

TIME TABLE

TIME	Monday	Tuesday	Wednesday	Thursday	Friday
	May 21	May 22	May 23	May 24	May 25
9.00 - 9.45	Registration	O-Starzewski	Del Piero	Del Piero	Ghosh
9.45 - 10.30	Talreja	O-Starzewski	Del Piero	Del Piero	Ghosh
11.00 - 11.45	Talreja	Del Piero	Talreja	O-Starzewski	Trovalusci
11.45 - 12.30	Talreja	Del Piero	Talreja	O-Starzewski	Trovalusci
14.00 - 14.45	O-Starzewski	Talreja	Ghosh	Ghosh	
14.45 - 15.30	O-Starzewski	Talreja	Ghosh	Ghosh	
16.00 - 16.45	Sadowski	Sadowski	Sadowski	Trovalusci	
16.45 - 17.30	Sadowski	Sadowski	Trovalusci	Trovalusci	

ADMISSION AND ACCOMMODATION

Applicants must contact CISM Secretariat at least one month before the beginning of the course. Application forms should be sent on-line through our web site: <http://www.cism.it> or by post.

A message of confirmation will be sent to accepted participants. If you need assistance for registration please contact our secretariat.

The 700,00 Euro registration fee includes a complimentary bag, four fixed menu buffet lunches (Friday not included), hot beverages, on-line/downloadable lecture notes and wi-fi internet access.

A limited number of participants from universities and research centres who are not supported by their own institutions can be offered board and/or lodging in a reasonably priced hotel.

Requests should be sent to CISM Secretariat by **March 21, 2012** along with the applicant's curriculum and a letter of recommendation by the head of the department or a supervisor confirming that the institute cannot provide funding.

Preference will be given to applicants from countries that sponsor CISM.

Information about travel and accommodation is available on our web site, or can be mailed upon request.

For further information please contact:

CISM
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 Piazza Garibaldi 18
 33100 Udine (Italy)
 tel. +39 0432 248511 (6 lines)
 fax +39 0432 248550
 e-mail: cism@cism.it

Centre International des Sciences Mécaniques
 International Centre for Mechanical Sciences

ACADEMIC YEAR 2012
 The Cercignani Session



MULTISCALE MODELLING OF COMPLEX MATERIALS

Advanced School
 coordinated by

Tomasz Sadowski
 Lublin University of Technology
 Poland

Patrizia Trovalusci
 "Sapienza" University of Rome
 Italy

Udine, May 21- 25, 2012

MULTISCALE MODELLING OF COMPLEX MATERIALS

Various types of complex materials, made of very different constituents, are used nowadays in engineering practice. The most important of these are fibrous composites, laminates and heterogeneous multiphase materials with an intricate internal structure including: porosity, reinforcement in the form of short fibres and particles of various properties, shapes and sizes, filled in different media. It is widely recognized that important macroscopic properties like the macroscopic stiffness and strength are governed by multiphysics processes (e.g. damage due to heat transfer or fluid penetration) that occur at one to several scales below the level of observation. A thorough understanding of how these processes influence the reduction of stiffness and strength, is the key both to the analysis of existing, and to the design of improved, complex materials.

The course will bring together experts dealing with materials science, theoretical mechanics, experimental and computational techniques at multiple scales and will provide a sound base and a framework for many applications that are hitherto treated in a phenomenological sense.

The aim of this course is to present a series of lectures by researchers specialized in multiscale and multiphysics modelling and the simulation of complex materials. The basic principles of multiscale modelling strategies will be formulated with reference to modern complex multiphase materials subjected to various types of mechanical and thermal loadings, and to environmental effects. Since the mechanical behaviour plays a central role, the focus will be on problems where mechanics is highly

coupled with other concurrent physical phenomena. The study of how these various length scales and multiphysical processes can be bridged or taken into account simultaneously is particularly relevant for complex materials, because they have a well-defined structure at the nano, micro and meso-levels. For this reason, advances in multiscale modelling and analysis made here, are directly applicable to classes of materials which either have a wider (possibly fractal) range of relevant microstructural scales, such as metals, or have a random microstructures, e.g. cementitious composites. In order to achieve a comprehensive description of the multiscale phenomena, not directly related to the design of high performance materials, attention will also be focused on the foundations

of continuum mechanics currently adopted to model non-classical continua with a substructure, for which internal length scales play a crucial role. This is particularly so for some specific continua, such as second gradient, micropolar, or other multifield media. A special class of continua, characterized by displacement fields discontinuous on singular surfaces and by a cohesive energy defined on the discontinuity set, will be presented as an example of how phenomena occurring at the microscale may strongly influence the macroscopic response. Finally, using variational techniques based on energy minimization, it will be shown how a cohesive model can describe a large class of material responses, including fracture, damage and plasticity.

PRELIMINARY SUGGESTED READINGS

1. S. Ghosh. Micromechanical Analysis and Multi-Scale Modeling Using the Voronoi Cell Finite Element Method. CRC Press (scheduled for publication in July 2011).

2. R. de Borst, T. Sadowski (Eds) 2008. Lecture Notes on Composite Materials, Springer, pp. 237.

3. M. Ostoja-Starzewski 2008. Microstructural Randomness and Scaling in Mechanics of Materials, Modern Mechanics and Mathematics Series. Chapman & Hall/CRC/Taylor & Francis.

4. J. Li and M. Ostoja-Starzewski 2010. Fractals in elastic-hardening plastic materials. Proc. R. Soc. Lond. A 466, 603-621.

5. G. Del Piero 2009. On the method of virtual powers in continuum mechanics. Journal of Mechanics of Materials and Structures 4 (2), 281-292.

6. G. Del Piero and L. Truskinovsky 2009. Elastic bars with cohesive energy. Continuum Mechanics and Thermodynamics 21 (2), 141-171.

INVITED LECTURERS

Gianpietro Del Piero - Università di Ferrara, Italy

6 lectures on:

On the method of virtual power in continuum mechanics. Higher gradient and micropolar continua as specific cases. An example of multi-scale modeling: the cohesive energy model.

Somnath Ghosh - Johns Hopkins University, Baltimore, MD, USA

6 lectures on:

Integrated multi-scale characterization and modeling of ductile failure in heterogeneous materials.

Martin Ostoja-Starzewski - University of Illinois at Urbana-Champaign, IL, USA

6 lectures on:

Fractals and randomness in mechanics of materials.

Tomasz Sadowski - Lublin University of Technology, Poland

5 lectures on:

Modelling and experimental verification of damage and fracture processes of composites under mechanical and thermal loading.

Ramesh Talreja - Texas A&M University, College Station, TX, USA

7 lectures on:

Multiscale modelling of damage and failure in composite materials. Micro-damage mechanics, macro-damage mechanics, and synergistic damage mechanics.

Patrizia Trovalusci - "Sapienza" University of Rome, Italy

5 lectures on:

Molecular approaches for multifield continua: origins and actual developments with applications to fibre composites and masonry-like materials.

LECTURES

All lectures will be given in English. Lecture notes can be downloaded from CISM web site, instructions will be sent to accepted participants.

**MULTISCALE MODELLING
OF COMPLEX MATERIALS**

Udine, May 21 - 25, 2012
Application Form
(Please print or type)

Surname _____

Name _____

Affiliation _____

Address _____

E-mail _____

Phone _____ Fax _____

Method of payment upon receipt of confirmation (Please check the box)

The fee of Euro 700,00 includes IVA/VAT tax and excludes bank charges

I shall send a check of Euro _____

Payment will be made to CISM - Bank Account N° 094570210900,
VENETO BANCA - Udine (CAB 12300 - ABI 05035 - SWIFT/BIC VEBHIT2M -
IBAN CODE IT46 N 05035 12300 09457 0210900).
Copy of the receipt should be sent to the secretariat

I shall pay at the registration counter with check, cash or VISA
Credit Card (Mastercard/Eurocard, Visa, CartaSi)

**IMPORTANT: CISM is obliged to present an invoice for the above sum. Please
indicate to whom the invoice should be addressed.**

Name _____

Address _____

C.F.* _____

VAT/IVA* No. _____

(*) Only for EU residents or foreigners with a permanent business activity in Italy.

Only for Italian Public Companies

I ask for IVA exemption (ex law n. 537/1993 - art. 14 comma 10).

Privacy policy: I understand that data received via this form will be used only to provide
information about CISM and its activities, within the limits set by the Italian legislative
decree no. 196/2003 and subsequent amendments.

Complete information on CISM's privacy policy is available at [http://www.cism.it/courses/
privacy_statement/](http://www.cism.it/courses/privacy_statement/)

I have read the "Admission and Accommodation" terms and conditions and agree.

Date _____ Signature _____