

TIME TABLE

TIME	Monday	Tuesday	Wednesday	Thursday	Friday
	August 29	August 30	August 31	September 1	September 2
09.00 - 09.45	Registration	Forde	Suo	McMeeking	Bacca
09.45 - 10.30	Bernheim	Forde	Suo	McMeeking	Bacca
11.00 - 11.45	Bernheim	Suo	Bacca	McMeeking	McMeeking
11.45 - 12.30	Forde	Suo	Bacca	Lucantonio	McMeeking
14.00 - 14.45	Forde	Bernheim	Suo	Lucantonio	
14.45 - 15.30	Forde	Bernheim	Suo	De Simone	
16.00 - 16.45	Bernheim	Lucantonio	Poster Session	De Simone	
16.45 - 17.30	Bernheim	Lucantonio	Poster Session	De Simone	
18.00	Welcome aperitif				

ADMISSION AND ACCOMMODATION

The course is offered in a hybrid format giving the possibility to attend the course also by remote (on Microsoft Teams platform). On-site places are limited and assigned on first come first served basis.

The registration fees are:

- On-site participation, 600.00 Euro + VAT*

This fee includes a complimentary bag, five fixed menu buffet lunches, hot beverages, downloadable lecture notes.

Deadline for on-site application is July 29, 2022.

- Online participation, 250.00 Euro + VAT*

This fee includes downloadable lecture notes.

Deadline for online application is August 17, 2022.

Application forms should be sent on-line through the following web site: <http://www.cism.it>

A message of confirmation will be sent to accepted participants.

Upon request a limited number of on-site participants can be accommodated at CISM Guest House at the price of 30 Euro per person/night (mail to: foresteria@cism.it).

** where applicable (bank charges are not included)*

Italian VAT is 22%.

CANCELLATION POLICY

Applicants may cancel their registration and receive a full refund by notifying CISM Secretariat in writing (by email) no later than:

- July 29, 2022 for on-site participants (no refund after the deadline);

- August 17, 2022 for online participants (no refund after the deadline).

Cancellation requests received after these deadlines will be charged a 50.00 Euro handling fee. Incorrect payments are subject to Euro 50,00 handling fee.

GRANTS

A limited number of participants from universities and research centres who are not supported by their own institutions can request the waive of the registration fee and/or free lodging.

Requests should be sent to CISM Secretariat by **June 29, 2022** 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.

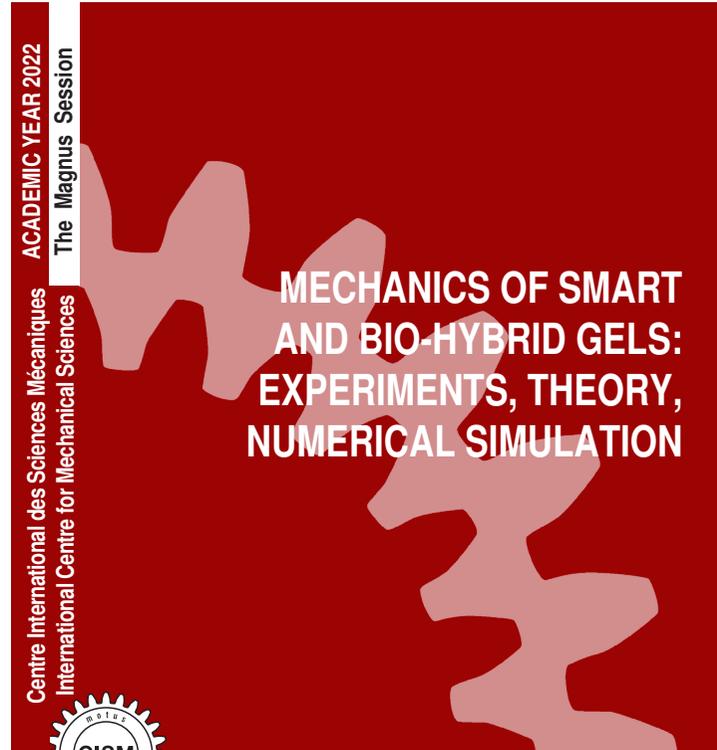
For further information please contact:

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Centre International des Sciences Mécaniques
International Centre for Mechanical Sciences

ACADEMIC YEAR 2022
The Magnus Session



Advanced School
coordinated by

Mattia Bacca
University of British Columbia
Vancouver, Canada

Alessandro Lucantonio
Scuola Superiore Sant'Anna
Pisa, Italy

Udine August 29 - September 2 2022

MECHANICS OF SMART AND BIO-HYBRID GELS: EXPERIMENTS, THEORY, NUMERICAL SIMULATION

The proposed course aims at creating a bridge between mechanics, chemistry, physics and biology to educate new scientists in the new and fast growing scientific framework of active soft matter. Many health treatments involving drug delivery and tissue transplant technology rely on a deep understanding of the physiological conditions of the living tissue involved. To achieve this, one needs to account for the coupling between the mechanical behavior of the tissue and its biochemical activity at multiple length scales, from intracellular mechanisms to tissue behavior at the organ level. In this framework, most of the scientific problems require cross-disciplinary expertise to be tackled, hence the emerging need for a new generation of scientists capable of combining fundamental concepts from different disciplines.

The course is aimed at researchers and graduate students in the fields of applied mathematics, mechanical and chemical engineering, physics, biology and biophysics.

Dr. Zhigang Suo will introduce the concept of hydrogel. Polymeric gels constitute a reliable physical model platform for most of the soft biological tissue constituting the human body hence this represents the foundation of this course. He will provide basic insight on the main mechanical properties of these materials such as adhesive strength, fracture toughness, fatigue resistance and viscoelasticity.

Dr. Alessandro Lucantonio will discuss the analytical and computational tools available today to describe the mechanical behavior of gels with particular focus on their poroelastic

behavior, which couples elasticity of the polymer network and species diffusion.

Dr. Mattia Bacca will discuss the thermodynamics of active deformation for materials depicted as a microstructural evolution.

The phenomenon emerges from a biochemical process, the activity of molecular motors powered by ATP hydrolysis, which alter the equilibrium state of the material, resulting in (active) macroscopic deformation.

Dr. Robert McMeeking will discuss the mechanics and thermodynamics of actin polymerization occurring within the cytoskeleton and the mechanics of cell adhesion. This will highlight the active and anisotropic characteristics of the material constituting living cells.

Dr. Antonio De Simone will provide an introduction of

fundamental concepts on crawling and deformation driven locomotion of living systems.

This will link the motility of a cell with its biochemical activity at the molecular level (actin- myosin, microtubule-dynein).

Dr. Nancy Forde lectures will provide insight into experimental techniques for characterization soft matter and measure molecular-scale phenomena. She will then provide theoretical and practical insight on micro rheology, single- molecule mechanics and other techniques to create synthetic molecular motors.

Finally, Dr. Anne Bernheim will provide insight into the theory and the experimental techniques utilized to recreate other cell-level mechanisms with in-vitro system and will conclude the course.

LECTURERS

Mattia Bacca - University of British Columbia, Vancouver, Canada
4 lectures on: Continuum mechanics and thermodynamics of active soft materials

1. Non-equilibrium thermodynamics of the continuum; 2. State variables and microstructure evolution of materials; 3. Energy transduction and chemo-mechanics of materials; 4. Contraction of an active gel.

Anne Bernheim - Ben-Gurion University of the Negev, Be'er Sheva, Israel

6 lectures on: In-vitro reconstitution of the contractile cytoskeleton

1. In vitro system as a model for reconstituting cellular processes; 2-3. Actin based motility driven by actin polymerization; 4. Active gels - self-organization and patterning; 5. Actomyosin gels - contractility and poroelasticity; 6. Spontaneous 3D shape transitions of contractile actomyosin gel sheets.

Antonio De Simone - MathLab, SISSA, Trieste, Italy

3 lectures on: Systems of motors and bio-filaments and their role in cell motility

1. Dyneins and microtubules in eukaryotic cilia and flagella; 2. Shape programming in biological and artificial systems.

Nancy Forde - Simon Fraser University, Burnaby, Canada

5 lectures on: Mechanical properties of biological systems at the nano- and micro-scale

1. (Bio)Polymer mechanics - theory and experiment; 2. Single-molecule mechanics techniques; 3. DNA mechanics; 4. Microrheology - experimental approaches; 5. Collagen mechanics - from molecules to the matrix; 6. Synthetic molecular motors.

Alessandro Lucantonio - The BioRobotics Institute, Scuola Superiore Sant'Anna, Pisa, Italy

4 lectures on: Theoretical and computational modeling of polymer gels

1. Introduction to polymer physics and review of coupled models for swelling gels; 2. Asymptotic analysis of transient and steady swelling phenomena; 3. Poroelastic fracture in gels; 4. Finite element formulation of the coupled model and applications.

Robert M. McMeeking - University of California Santa Barbara, Santa Barbara, USA

5 lectures on: Cell contractility and adhesion

1. Acto-myosin stress fibres and cell adhesion; 2. Biochemomechanical mechanisms of contractility; 3. Model of contractility/signaling interactions and in vitro behavior; 4. Interaction of cells with compliant substrates; 5. Modeling in vivo behavior.

Zhigang Suo - Harvard University, Cambridge, MA, USA

6 lectures on: Hydrogels

1. Hydrogel ionotronics and bioelectronics; 2. Tough hydrogels; 3. Fatigue of hydrogels; 4. Stretchable materials of high toughness and low hysteresis; 5. Hydrogel adhesion; 6. Poroelasticity of hydrogels.

PRELIMINARY SUGGESTED READINGS

W. Hong, X. Zhao, J. Zhou, Z. Suo (2005) "A theory of coupled diffusion and large deformation in polymeric gels" *Journal of the Mechanics and Physics of Solids* 56 1779-1793.

A. Lucantonio, P. Nardinocchi, L. Teresi (2013) "Transient analysis of swelling-induced large deformations in polymer gels" *Journal of the Mechanics and Physics of Solids* 61 205-218.

M. Bacca, O.A. Saleh, R.M. McMeeking (2018) "Contraction of polymer gels created by the activity of molecular motors" *Soft Matter* 15 4467-4475.

V.S. Deshpande, R.M. McMeeking, A.G. Evans (2006) "A bio-chemo-mechanical model for cell contractility" *Proceedings of the National Academy of Sciences - USA* 103 14015-14020.

G. Noselli, A. Beran, M. Arroyo, A. DeSimone (2019) "Swimming euglena respond to confinement with a behavioural change enabling effective crawling" *Nature Physics* 179 799-805.

M.W.H. Kirkness, K. Lehmann, N.R. Forde (2019) "Mechanics and Structural Stability of the Collagen Triple Helix" *arXiv:1903.07276*.

A. Bernheim-Groswasser, N. Gov, S. Safran, N. Tzliil (2018) "Living matter: mesoscopic active materials" *Advanced Materials* 30 1707028.

LECTURES

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