contact:*	http://www.compsafe2014.org/
5 - 9 May 2014	**Non-linear Computational solid & Structural Mechanics**		
	Venue: Pavia, Italy	*Contact:*	http://www.unipv.it/compmech/courses.html
13 - 24 May 2014	**USACM/UTAM Symposium on Connecting Multiscale Mechanics to Comlex Material Design**		
	Venue: Evanston, Illinois	*Contact:*	ruth@usacm.org
25 - 29 May 2014	**CJK-OSM8: Japan Korea Symposium on Optimization of Sgructural & Mechanical Systems**		
	Venue: Gyeongju, Korea	*Contact:*	secretariat@cjk-osm8.org
8 - 12 June 2014	**CWE2014: 6th International Symposium on Computational Wind Engineering**		
	Venue: Hamburg, Germany	*Contact:*	cwe2014 at zmaw.de
9 - 11 June 2014	**HPSM/OPTI 2014: High Performance & Optimum Design of Structures & Materials**		
	Venue: Ostend, Belgium	*Contact:*	http://www.wessex.ac.uk/hpsmopti2014?e=0-57618
30 June - 2 July 2014	**EURODYN 2014: European Conference on Structural Dynamics**		
	Venue: Porto, Portugal	*Contact:*	www.fe.up.pt/eurodyn2014
30 June - 3 July 2014	**International Conference on Multibody System Dynamics**		
	Venue: Pusan, Korea	*Contact:*	peter.eberhard@itm.uni-stuttgart.de
30 June - 4 July 2014	**ECF20: 20th European Conference on Fracture**		
	Venue: Trodheim, Norway	*Contact:*	ecf20 at videre.ntnu.no
15 - 19 July 2014	**Dynamics of Capsults, Besicles and Cells in Flow**		
	Venue: Compiegne, France	*Contact:*	a.salsac@utc.fr
20 - 25 July 2014	**ECCM V and ECFD VI: Eur. Conf. on Computational Methods / Fluid Dynamics**		
	Venue: Barcelona, Spain	*Contact:*	http://www.wccm-eccm-ecfd2014.org/
20 - 25 July 2014	**WCCM XI: World Congress on Computational Mechanics**		
	Venue: Barcelona, Spain	*Contact:*	http://www.wccm-eccm-ecfd2014.org/
1 - 4 Sept 2014	**Innovative Numerical approaches for Material & Structures in Multiscale Problems**		
	Venue: Cologne, Germany	*Contact:*	kerstin.weinberg@uni-siegen.de
7 - 11 Sept 2014	**Uncertainties 2014: 2nd Int. Symposium on Uncertainty Quantification & Stochastic Modeling**		
	Venue: Rouen, France	*Contact:*	eduardo.souza@insa-rouen.fr
8 - 11 Sept 2014	**EngOpt 2014: 4th International Conference on engineering Optimization**		
	Venue: Lisbon, Portugal	*Contact:*	http://www.dem.ist.utl.pt/engopt2014
19 - 22 October 2014	**MM&FGM 2014: 13th Int. Symp. Multiscale multifunctional& Functionally**		
	Venue: Sao Pauo, Brazil	**Contact:**	**http://fgm2014.poli.usp.br**
22 - 24 Dec 2014	**SEC2014: Structural Engineering Convention**		
	Venue: Delhi, India	*Contact:*	civil.iitd.ac.in/sec2014/
27 - 29 April 2015	**PANACM-2015 - Pan-American Congress on Computational Mechanics**		
	Venue: Buenos Aires, Argentina	*Contact:*	http://congress.cimne.com/PANACM2015
18 - 20 May 2015	**COUPLED PROBLEMS 2015: VI Int. Conf. on Coupled Problems in Science and Engineering**		
	Venue: Venice, Italy	**Contact:**	coupledproblems@cimne.upc.edu
15 - 17 June 2015	**MARINE 2015: VI International Conference on Computational Methods in Marine Engineering**		
	Venue: Rome, Italy	*Contact:*	marine@cimne.upc.edu
1 - 3 September 2015	**COMPLAS XIII: International Conference on Computational Plasticity**		
	Venue: Barcelona, Spain	*Contact:*	complas@cimne.upc.edu
14 - 16 September 2015	**ICCB´2015: Sixth International Conference on Computational Bioengineering**		
	Venue: Barcelona, Spain	*Contact:*	iccb2015@cimne.upc.edu
28 - 30 September 2015	**PARTICLES 2015: IV International Conference on Particle-based Methods**		
	Venue: Barcelona, Spain	*Contact:*	particle-basedmethods@cimne.upc.edu
19 - 21 October 2015	**STRUCTURAL MEMBRANES 2015: VII Int. Conf. on Textile Composites & Inflatable Structures**		
	Venue: Barcelona, Spain	*Contact:*	membranes@cimne.upc.edu
24 - 29 July 2016	**APCOM 2016: 6th Asia Pacific Congress on Computational Mechanics**		
	Venue: Seoul, Korea	*Contact:*	http://apacm-association.org
24 - 29 July 2016	**WCCM XII: World Congress on Computational Mechanics**		
	Venue: Seoul, Korea	*Contact:*	http://kscm-society.org

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