TIME TABLE

TIME	Monday	Tuesday	Wednesday	Thursday	Friday
	July 5	July 6	July 7	July 8	July 9
09.00 - 09.45	Registration	Datta	Erdogdu	Verboven	Fischer
09.45 - 10.30	Teresi	Datta	Erdogdu	Verboven	Verboven
11.00 - 11.45	van der Sman	Charalambides	Fischer	Fischer	Teresi
11.45 - 12.30	van der Sman	Charalambides	Fischer	Fischer	Teresi
14.00 - 14.45	Charalambides	Erdogdu	Verboven	Erdogdu	
14.45 - 15.30	Charalambides	Erdogdu	Verboven	Datta	
16.00 - 16.45	Teresi	van der Sman	Datta	van der Sman	
16.45 - 17.30	Teresi	van der Sman	Datta	Charalambides	
18.00	Welcome aperitif	Poster Session			

ADMISSION AND ACCOMMODATION

The course is offered in a hybrid format, allowing participants the flexibility to attend either in person or remotely via the Microsoft Teams platform. Admission to on-site attendance is granted on a first-come, first-served basis to comply with the capacity of the lecture room.

Registration fees:

- **Early Bird On-Site Participation: € 650.00 + VAT***
  Deadline: May 5, 2027
- **Late On-Site Participation: € 800.00 + VAT***
  Deadline: June 23, 2027
- **Live Streaming Online Participation: € 250.00 + VAT***
  Deadline: June 23, 2027

On-site participation includes a complimentary bag, five fixed menu buffet lunches, hot beverages, downloadable lecture notes.
Online participation includes downloadable lecture notes.

Application forms should be submitted online through the website: http://www.cism.it. A confirmation message will be sent to participants whose applications are accepted.
Upon request, and subject to availability, a limited number of on-site participants can be accommodated at the CISM Guest House for € 35 per person per night. To request accommodation, please contact: 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 the CISM Secretariat in writing (via email) no later than:
- May 5, 2027, for early bird on-site participation;
- June 5, 2027, for late on-site participation;
- June 23, 2027, for online participation.

No refunds after the deadlines. Cancellation requests received before these deadlines and incorrect payments will be subject to a € 50.00 handling fee.

CISM GRANTS

A limited number of participants from universities and research centers who do not receive support from their institutions can request a waiver of the registration fee and/or free lodging.
Requests must be submitted via the CISM website by **May 5, 2027**. Applicants should select the relevant option in the online application form and provide a curriculum vitae and a letter of recommendation from their department head or supervisor confirming that their institution is unable to provide financial support. Preference will be given to applicants from countries that sponsor CISM.

For further information please contact:

CISM (Seat of the course)
Palazzo del Torso - Piazza Garibaldi 18 - 33100 Udine (Italy)
tel. +39 0432 248511 (6 lines)
e-mail: info@cism.it | www.cism.it

Centre International des Sciences Mécaniques
International Centre for Mechanical Sciences

ACADEMIC YEAR 2027
Andreas Acrivos Session

THE MECHANICS OF EDIBLE SOFT MATTER: FLUID/SOLID MODELING

CISM Advanced School
coordinated by

Luciano Teresi
University Roma Tre
Rome, Italy

Ruud van der Sman
Wageningen University & Research
Wageningen, The Netherland

Udine *July 5 - 9* 2027

THE MECHANICS OF EDIBLE SOFT MATTER: FLUID/SOLID MODELING

The structuring of food materials during processing relies on continuous and rapid transitions between fluid-like and solid-like states. These state transformations govern critical operations, including spray drying, baking, frying, extrusion, and 3D food printing. Developing predictive continuum models for these operations remains a major hurdle in modern food engineering.

This challenge stems from the need for a unified theoretical framework bridging fluid mechanics, large-deformation solid mechanics, non-linear rheology, and multiphysics transport phenomena. Soft matter mechanics has undergone significant conceptual advancements; modern large-deformation continuum frameworks for soft solids now share fundamental structural similarities with viscoelastic fluid models. By leveraging non-equilibrium thermodynamics, these formulations yield consistent descriptions integrating elasticity, viscosity, yield stress, plasticity, and structural evolution. This convergence offers a mathematically rigorous pathway toward dissolving the traditional boundary between fluid and solid mechanics within a single constitutive setting.

In solid mechanics, unified continuum frameworks capture complex couplings between finite deformation and mass transport, as demonstrated in hydrogel swelling and poroelastic media. Comparable multiphysics interactions are central to food structuring. For example, during high-moisture extrusion of plant-based meat analogs, flow-induced phase separation generates distinct microstructures, localized lubrication layers, and syneresis. Describing such complex behaviors exceeds traditional purely rheological or elastic models, demanding an integrated multiphysics approach combining mechanics, mass transport, thermal dynamics, and phase behavior.

Concurrently, advanced rheological formulations, particularly Thixotropic-Elasto-Visco-Plastic (TEVP) models, are indispensable for capturing history-dependent flow, structural breakdown, and yield dynamics in doughs, dense emulsions, and concentrated protein suspensions. Bridging TEVP rheology with finite-strain hyperelasticity and plasticity theory provides a robust foundation for modeling materials that continuously transition between flowing liquid-like states and load-bearing solid networks. Incorporating moisture transport, thermal fields, phase separation, and microstructural evolution into a unified constitutive framework opens new horizons for predictive food modeling. Such integrative theories are essential for transitioning food process engineering from empirical trial-and-error toward rational, physics-based design.

This Advanced School provides participants with the conceptual, thermodynamic, and mathematical building blocks to construct, implement, and critically assess these unified theoretical and computational frameworks. Through dedicated modules on continuum mechanics, non-equilibrium thermodynamics, and transport phenomena, attendees will gain foundational tools to tackle complex fluid/solid modeling challenges across modern food science and engineering.

PRELIMINARY SUGGESTED READINGS

Nardinocchi, et al. (2026). Mechanics of Swelling, RSC. doi:10.1039/9781837676736

Curatolo, et al. (2026). Soft Matter. doi:10.1039/D5SM01263E

Xiong, et al. (2027). J. Food Eng. doi:10.1016/j.jfoodeng.2026.113153

Elezoglou, et al. (2026). J. Food Eng. doi:10.1016/j.jfoodeng.2026.113144

Makrypidis, et al. (2026). J. Non-Newtonian Fluid Mech. doi:10.1016/j.jnnfm.2026.105646

Erdogdu, et al. (2017). J. Food Eng. doi:10.1016/j.jfoodeng.2017.05.030

Coskun, et al. (2022). Innov. Food Sci. Emerg. Technol. doi:10.1016/j.ifset.2022.103184

Karatas, et al. (2023). Innov. Food Sci. Emerg. Technol. doi:10.1016/j.ifset.2023.103345

Datta, A.K. (2026). Digital Food Physics & Modeling. ecornell.cornell.edu/custom/foodphysics/

Datta, et al. (2012). Faraday Discuss. doi:10.1039/C2FD20042B

Datta, et al. (2022). Nat. Food. doi:10.1038/s43016-022-00617-5

Ghosh, et al. (2026). Chem. Eng. Sci. doi:10.1016/j.ces.2026.124268

Piovesan, et al. (2021). Trends Plant Sci. doi:10.1016/j.tplants.2021.07.010

Xiao, et al. (2023). J. Food Eng. doi:10.1016/j.jfoodeng.2023.111432

Verreydt, et al. (2022). Postharvest Biol. Technol. doi:10.1016/j.postharvbio.2022.112083

Van Cauteren, et al. (2026). J. Exp. Bot. doi:10.1093/jxb/erag405

Ramos, et al. (2025). Europhys. News. doi:10.1051/epn/2025309

Bertsch, et al. (2022). Food Funct. doi:10.1039/d2fo01247b

Bertsch, et al. (2021). Acta Biomater. doi:10.1016/j.actbio.2021.05.051

INVITED LECTURERS

Maria Charalambides - Imperial College, London, UK
5 lectures on: Mechanical characterization and modeling of soft solid foods, covering fracture mechanics, FEA, extrusion, and sheeting. They extend to human digestion and oral mechanics (rheology, tribology) to link food structure with consumer perception.

Ashim Datta - Cornell University, Ithaca, NY, USA
5 lectures on: Coupled multiphase transport and deformation in food. Covering poromechanics, moisture/gas-driven shape changes, and electromagnetic heating. Includes mathematical formulations, computational challenges, and AI surrogate models for design.

Ferruh Erdogdu - Ankara University, Turkey
5 lectures on: Fluid flow coupled to multiphysics in food processing, covering fluid dynamics, heat transfer, and electromagnetics. They focus on process design, scale-up of sustainable systems, and computational tools for efficiency, safety, and quality.

Peter Fischer - ETH Zurich, Switzerland
5 lectures on: Food Rheology, Physiology, Nutrition and Health. Bridging rheology, processing, and materials science, they focus on structural design to directly link rheological properties to optimal physiological uptake, nutrition, health, and digestion.

Ruud van der Sman - Wageningen University & Research, The Netherlands
5 lectures on: Modeling Foods Between Fluid and Solid States. Exploring transitions in snack pore formation, meat analog flow, and 3D printing, they bridge fluid and solid mechanics into rate-based constitutive models for solidifying food pastes.

Luciano Teresi - University Roma Tre, Rome, Italy
5 lectures on: Mechanics of Swelling. Covering chemo-mechanical coupling between elasticity and solvent transport, they examine how swelling drives shape changes, transient instabilities, and wrinkling patterns in complex food materials.

Pieter Verboven - KU Leuven, Belgium
5 lectures on: Tomography techniques and image analysis. Covering multiscale structure quantification, pore network modeling, and CFD for transport, they use discrete element modeling to link microstructural geometry with macroscale food mechanics.

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.