TIME TABLE

TIME	Monday	Tuesday	Wednesday	Thursday	Friday
	October 11	October 12	October 13	October 14	October 15
09.00 - 09.45	Registration	Wriggers	Scovazzi	Düster	Berrone
09.45 - 10.30	Wriggers	Wriggers	Scovazzi	Düster	Berrone
11.00 - 11.45	Larson	Berrone	Berrone	Scovazzi	Wriggers
11.45 - 12.30	Larson	Berrone	Berrone	Scovazzi	Wriggers
14.00 - 14.45	Düster	De Lorenzis	Düster	Larson	
14.45 - 15.30	Düster	De Lorenzis	Düster	Larson	
16.00 - 16.45	Scovazzi	Larson	De Lorenzis	De Lorenzis	
16.45 - 17.30	Scovazzi	Larson	De Lorenzis	De Lorenzis	
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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: August 11, 2027

- Late On-Site Participation: € 800.00 + VAT*
Deadline: September 29, 2027

- Live Streaming Online Participation: € 250.00 + VAT*
Deadline: September 29, 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:
- August 11, 2027, for early bird on-site participation;
- September 11, 2027, for late on-site participation;
- September 29, 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 **August 11, 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
Ted Bohdan Belytschko Session

NOVEL TECHNIQUES FOR INTERFACE TREATMENT IN MECHANICS

CISM Advanced School
coordinated by

Peter Wriggers
Leibniz University Hannover
Garbsen, Germany

Guglielmo Scovazzi
Duke University
Durham, NC, USA

Udine ***October 11 - 15*** 2027

NOVEL TECHNIQUES FOR INTERFACE TREATMENT IN MECHANICS

Modern computational mechanics increasingly requires the accurate and robust representation of interfaces between materials, phases, and physical domains. Classical finite element methods (FEMs), which are based on conforming meshes aligned with the geometry, often reach their limit of performance and robustness when interfaces evolve, exhibit discontinuities, or require high geometric fidelity without excessive remeshing effort. Geometric representations of interfaces may sometimes be imperfect, if obtained by means of scanning/imaging techniques, which are emerging as a prime tool in the development of Digital Twins (DTs) of mechanical systems. Applications such as fracture mechanics, multi-phase flows, additive manufacturing, composite materials, and contact problems rely fundamentally on numerical strategies that can resolve complex interfaces with optimal computational efficiency.

This course addresses these challenges by discussing advanced interface treatment. The topics covered represent state-of-the-art approaches in computational science and engineering, including third-media contact formulations; the Finite Cell Method; phase-field models for diffuse interfaces; unfitted discretization using CutFEM, the Shifted Boundary/Interface Method, and Optimization-Based Methods for embedded geometries and interfaces, as representative of the broad class of unfitted-mesh techniques. Together, these methods enable accurate simulations in situations where classical mesh-conforming strategies become impractical or break down entirely. Students will gain both conceptual insight and hands-on experience in these modern techniques, preparing them for current and emerging research challenges.

The primary objective of this course is to provide a comprehensive understanding of numerical interface treatment in the context of numerical methods. The course consists of an introductory discussion on: The classification of interface phenomena (geometric, physical, kinematic) and selection of appropriate numerical strategies for their treatment and the mathematical/numerical challenges of representing discontinuities, evolving boundaries, and complex geometries in advanced technologies based on FEM. Emphasis will be given on variational problem formulation, weak imposition of boundary conditions, numerical stability, matrix conditioning, and algebraic solution techniques. The following topics will be discussed in detail:

- the CutFEM framework;
- the Finite Cell Method (FCM);
- the Shifted Boundary/Interface Method (SB/IM);
- Third-Medium and Dual-Mortar contact formulations enabling robust contact enforcement between nonmatching surfaces;
- Phase-Field techniques for modelling fractures, phase transitions, and diffuse-interface phenomena;
- Optimization-based algorithms for the treatment of fracture networks and application to large scale fracture simulations.

PRELIMINARY SUGGESTED READINGS

Düster, E. Rank, B. Szabó. (2017) The p-Version of the Finite Element and Finite Cell Methods. In E. Stein, R. de Borst, T.J.R. Hughes, editors: Encyclopedia of Computational Mechanics, 2nd Edition. Solids and Structures, Part 1, Chapter 4, John Wiley & Sons.

P. Wriggers, Ph. Junker, J. Korelc. (2025) A third medium approach for contact using first and second order finite elements. Computer Methods in Applied Mechanics and Engineering, 435, 117740.

A. Main, G. Scovazzi. (2018) The shifted boundary method for embedded domain computations. Part I: Poisson and Stokes problems. Journal of Computational Physics, 372, 972–995.

J.H. Collins, K. Li, A. Lozinski, G. Scovazzi. (2026) Gap-SBM: A new conceptualization of the shifted boundary method with optimal convergence for the Neumann and Dirichlet problems. Computer Methods in Applied Mechanics and Engineering, 453, 118793.

E. Burman, P. Hansbo, M. G. Larson, S. Zahedi. (2025) Cut Finite Element Methods. Acta Numerica, 34, 1–121.

S. Berrone, S. Scialò, F. Vicini. (2019) Parallel Meshing, Discretization, and Computation of Flow in Massive Discrete Fracture Networks. SIAM Journal on Scientific Computing, 41(4), C317–C338.

S. Berrone, F. Vicini. (2025) Effective Polygonal Mesh Generation and Refinement for VEM. Mathematics and Computers in Simulation, 231, 239–258.

N. Provatas, K. Elder. (2010) Phase-Field Modeling in Materials Science and Engineering. Wiley.

H. Gomez, K. van der Zee. (2017) Computational Phase-Field Modeling. Encyclopedia of Computational Mechanics. Wiley.

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.

INVITED LECTURERS

Peter Wriggers - Leibniz University Hannover, Garbsen, Germany
5 lectures on:
Development of third-media contact formulations, comparison of different regularisation techniques. Two- and three-dimensional applications. Comparisons with mortar and penalty methods. Discussion of key implementation and robustness issues for different problem classes.

Guglielmo Scovazzi - Duke University, Durham, NC, USA
6 lectures on:
The Shifted Boundary/Interface Method: prototypical shifted Dirichlet and Neumann conditions for the Poisson and Stokes problems. Applications to CFD, linear/nonlinear solid mechanics, contact and fracture mechanics, moving interface problems.

Alexander Düster - Hamburg University of Technology, Germany
6 lectures on:
Finite cell method, numerical integration, material interface enrichment. Applications: microstructured materials, homogenization, bone mechanics, vibroacoustic simulation of damping materials, phase-field fracture, and third-medium contact.

Stefano Berrone - Politecnico di Torino, Italy
6 lectures on:
Simulation of flow in Discrete Fracture Networks using conforming and non-conforming mesh approaches, with particular emphasis on PDE-constrained optimization techniques for domain decomposition and efficient parallel computation.

Mats G. Larson - Umea University, Sweden
6 lectures on:
The basic ideas of cut finite element methods (CutFEM): construction of the method, weak enforcement of constraints, stabilization of cut elements, and basic stability and convergence bounds, along with a couple of relevant engineering applications.

Laura De Lorenzis - ETH Zürich, Switzerland
6 lectures on:
Basics of phase-field models, the Allen-Cahn and the Cahn-Hilliard equations. Phase-field modeling of fracture. Phase-field modeling of phase transformations. Finite element discretization and efficient solution schemes. Advanced applications and open issues.