

TIME TABLE

TIME	Monday	Tuesday	Wednesday	Thursday	Friday
	July 12	July 13	July 14	July 15	July 16
09.00 - 09.45	Registration	Bermejo	Bermejo	Augustin	Chassagne
09.45 - 10.30	Bermejo	Bermejo	Bermejo	Augustin	Chassagne
11.00 - 11.45	Bermejo	Augustin	García-Villalba	Chassagne	del Álamo
11.45 - 12.30	del Álamo	Augustin	García-Villalba	Chassagne	del Álamo
14.00 - 14.45	del Álamo	del Álamo	Augustin	García-Villalba	
14.45 - 15.30	Chassagne	del Álamo	Augustin	García-Villalba	
16.00 - 16.45	Boyle	García-Villalba	Boyle	Boyle	
16.45 - 17.30	Boyle	García-Villalba	Boyle	Boyle	
18.00	Welcome aperitif				

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 12, 2027

- **Late On-Site Participation: € 800.00 + VAT***

Deadline: June 30, 2027

- **Live Streaming Online Participation: € 250.00 + VAT***

Deadline: June 30, 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 12, 2027, for early bird on-site participation;
- June 12, 2027, for late on-site participation;
- June 30, 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 12, 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

COMPUTATIONAL MODELLING OF THE HEART: FROM FUNDAMENTALS TO CLINICAL APPLICATIONS

CISM Advanced School
coordinated by

Juan Carlos del Álamo
University of Washington, USA

Manuel García-Villalba
TU Wien, Austria

Udine July 12 - 16 2027

COMPUTATIONAL MODELLING OF THE HEART: FROM FUNDAMENTALS TO CLINICAL

Recent progress in the fields of computational modeling, data science, and artificial intelligence have shaken the landscape of cardiovascular research. In parallel, state-of-the-art medical imaging technologies now provide streams of patient data of unprecedented volume and detail. The convergence of these advances with the growth in processing power and communication infrastructure has made it possible to run patient-specific models of high fidelity or in large numbers, and empowered inter-disciplinary collaborations that are accelerating further developments of multi-scale, multi-physics models.

These synergies are driving a revolution in cardiovascular science by offering increasingly realistic digital twins to investigate disease mechanisms, facilitate medical device design and implantation planning, search

for therapeutic targets, and improve diagnosis. However, the translation of computational advances to improve clinical decision support systems also faces significant challenges. It is necessary to be able to handle and manage vast amounts of data, coming from various sources and with different formats. Running patient-specific models with high fidelity requires significant computational resources. Multi-scale and multi-fidelity models can alleviate this requirement but involve careful integration. Building end-to-end simulation pipelines demands thorough software engineering and multi-disciplinary collaboration. Acquiring the imaging data that feeds these pipelines is often challenging when it is not clinically indicated. Multi-physics models reduce the amount of necessary image data and allow for studying mechanistic questions. However, they rely on model parameters

that are difficult to measure experimentally. Moreover, before clinical support systems can be implemented, rigorous validation against real-world clinical data is required. Other challenges are related to regulation, ethics or gaining the trust in the models of healthcare professionals, such as doctors and nurses, among others. Overcoming these challenges is essential to realize the full potential of current cardiovascular research and requires a new generation of scientists trained in all these aspects.

This course will review core competencies and novel developments in cardiac computational modeling. Particular attention will be given to multi-physics, multi-scale model development, digital twins, and physics-informed inference from medical images. We will consider patient-specific modeling beyond cardiovascular

geometry, and review simulation pipeline automation and integration into clinical decision support systems. The course curriculum will cover fundamental topics in cardiac biomechanics and state-of-the-art modeling techniques. It will also discuss machine learning and AI tools for image analysis and provide examples of computational models adopted into clinical decision support systems.

The course is aimed at graduate students of applied sciences and engineering interested in all aspects of cardiac bio-electro-mechanics, including imaging and computing. Researchers specializing in one field (e.g., electrophysiology) interested in branching out to other areas (e.g., fluid-structure interaction) are also welcome to attend this course. The course will feature poster sessions to spark cross-disciplinary communication among participants.

PRELIMINARY SUGGESTED READINGS

N. Ahmadi et al. Physics-Informed Machine Learning in Biomedical Science and Engineering. *Annu. Rev. Biomed. Eng.* 2026; 28:309-336

A. Arzani et al. Machine learning for cardiovascular biomechanics modeling: challenges and beyond. *Annals Biomed. Eng.* 2022; 50(6), 615–627

C. M. Augustin et al. A computationally efficient physiologically comprehensive

3D–0D closed-loop model of the heart and circulation *Comput. Meth. Appl. Mech. Eng.* 2021; 386: 114092

P. Boyle et al. Fibrosis, atrial fibrillation and stroke: clinical updates and emerging mechanistic models. *Heart* 2021;107:99-105

A. L. Brown et al. Cardiac mechanics modeling: recent developments and current challenges. *J. Elasticity* 2026; 158, 28

C. Chen et al. Deep learning for cardiac image segmentation: A review, *Frontiers Cardiovasc. Med.*, 7, 2020

A. De Vecchi et al. Digital Twins for Predictive Modelling of Thrombosis and Stroke Risk. *Thromb. Haemost.* 2026; 126(08): 775-794

K. Gillette et al. A framework for the generation of digital twins of cardiac electrophysiology from clinical 12-leads ECGs. *Med. Image Anal.* 2021; 71: 102080

G. Plank et al. The openCARP simulation environment for cardiac electrophysiology. *Comput. Meth. Prog. Biomed.* 2021;208:106223

D. Qiu et al., “Local Mechanical Characterization of Cardiovascular Tissues: Methods, Challenges, and Pathways to Clinical Use.” *Frontiers Mech. Eng.* 2025; 11:1703081

R. Verzicco. Electro-fluid-mechanics of the heart. *J. Fluid Mech.*, 2022; 941, P1

INVITED LECTURERS

Augustin Christoph - Medical University of Graz, Austria
6 lectures on:
Cardiovascular Tissue Biomechanics. Cardiac Electromechanics. Computational modeling techniques and finite element methods. Multi-scale, multi-physics simulations. Computational models in clinical settings.

Bermejo Javier - Gregorio Marañón Hospital, Spain
6 lectures on:
Place for engineers in cardiovascular medicine. The basics: anatomy and physiology of the cardiovascular system. An overview of cardiac diseases. In silico, pre-clinical and clinical cardiovascular research. Transferring R&D to the bedside.

Boyle Patrick M. - University of Washington, USA
6 lectures on:
Cardiac electrophysiology overview. Cell-Scale: Ion channels, action potentials, and calcium handling. Tissue-Scale: Gap junctions, impulse propagation, and anisotropy. Arrhythmia: ectopic beats, reentry, and fibrillation. Interventions: drugs, catheter ablation, and defibrillation.

Chassagne Fanette - Mines Saint-Etienne, France
5 lectures on:
Cardiac medical devices. Inverse methods to identify mechanical properties of cardiac tissues. Experimental validation of fluid-structure interaction models. Methodologies for bridging in silico and in vitro (or in vivo) data, and ensuring model credibility in a clinical context.

del Álamo Juan Carlos - University of Washington, USA
6 lectures on:
Cardiac Imaging, Segmentation, and Model Generation. Reduced-order Models of the Cardiovascular System. Machine Learning for Cardiac Flow Imaging. Uncertainty Quantification. Cardiac thrombosis and embolism.

García-Villalba Manuel - TU Wien, Austria
6 lectures on:
Computational fluid dynamics. Immersed boundary methods. Fluid-structure interaction methods. High-performance computing. Verification, validation. Cardiac valves.

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.