

TIME TABLE

TIME	Monday July 15	Tuesday July 16	Wednesday July 17	Thursday July 18	Friday July 19
9,00 - 9,45	Registration	Del Piero	Del Piero	Owen	Le
9,45 - 10,30	Del Piero	Del Piero	Owen	Owen	Le
11,00 - 11,45	Silhavy	Owen	Deseri	Deseri	Deseri
11,45 - 12,30	Silhavy	Owen	Paroni	Deseri	Paroni
14,30 - 15,15	Del Piero	Silhavy	Silhavy	Le	
15,15 - 16,00	Del Piero	Silhavy	Silhavy	Le	
16,30 - 17,15	Marigo	Le	Marigo	Marigo	
17,15 - 18,00	Marigo	Le	Marigo	Marigo	

### ADMISSION AND ACCOMMODATION

The registration fee amounts to 620,00 € or 430,00 € for participants on regular staff of Universities and Academies of Sciences.

Applicants should send their application form at the latest one month before the beginning of the course. Registration can be made by post, or on-line through our web site: <http://www.cism.it>.

A limited number of participants from Universities and Academies who are not supported by their own Institutions can be offered board and/or lodging at the University Residence (or a middle class hotel). **For this they should apply to the Secretariat of CISM by May 15, 2002** and enclose a curriculum and a letter of recommendation by the Dean confirming that the Institute has no funds for financing their participation. Preference will be given to applicants coming from countries which have adhered to CISM and contribute to its operating resources.

A list of hotels in Udine is available at <http://www.cism.it> or sent by post upon request. A limited number of single rooms are usually available at the University Residence at the price of approx. 18,00 € per person per night. Those interested should apply promptly through CISM.

For further information please contact:

CISM  
 Palazzo del Torso  
 Piazza Garibaldi 18  
 33100 Udine (Italy)  
 tel. +39 0432 248511 (6 lines)  
 fax +39 0432 248550  
 E-mail: [cism@cism.it](mailto:cism@cism.it)  
<http://www.cism.it>



ACADEMIC YEAR 2002

The Morecki Session

***MULTISCALE MODELING  
IN CONTINUUM MECHANICS  
AND STRUCTURED DEFORMATIONS***

Advanced School  
Coordinated by

**G. Del Piero, University of Ferrara, Italy  
D.R. Owen, Carnegie Mellon University, PA, USA**

**Udine, July 15 - 19, 2002**

**International Centre for Mechanical Sciences  
Centre International des Sciences Mécaniques**

## **MULTISCALE MODELING IN CONTINUUM MECHANICS AND STRUCTURED DEFORMATIONS**

The purpose of the course is to present some recent progress in two active and related areas of continuum mechanics: fracture mechanics and structured deformations.

The course is divided into two parts. The first part deals with the theory of structured deformations, a basic concept that can be used to describe smooth and non-smooth geometrical changes at different length scales, including, for example, both slip and microslip and, of particular interest in the second part of this course, both macroscopic fracture and microfracture.

The foundations of the theory of structured deformations will be presented in a self-contained way. They will be employed in the formulation of field theories for bodies undergoing deformations at different scales.

The extension of the theory to deformations expressed by higher order gradients will be considered in detail. The theory will also be applied to the study of single crystals undergoing single or multiple slip.

In the second part of the course, the energetics of isotropic nonlinear elastic bodies will be discussed, followed by a variational formulation for nonlinear crack problems in which the conditions for crack equilibrium or propagation are determined by the asymptotic behavior of the strain and stress fields near the tip of the crack. Finally, an evolutionary model for fracture will be presented within Griffith's scheme for brittle fracture. It will be accompanied by several examples, solved either by asymptotic methods (for composite plates or beams) or by an accurate finite element scheme. Both techniques are based on the concept of Gamma-convergence.

The course is addressed to researchers in the field of Continuum Mechanics, interested in recent developments of theories for modeling material response, theoretical approaches to fracture mechanics, unified theories for different aspects of material behavior, and solution of problems involving materials with internal microstructure.

### **INVITED LECTURERS**

G. DEL PIERO - University of Ferrara, Italy

6 lectures on:

Foundations of the theory of structured deformations: kinematics, simple deformations, structured deformations, approximation theorem, energetics, stress. The "strong" formulation of Del Piero and Owen, versus the "weak" formulation of Choksi and Fonseca.

L. DESERI - University of Ferrara, Italy

3 lectures on:

Crystalline plasticity and structured deformations; geometry of single crystals undergoing single or multiple slip; energetics in the setting of two-level shears; loading and unloading without dissipation; yielding; non-smooth hardening.

K.C. LE - University of Bochum, Germany

6 lectures on:

Variational problems of crack equilibrium and crack propagation; governing equations and boundary conditions; equilibrium criterion at the crack tip; motion of an elastic body with a propagating crack; asymptotic behavior of the near-crack tip field.

J.J. MARIGO - University of Paris, France

6 lectures on:

An evolution scheme and numerical approximation techniques for fracture mechanics; the evolutionary scheme of Francfort and Marigo within the Griffith scheme for brittle fracture; solution techniques based on the concept of Gamma-convergence.

D.R. OWEN - Carnegie Mellon University, USA

5 lectures on:

Field theories for bodies undergoing disarrangements; structured motions; refined description of contact and body forces; balance laws; dissipation; a theory of elasticity with disarrangements.

R. PARONI - University of Udine, Italy

3 lectures on:

Second-order structured deformations; approximation theorem and energetics in different settings: classical, SBV<sub>2</sub>, SBH.

M. SILHAVY - University of Prague, Czech Republic

6 lectures on:

Energy minimization for isotropic nonlinear elastic bodies; quasiconvexity, polyconvexity, rank-one

convexity- of isotropic functions; differentiability; formulas for the first and second differentials; relaxation of invariant functions; relaxation of invariant sets.

### **PRELIMINARY SUGGESTED READINGS**

J.M. Ball, Convexity conditions and existence theorems in nonlinear elasticity, Arch. Rational Mech. Analysis 63, 337-403, 1977.

B. Bourdin, G. Francfort, J.J. Marigo, Numerical experiments in revisited brittle fracture, Journal of Mechanics and Physics of Solids, 48, 797-826, 2000.

R. Choksi, G. Del Piero, I. Fonseca, D.R. Owen, Structured deformations as energy minimizers in models of fracture and hysteresis, Math. & Mech. of Solids 4, 321-356, 1999.

P. Ciarlet, Mathematical Elasticity, Vol.1, North-Holland, 1998.

G. Del Piero, D.R. Owen, Structured deformations, Lecture Notes, Gruppo Naz. Fisica Matematica (GNFM) Ravello 1997, Quaderni Ist. Naz. di Alta Matematica (INDAM) n. 58, 2000.

L. Deseri, D.R. Owen, Active slip-band separation and the energetics of slip in single crystals, Int. J. Plasticity 16, 1411-1418, 2000.

M.E. Gurtin, An introduction to Continuum Mechanics, Academic Press, 1981.

G. Francfort, J.J. Marigo, Revisiting brittle fracture as an energy minimization problem, J. Mech. Phys. Solids 46, 1319-1342, 1998.

D.R. Owen, R. Paroni, Second-order structured deformations, Arch. Rational Mech. Analysis 155, 215-235, 2000.

M. Silhavy, The mechanics and thermodynamics of continuous media, Springer, Berlin 1997 (Chapters I and II).

M. Silhavy, On isotropic rank-one convex functions, Proc. Roy. Soc. Edinburgh 129a, 1081-1105, 1999.

H. Stumpf, K.C. Le, Variational principles of nonlinear fracture mechanics, Acta Mechanica 83, 25-37, 1990.

### **LECTURES**

All lectures will be given in English. Lecture notes can be downloaded from CISM web site after registration.

**MULTISCALE MODELING IN CONTINUUM MECHANICS  
AND STRUCTURED DEFORMATIONS**

**Udine, July 15 - 19, 2002**

**Registration Form**  
(Please print or type)

Surname \_\_\_\_\_

Name \_\_\_\_\_

Affiliation \_\_\_\_\_

Address \_\_\_\_\_  
\_\_\_\_\_

E-mail \_\_\_\_\_

Phone \_\_\_\_\_ Fax \_\_\_\_\_

**Method of Payment - (Please check boxes)**

- I enclose a check of Euro 620,00 / 430,00 (IVA, VAT included and excluded bank charges)
- Payment has been made on CISM - Bank Account N° 210900, Banco di Sicilia - Udine (CAB 12300-ABI 01020-SWIFT BSICITRRUDN) - Copy of the receipt should be sent to the secretariat
- I shall pay at the registration counter with a 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.* _____
IVA or VAT* _____

(\* Only for EC or Italian residents or foreigners with permanent business activity in Italy.

According to the Italian law 675/96 in defense of privacy, your personal data will be used exclusively for conducting the course unless upon your explicit authorization.

Date \_\_\_\_\_ Signature \_\_\_\_\_

**Please return to: CISM**

Piazza Garibaldi, 18  
33100 UDINE (Italy)