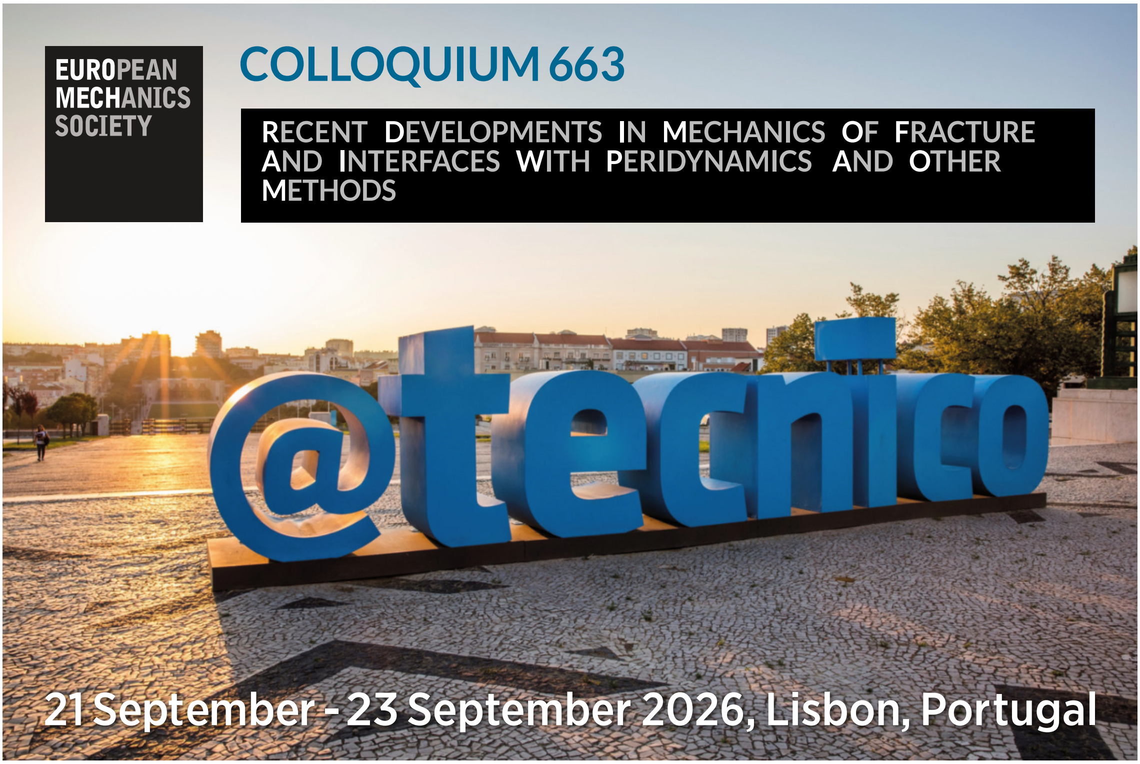
EUROPEAN MECHANICS SOCIETY

COLLOQUIUM 663

RECENT DEVELOPMENTS IN MECHANICS OF FRACTURE AND INTERFACES WITH PERIDYNAMICS AND OTHER METHODS



21 September - 23 September 2026, Lisbon, Portugal

PROGRAM

and

BOOK OF ABSTRACTS

Edited by:
Francisco João de Sousa Vieira | Francesco Scabbia | Alexander Hermann

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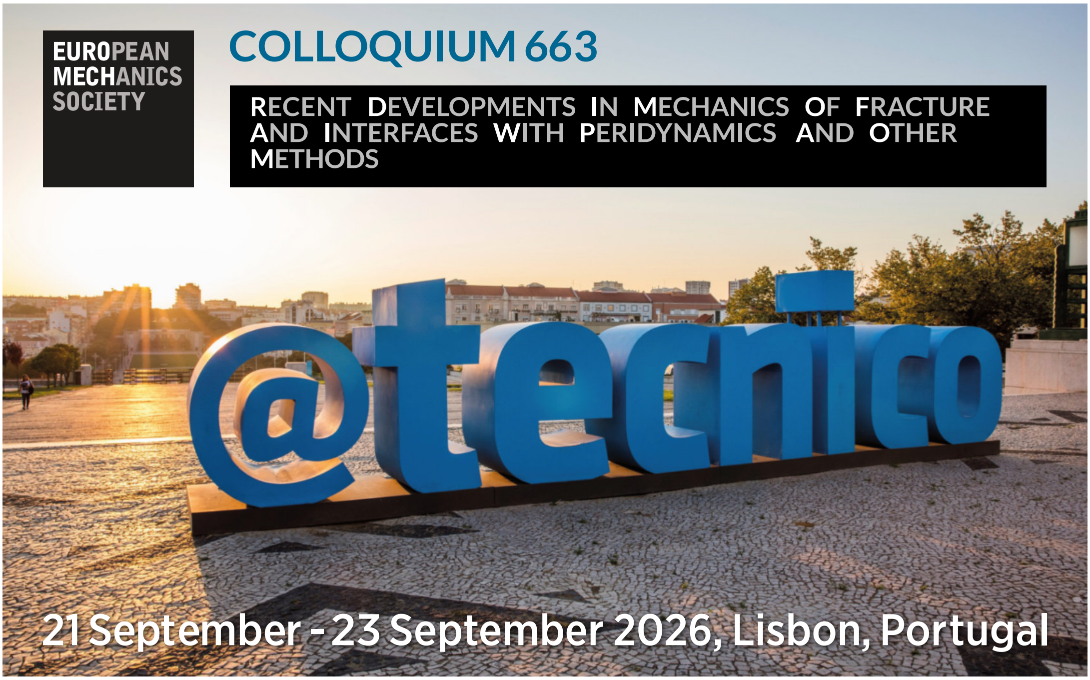

21 September - 23 September 2026, Lisbon, Portugal

PROGRAM

Title:

PROGRAM

EUROMECH - COLLOQUIUM 663

RECENT DEVELOPMENTS IN MECHANICS OF FRACTURE AND INTERFACES WITH PERIDYNAMICS AND OTHER METHODS

Edited by:

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September 2026

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1049-001 LISBOA

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Luís Barros
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Preface

On behalf of the Organizing Committee, it is our great pleasure to welcome you to Lisbon for EUROMECH Colloquium 663 - *Recent developments in mechanics of fracture and interfaces with peridynamics and other methods.*

As computational mechanics continues to evolve, addressing complex phenomena like crack initiation, material interfaces, and multiphysics coupling requires innovative mathematical and numerical approaches. This colloquium brings together researchers, scholars, and practitioners from around the globe to foster open dialogue, share ground-breaking developments, and evaluate peridynamics alongside other computational frameworks, such as phase field models and discrete discontinuity approaches.

Below, you will find an overview of the scientific scope and key themes guiding our discussions over the next three days. We wish you a highly inspiring, collaborative, and rewarding conference in Lisbon!

Scientific Scope

Peridynamics is a nonlocal continuum formulation that has demonstrated significant potential for addressing problems in which classical continuum models based on partial differential equations encounter difficulties, particularly the initiation and evolution of cracks and the mechanical behavior of material interfaces. Its governing equations use integral operators to account for the collective interactions between each material point and the other points within its neighborhood. Because spatial derivatives are not required, the governing equations remain valid at cracks, interfaces, and other discontinuities, allowing their formation and evolution to be described naturally within a unified framework.

This colloquium will focus on recent advances in the application of peridynamics to fracture and interface mechanics. Particular attention will be devoted to criteria for crack nucleation and propagation, fatigue and cyclic crack growth, dynamic fracture, fragmentation, impact, and penetration. Recent constitutive developments for heterogeneous, anisotropic, composite, architected, and metamaterial systems will also be discussed, together with approaches for representing evolving material interfaces, contact, friction, and nonlocal interactions across discontinuities. Multiscale and multiphysics developments will also be addressed, including micro-to-macro bridging and coupling with thermal, electrical, chemical, and fluid processes such as diffusion, corrosion, and electrochemical degradation. Computational advances will cover mesh-free discretizations, efficient solvers, GPU and parallel implementations, local–nonlocal coupling, finite element embeddings, and data-driven techniques for acceleration and calibration.

A central objective of the colloquium is to place peridynamics within the broader context of computational fracture mechanics through integrative and cross-method investigations. This perspective includes phase-field methods, XFEM, cohesive-zone models, SPH, and classical continuum formulations. Particular importance will be given to carefully designed benchmarks, experimental validation, quantitative assessments, and reproducible computational workflows. These efforts are essential for identifying the conditions under which each approach is most reliable, clarifying differences in their assumptions and predictions, and evaluating accuracy, robustness, computational cost, and scalability. By promoting shared benchmarks and transparent validation procedures, the colloquium aims to support the development of best practices and establish credible pathways toward predictive modeling of fracture and interface phenomena.

By bringing together theoretical, computational, and applied contributions from fields including composites, geomechanics, concrete, biomaterials, manufacturing, nanoscale mechanics, and materials design, the colloquium aims to identify open problems, define priorities for future research, and foster collaborations that advance the understanding and simulation of fracture and interface phenomena.

Lisbon, Portugal, 21–23 September 2026
The Organizing Committee


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RECENT DEVELOPMENTS IN MECHANICS OF FRACTURE AND INTERFACES WITH PERIDYNAMICS AND OTHER METHODS
@tecnico
21 September - 23 September 2026, Lisbon, Portugal

Contents:

Committees

CHAIRPERSON:

Francisco João de Sousa Vieira
National Laboratory for Civil Engineering
National Advanced Computing Centre
Portugal

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National Advanced Computing Centre
Portugal

SECRETARIAT:

Paula Jorge
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Conference Information

Conference Venue

EUROMECH Colloquium 663 takes place at Instituto Superior Técnico (IST) Congress Center situated in the Department of Civil Engineering and Architecture building (Pavilhão de Civil).

Av. Rovisco Pais, 1
1049-001 LISBOA
Portugal
GPS: Lat: N38° 44' 14,98" - W9° 8' 14,42".

Secretariat Open Hours

- Monday, 21 September > 08:30 - 17:00
- Tuesday, 22 September > 08:45 - 17:15
- Wednesday, 23 September > 08:45 - 16:00

Congress Center (Civil Engineering Building) Ground -1

Certificate of Participation

Certificates will be sent by e-mail after the conference upon request to: euromech663@tecnico.ulisboa.pt

Name Badges

Please use your name badge at all times, including technical sessions, lunches and social events.

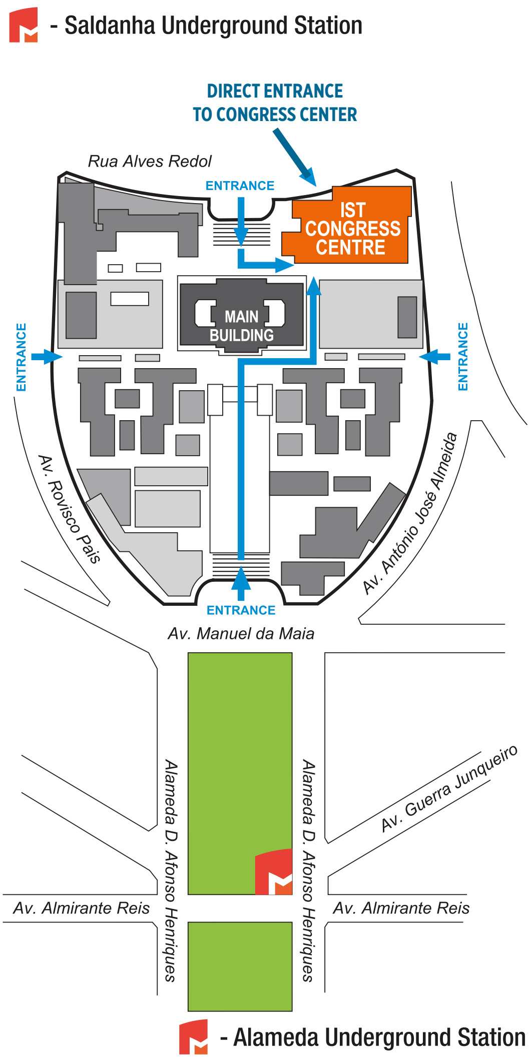
Coffee Breaks

The coffee breaks will take place in the Hall -2 of the conference center (see map of the conference center) and will be open to all participants. Kindly wear your name badge.

Lunches

Lunch will be served in Hall -2 of the conference center (see the conference center map) and will be available to all participants. A selection of lunch options will be provided each day, including a vegetarian option. Please wear your name badge to access the lunch area.

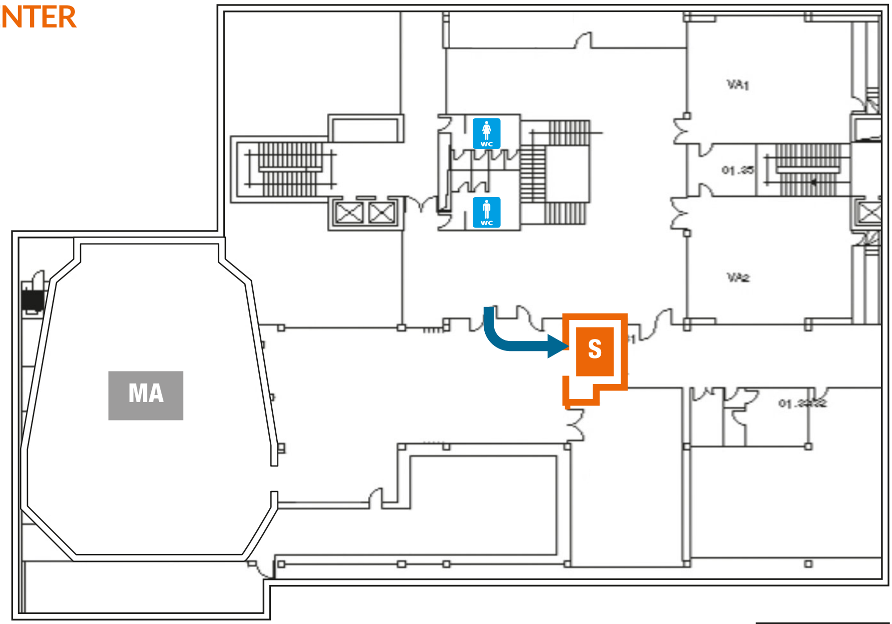
PLANT OF INSTITUTO SUPERIOR TÉCNICO
With the location of the Congress Centre



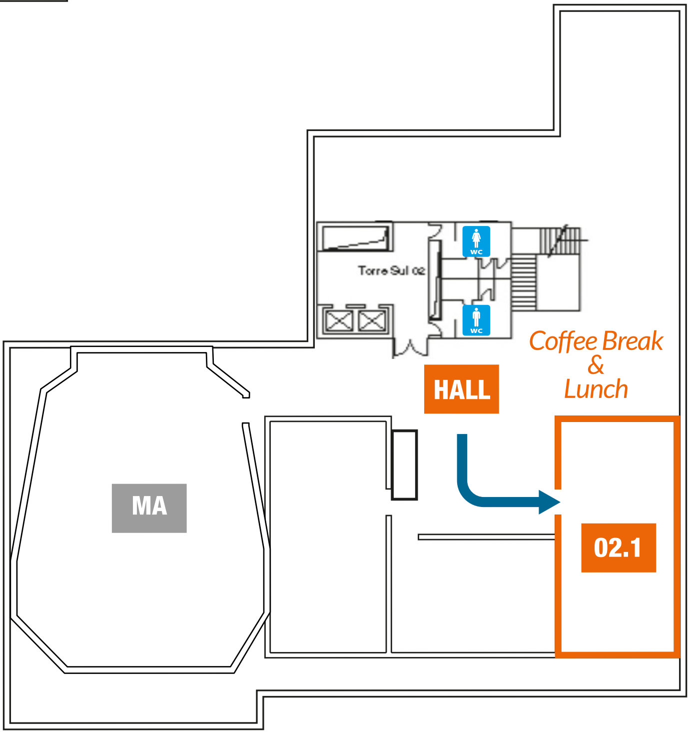
Conference Information

Congress Center Floor Plans

CONGRESS CENTER
Floor -1



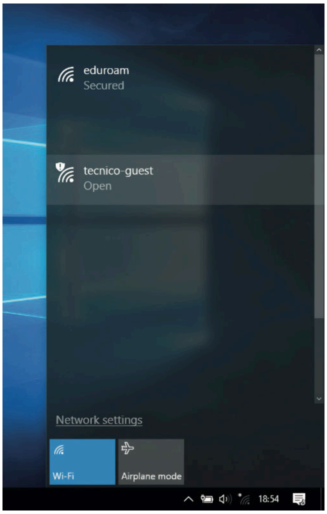
MA - Main Auditorium
S - Secretariat
02.1 - Session Room

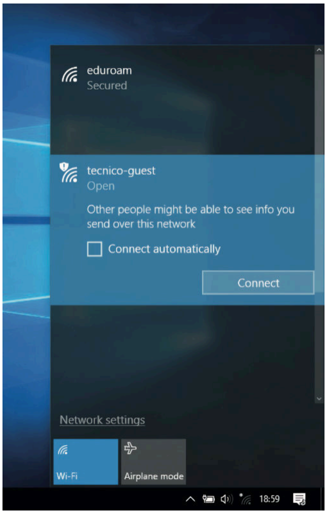


CONGRESS CENTER
Floor -2

Conference Information

Wireless Internet Access





Step 1: Browse available wireless networks and select "tecnico-guest"

Step 2: Open your web browser and access the website " wifi.tecnico.ulisboa.pt"
(most of the computers will do it automatically)

Click on the (blue) button "Ligar"

Step 3: Enter the following credentials:

Step 4: Account name: **Euromech663**
Password: **2s65mB**

Instructions for Presenters

- Each Oral presentation will take 15 minutes including discussion.
- The files required for the presentation (PowerPoint or PDF) should be uploaded, and tested to ensure compatibility, during the coffee or lunch breaks before the beginning of the session.
- The lecture rooms contain a Windows PC, with Office and Acrobat PDF Reader, connected to a data projector. The use of personal computers is not recommended.
- Technical support will be provided on-site by the **EUROMECH663** staff to ensure a smooth delivery of all presentations.

Social Program

Social Dinner > 21 September | 20:00

Join us for the **Dinner** at the ***Museu da Cerveja,*** a unique restaurant and museum located in the magnificient *Praça do Comércio*, one of Lisbon´s most celebrated historic squares.

Overlooking the *Tagus River*, this iconic location offers the perfect setting to enjoy Portuguese gastronomy while experiencing the rich history and vibrant atmosphere of the city´s historic waterfront.

Conference Dinner > 22 September | 18:15

Before the **Conference Dinner**, participants are invited to enjoy a self-guided visit to the ***Castelo de São Jorge***, Lisbon's iconic medieval castle, exploring its historic walls and enjoying breathtaking panoramic views over the historic city and the *Tagus River*.

The evening will continue with dinner in this unique and historic setting, offering an unforgettable experience in one of Lisbon's most emblematic landmarks.

Map of Lisboa

Network Map / Underground Lines

linha **Azul** Blue line

linha **Amarela** Yellow line

linha **Verde** Green line

linha **Vermelha** Red line

General Tourist Information

Getting to Lisbon by air

Direct flights from most of European cities, North or South America and Africa land at the Portela Airport, terminal 1. A taxi ride from the airport to IST is about 4-5 km that takes 10-15 min, depending on traffic, and should cost around 8,00€. To downtown, the taxi ride is about 7 km and should cost around 10,00€. 1,60€ is charged for the transportation of luggage or animals.

A sure option is the "Taxi Voucher", a prepaid taxi service starting at 16,00€, on sale at the "Information Desk" in the arrival terminal. Lisbon Airport has its own Metro Station, Aeroporto - red line (see map of Lisbon with subway lines). Other options are the AeroBus and the Aeroshutle (4,00€).

Getting to Lisbon by car

Drivers can use highway A1 when coming from the North, highway A2, through the 25 de Abril bridge, when coming from the South, and highway A12, through Vasco da Gama bridge, when coming from the Northeast.

Getting to Lisbon by train

The St. Apolónia station is the terminal for trains arriving from the North of Portugal. Another option is to use the train station Oriente. From the South of Portugal an option is to use the train station Oriente. Connections to the metro lines exist at both stations (St. Apolónia - blue line, Oriente - red line).

Moving around

Taxi:

Lisbon is served by an extensive network of public transportation that can take you anywhere in the city and to its surroundings. Taxis (black and green or beige) are cheap when comparing to most of the European countries. They can be called by phone, picked-up on taxi plazas or stopped on the street. The fare on the taxi meter should start at 3,25€ (daytime pick-up) or 3,90€ (night time). Outside the city limits, city fares are charged per kilometer. 1,60€ is charged for the transportation of luggage or animals. Before taking a taxi, inquire about the fare.

Metro:

The Lisbon Metro is a very comfortable and an easy way to reach most of the city, from 6:30 to 1:00. The Metro lines reach most of the city being the Metro stations close to IST:

- Alameda (red and green line)
- Saldanha (red and yellow line)

Bus:

The bus routes cover all Lisbon and extend to its outskirts. The tickets can be pre-paid, at the counters of Carris, the surface transportation operator for Lisbon, or bought aboard the bus, electric cars or funiculars. For IST hop off at one of the following bus stops:

- Av. Manuel da Maia
- Av. Rovisco Pais
- Arco do Cego

Metro and Bus Fares:

- Reusable navegante occasional card: 0,50€
- Metro/Carris single ticket (loaded on the card): 1,90€
- Carris bus (on-board fare): 2,30€
- Tram (on-board fare): 3,30€

Trains:

Suburban trains to Estoril and Cascais depart from the Cais do Sodré train station; to the south of the river cities depart from Roma - Areeiro (Entrecampos); and to Sintra depart from Rossio or Oriente train stations.

The ride to Cascais or to Sintra should take about 35-45 min, each way. The train ride to south of the river is a highlight as the train will cross the 25 de Abril bridge with magnificent views of Lisbon.

For IST, the nearby train stations are:

- Roma - Areeiro
- Entrecampos

Other General Information

- National emergency number: 112
- Electricity: 220V, 50 Hz with standard European power sockets
- Temperature: high 28°C - low 18°C
- Currency: Euro (€)
- Banks: working hours are 8:30 – 15:00 *(Monday-Friday)*
- Pharmacies: 9:00 – 19:00
- Shops: 9:00 – 19:00
- Shopping Malls: 10:00 – 23:00

Main Museums in Lisbon:

- **Centro de Arte Moderna** *(Modern Art Museum)*
- **Museu do Oriente** *(Oriente Museum)*
- **Museu Calouste Gulbenkian** *(Calouste Gulbenkian Museum)*
- **Museu dos Coches** *(Coach Museum)*
- **Museu Nacional de Arte Antiga** *(National Museum for Ancient Art)*
- **Colecção Berardo** *(The Berardo Collection)*
- **Museu do Azulejo** *(Tile Museum)*
- **Aqueduto das Águas Livres** *(Águas Livres' Aqueduct)*
- **Basílica da Estrela** *(Estrela Basilica)*
- **Castelo de São Jorge** *(Saint George's Castle)*
- **Sé Patriarcal** *(Patriarchal Church)*
- **Mosteiro dos Jerónimos** *(Jerónimos Monastery)*
- **Padrão dos Descobrimentos** *(Monument to the Overseas Discoveries)*
- **Torre de Belém** *(Belém Tower)*

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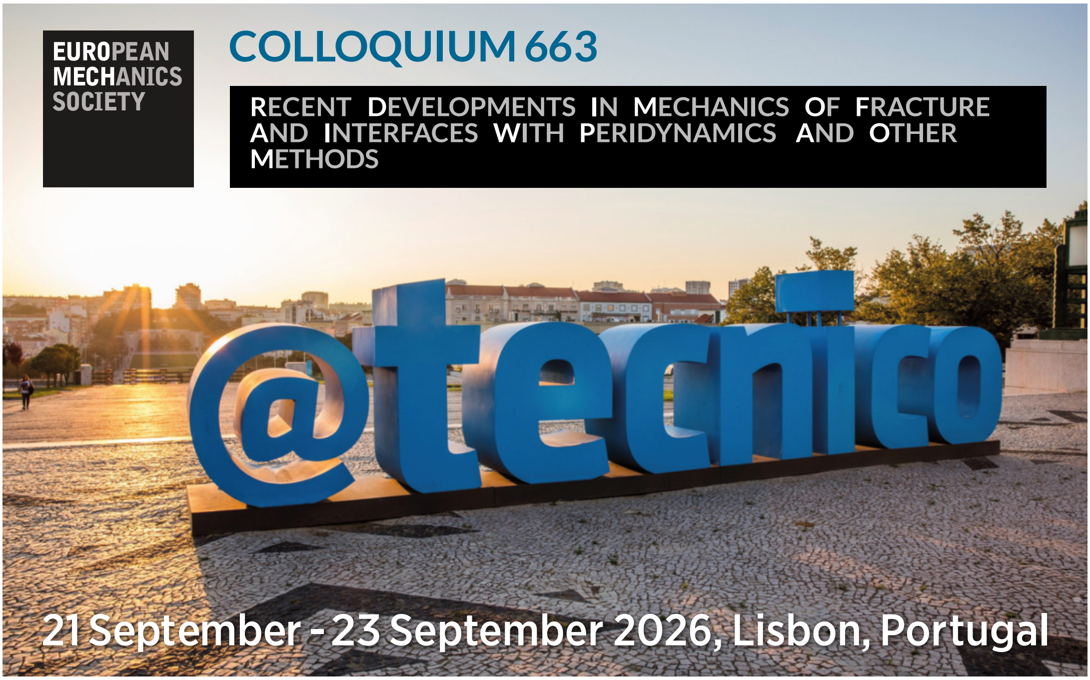

21 September - 23 September 2026, Lisbon, Portugal

SCIENTIFIC PROGRAM

Program at a Glance

Monday | **21 September** | 2026	
08:30 - 09:00	**Registration**
09:00 - 09:30	**Conference Opening**
09:30 - 10:15	**KEYNOTE LECTURE I**
10:15 - 10:45	*Coffee Break*
10:45 - 12:25	**PLENARY SESSION I**
12:30 - 14:00	*Lunch*
14:00 - 14:45	**KEYNOTE LECTURE II**
14:45 - 15:35	**PLENARY SESSION II**
15:35 - 16:05	*Coffee Break*
16:05 - 16:55	**PLENARY SESSION III**
20:00	*Social Dinner Museu da Cerveja*

Tuesday | **22 September** | 2026	
08:45 - 09:00	**Registration**
09:00 - 10:45	**KEYNOTE LECTURE III**
09:45 - 10:15	*Coffee Break*
10:15 - 12:20	**PLENARY SESSION IV**
12:30 - 14:00	*Lunch*
14:30 - 16:00	**PLENARY SESSION V**
16:00 - 16:30	*Coffee Break*
16:30 - 17:15	**KEYNOTE LECTURE IV**
18:00	*Visit to Castelo S. Jorge*
20:00	*Conference Dinner Castelo São Jorge*

Wednesday | **23 September** | 2026	
08:45 - 09:00	**Registration**
09:00 - 10:45	**KEYNOTE LECTURE V**
09:45 - 10:15	*Coffee Break*
10:15 - 12:20	**PLENARY SESSION VI**
12:30 - 14:00	*Lunch*
14:00 - 14:45	**KEYNOTE LECTURE VI**
14:45 - 16:00	**PLENARY SESSION VII**

PROGRAM

Monday | **21 September** | 08:30 - 12:25

Conference Hall 01	
08:30 - 09:00	**Registration**

Room 2.01	
09:00 - 09:30	**Conference Opening**

Room 2.01	KEYNOTE LECTURE I	Chair *Francesco Scabbia*
TIME	**TITLE**	**SPEAKER**
09:30 - 10:15	**Efficient solution to peridynamic models of fracture and corrosion**	*Florin Bobaru*

10:15 - 10:45	*Coffee Break*

Room 2.01	PLENARY SESSION I		Chair *Francesco Scabbia*	
TIME	**ID**	**TITLE**	**AUTHORS**	**SPEAKER**
10:45 - 11:10	307	**A Dilatation-Enhanced Damage Model for the Fast Convolution-Based Method Peridynamics**	*Zhikun Zhou, Pan Wu, Xingchuan Liao, Xin Lai, Lisheng Liu, Florin Bobaru, Ziguang Chen*	*Zhikun Zhou*
11:10 - 11:35	413	**Perifit: An open-source Python Package for Surface Correction in Peridynamics**	*Arman Shojaei*	*Arman Shojaei*
11:35 - 12:00	421	**An Optimization-Based Algorithm for Surface and Boundary Corrections in Bond-Based Peridynamics**	*Greta Ongaro, Arman Shojaei, Alexander Hermann, Stewart A. Silling, Christian J. Cyron, Patrizia Trovalusci*	*Greta Ongaro*
12:00 - 12:25	424	**Peridynamic Formulation of Interfacial Thermal Resistance**	*Shiwei Hu, Tianbai Xiao, Yonghao Zhang*	*Shiwei Hu*

12:30 - 14:00	*Lunch*

PROGRAM

Monday | **21 September** | 14:00 - 16:55

Room 2.01	KEYNOTE LECTURE II	Chair *Erdogan Madenci*
TIME	**TITLE**	**SPEAKER**
14:00 - 14:45	**Linking the Scales Towards Non-Conventional Polymer Composites**	*Pedro Camanho*

Room 2.01	PLENARY SESSION II		Chair *Erdogan Madenci*	
TIME	**ID**	**TITLE**	**AUTHORS**	**SPEAKER**
14:45 - 15:10	314	**Investigation of Static and Dynamic Fracture Behaviors in Orthotropic Functionally Graded Composite Laminates Via OSPD**	*Hanlin Wang, Lei Ju, Satoyuki Tanaka, Erkan Oterkus*	*Hanlin Wang*
15:10 - 15:35	289	**Failure Analysis of Composite Beam Based on Peridynamics Theory**	*Zhenghao Yang, Konstantin Naumenko*	*Zhenghao Yang*

15:35 - 16:05	*Coffee Break*

Room 2.01	PLENARY SESSION III		Chair *Erdogan Madenci*	
TIME	**ID**	**TITLE**	**AUTHORS**	**SPEAKER**
16:05 - 16:30	287	**Coupling a Peridynamic Corrosion Model with an Agent-Based Cell Model to Study the Interaction Between Magnesium Implant Biodegradation and Bone Regeneration**	*Mylena Mordhorst, Alexander Hermann, Chiara Dazzi, Heike Helmholz, Sara Checa, Regine Willumeit-Roemer, Christian J. Cyron*	*Mylena Mordhorst*
16:30 - 16:55	290	**Peridynamic Modeling of Non-Uniform Degradation in Bioresorbable Screws**	*Lorenzo Zoboli, Ludovica Chimenti, Pierfrancesco Gaziano, Giuseppe Vairo, Alessio Gizzi*	*Lorenzo Zoboli*

20:00	*Social Dinner Museu da Cerveja*

PROGRAM

Tuesday | 22 September | 08:45 - 12:20

Conference Hall 01	
08:45 - 09:00	**Registration**

Room 2.01	KEYNOTE LECTURE III	Chair *Francisco Vieira*
TIME	**TITLE**	**SPEAKER**
09:00 - 09:45	**Nucleation and Propagation of Brittle Fracture as a Constrained Energy Minimization Problem**	*Oscar Lopez-Pamies*

09:45 - 10:15	*Coffee Break*

Room 2.01	PLENARY SESSION IV		Chair *Francisco Vieira*	
TIME	**ID**	**TITLE**	**AUTHORS**	**SPEAKER**
10:15 - 10:40	283	**Generalised Phase Field Modelling of Fracture in Gyroid Structures: Numerical and Experimental Insights Using Additively Manufactured PLA Specimens**	*Deison Preve, Jasen Zenzerović, Emanuele Avoledo, Manish Kumar, Enrico Salvati*	*Deison Preve*
10:40 - 11:05	277	**Bridging Phase-Field and Peridynamic Corrosion Modeling via a Convergent Nonlocal KKS Extension**	*Alexander Hermann, Arman Shojaei, Christian Cyron*	*Alexander Hermann*
11:05 - 11:30	285	**An Anisotropic Heat Transfer Peridynamic Framework for Melt Pool Geometry Prediction in Metal Additive Manufacturing**	*Qi-Qing Liu, Francesco Scabbia, Ugo Galvanetto, Mirco Zaccariotto*	*Qi-Qing Liu*
11:30 - 11:55	304	**Phase-Field Peridynamics for Brittle Fragmentation with Large Deformations**	*Kai Partmann, Christian Wieners, Kerstin Weinberg*	*Kai Partmann*
11:55 - 12:20	313	**Theoretical model for Characterizing the Confining Pressure-Dependent Compressive Strength of Rock materials**	*Hu Xingyue, Li Weiguo, Wei Tianqi*	*Hu Xingyue*

12:30 - 14:00	*Lunch*

PROGRAM

Tuesday | **22 September** | 14:00 - 16:55

Room 2.01	PLENARY SESSION V		Chair *Aurélio Araújo*	
TIME	**ID**	**TITLE**	**AUTHORS**	**SPEAKER**
14:00 - 14:25	311	**Peridynamic Modeling of Brain Tissue**	*Francesco Scabbia, Vito Diana, Francesca Fantoni, Mirco Zaccariotto, Andrea Bacigalupo, Ugo Galvanetto*	*Francesco Scabbia*
14:25 - 14:50	302	**Mixed Scheme about ROM/FOM with Space-Adaptive Partitioning Strategy for Quasi-Static Peridynamic Fracture Simulation**	*Haolun Zhang, Xinning Xie, Jiashu Lu, Yufeng Nie*	*Haolun Zhang*
14:50 - 15:15	280	**Modeling Size Effects in Plates using a Cosserat-Enhanced Peridynamic Correspondence Framework**	*Przemyslaw Nosal, Francesco Scabbia, David Morin*	*Przemyslaw Nosal*
15:15 - 15:40	292	**A Peridynamic Viscoelastic-Plastic Model for Ice Applicable Across Wide Ranges of Strain Rates**	*Chenxi Zhang, Qigang Wu, Mirco Zaccariotto, Ugo Galvanetto, Francesco Scabbia, Yanzhuo Xue, Baoyu Ni*	*Chenxi Zhang*

15:40 - 16:10	*Coffee Break*

Room 2.01	KEYNOTE LECTURE IV	Chair *Aurélio Araújo*
TIME	**TITLE**	**SPEAKER**
16:10 - 16:55	**Damage Evolution in State-Based Peridynamics**	*Stewart Silling*

18:00	*Visit to Castelo S. Jorge*
20:00	*Conference Dinner Castelo São Jorge*

PROGRAM

Wednesday | **23 September** | 08:45 - 12:20

Conference Hall 01	
08:45 - 09:00	**Registration**

Room 2.01	KEYNOTE LECTURE V	Chair *Alexander Hermann*
TIME	**TITLE**	**SPEAKER**
09:00 - 09:45	**Peridynamics for Size-Dependent Fracture Behavior of Quasi-Brittle Materials**	*Erdogan Madenci*

09:45 - 10:15	*Coffee Break*

Room 2.01	PLENARY SESSION VI		Chair *Alexander Hermann*	
TIME	**ID**	**TITLE**	**AUTHORS**	**SPEAKER**
10:15 - 10:40	320	**New peridynamic kernels for stable general anisotropic materials**	*Francisco Vieira, Francesco Scabbia, Aurélio Araújo*	*Francisco Vieira*
10:40 - 11:05	286	**Peridynamic Modeling of Fatigue Crack Initiation in Additively Manufactured Inconel 718: Competition Between Surface Roughness and Internal Defects**	*Majid Nasrollahnejad, Francesco Scabbia, Mirco Zaccariotto, Ugo Galvanetto*	*Majid Nasrollahnejad*
11:05 - 11:30	319	**Fatigue Crack Propagation in a Railway Structure using Peridynamics**	*Emília Paulo, Francisco Vieira, Aurélio Araújo*	*Aurélio Araújo*
11:30 - 11:55	301	**An Efficient Bond-Wise Computational Framework With a Low-Rank Incrementally Updated Preconditioned Solver for Fracture Simulations in Peridynamics**	*Xinning Xie, Haolun Zhang, Jiashu Lu, Yufeng Nie*	*Xinning Xie*
11:55 - 12:20	310	**Integration of Peridynamics into The Floating Frame of Reference Approach for the Study of Fracture in Multibody Systems**	*João Pagaimo, Francisco Vieira, Aurélio Araújo, Jorge Ambrósio*	*João Pagaimo*

12:30 - 14:00	*Lunch*

PROGRAM

Wednesday | **23 September** | 14:00 - 16:00

Room 2.01	KEYNOTE LECTURE VI	Chair *Florin Bobaru*
TIME	**TITLE**	**SPEAKER**
14:00 - 14:45	**Damage and Fracture in Solids: Alternative Regularizations, Discretization Techniques, and a Localizing Gradient-Damage Implementation with Mesh Cutting**	*Pedro Areias*

Room 2.01	PLENARY SESSION VII		Chair *Florin Bobaru*	
TIME	**ID**	**TITLE**	**AUTHORS**	**SPEAKER**
14:45 - 15:10	282	**Force-Heat Equivalence Energy Density Principle and its Applications to the Characterization of Material Properties under Extreme Conditions**	*Weiguo Li, Tianqi Wei, Xingyue Hu*	*Tianqi Wei*
15:10 - 15:35	303	**Operator-Preserving Surface Correction For Projected Viscous Peridynamic Flow Via Tensor Generalized Moving Least Squares and Polynomial Boundary Extrapolation**	*Ahmadreza Mirzapour, Arman Shojaei, Alexander Hermann, Christian Cyron*	*Ahmadreza Mirzapour*
15:35 - 16:00	308	**Peridynamics with Strain Gradient Elasticity for Microstructural Size Effect**	*Erdogan Madenci, Cody Mitts, Elias C. Aifantis*	*Erdogan Madenci*

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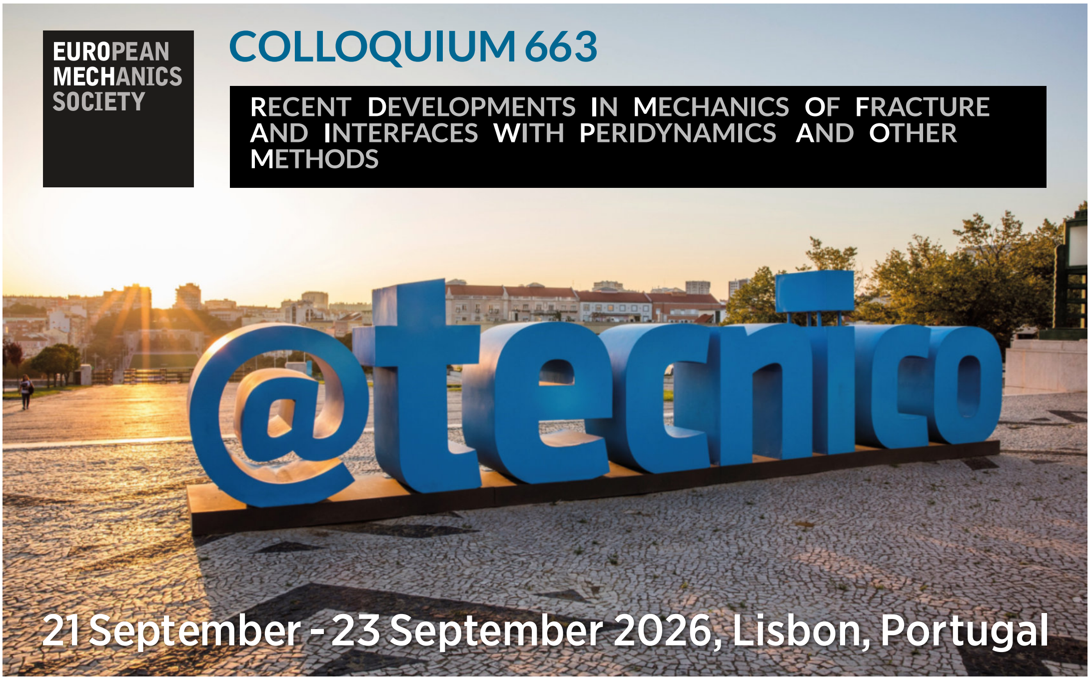

21 September - 23 September 2026, Lisbon, Portugal

BOOK OF ABSTRACTS

Abstract ID Keynote Lecture I

EFFICIENT SOLUTION TO PERIDYNAMIC MODELS OF FRACTURE AND CORROSION

Florin Bobaru

University of Nebraska-Lincoln

Keywords: peridynamics, FCBM, fracture, weak interfaces, corrosion

As a nonlocal model, peridynamics (PD) leads to computations that tend to be very costly, since mesh-independent results require a sufficiently large number of discretization nodes be used inside the nonlocal interaction region. This tends to limit the time scales and length scales one can access in simulations. To be able to reach engineering-relevant scales with our PD models, faster solvers are needed. The Fast Convolution-Based Method (FCBM) for PD is a pseudo-spectral method that helps us compute solutions to PD models with efficiency. Originally introduced in [1] for diffusion problems, the method has been extended to treat elasticity and brittle fracture problems ([2,3]) in arbitrary domains, large deformation plasticity and ductile failure ([4]), and corrosion damage problems ([5,6]). This new discretization method can speed up computations by orders of magnitude when compared with the usual meshfree discretization of peridynamic models [3,5]. In this presentation I will discuss the FCBM for PD models of fracture and damage as well as for corrosion models that can simulate pitting and uniform corrosion, in homogeneous and heterogeneous materials. I will cover dynamic and quasi-static fracture, including failure at a weak interface induced by nano-indentation. Corrosion damage is an example of a problem in which an interface, the solid-electrolyte interface is moving. I will discuss how one can simulate corrosion (dissolution) in a composite material that features regions with faster or slower corrosion rates. The method is implemented in Matlab and taking advantage of GPU-based computations is simple. The PeriFast version on GitHub for dynamic brittle fracture has a simple damage criterion (base on the strain energy density reaching a critical value) that makes it applicable to mode-I dominated fracture, but leads to incorrect results for compression or shear loading. I will discuss a new damage model that works for general types of loading conditions. Compared with our previous results on peridynamic simulation of corrosion damage, the FCBM-PD allows us to efficiently compute the evolution of hundreds of pits growing, in 3D, in samples of cm dimensions. The new approach can help us predict some fine and important details of damage and failure at engineering-relevant scales.

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Abstract ID Keynote Lecture II

LINKING THE SCALES TOWARDS NON-CONVENTIONAL POLYMER COMPOSITES

Pedro Camanho

University of Porto

Keywords: Composite materials; multi-scale analyses; computational fracture mechanics

Reducing the environmental impact of aviation relies on developing new materials that enable more efficient jet engines, better aerodynamics, and structural weight reduction. While polymer composite materials have a large, accessible design space, they are currently used in a very conservative manner, limiting their full potential. This presentation will address the first step towards the development of composite structures and materials optimised across different length scales, namely the development and validation of models that link processing conditions, material microstructure, and structural performance. The relevant phenomena addressed range from polymer curing kinetics, non-local plasticity at the nanoscale, and fracture of structural components.

Abstract ID Keynote Lecture III

NUCLEATION AND PROPAGATION OF BRITTLE FRACTURE AS A CONSTRAINED ENERGY MINIMIZATION PROBLEM

Oscar Lopez-Pamies

University of Illinois at Urbana-Champaign

Keywords: Elasticity, Strength, Toughness, Energy Methods, Phase field

In this talk, I will present a macroscopic, or continuum, theory aimed at bringing resolution to a fundamental centuries-old problem in mechanics, that of describing and predicting when and where cracks nucleate and propagate in nominally elastic brittle materials under monotonic quasi-static loading conditions. In a nutshell, directly guided by the mathematical structure of the regularized phase-field theory of fracture initiated by Kumar, Francfort, and Lopez-Pamies (J. Mech. Phys. Solids 112 (2018), 523-551) and by the wide range of experiments that this regularized theory has been validated against, the proposed sharp theory posits that: cracks nucleate and propagate exclusively in regions where the strength surface of the material has been exceeded, following an evolution governed by the minimization of the sum of the potential (that is the elastic energy minus the work done by the externally applied forces) and surface energies. While the theory applies to materials with any elasticity (linear or nonlinear) and any material symmetry (isotropic or anisotropic), attention is restricted here to the most basic, but also most prominent, case of isotropic elastic brittle materials. For demonstration purposes, after its introduction and discussion, the theory is confronted with the so-called ``Nine Circles of Elastic Brittle Fracture'' --- a set of nine tests that span the entire range of well settled experimental knowledge on fracture nucleation and propagation --- on a hard material, a silicate glass, and a soft one, a synthetic rubber.

Abstract ID Keynote Lecture IV

DAMAGE EVOLUTION IN STATE-BASED PERIDYNAMICS

Stewart Silling

Lehigh University

Keywords: damage, fracture, nonlocal, peridynamic, thermodynamics

Fracture is modeled in peridynamics by associating a damage variable with each nonlocal bond. At any given bond, such damage can increase but not decrease over time. The bond damage depends on the loading history through some prescribed damage law. This damage law can assume either sudden bond breakage, which is historically the most commonly used method, or continuous growth of damage over time. Distinctive capabilities of damage modeling in peridynamics arise from the association of damage with bonds, rather than defining it as a function of position only. For example, at a given material point, the direction of the bonds with the most damage influences the orientation of cracks, which tend to grow normal to the direction of the most heavily damaged bonds. The nonlocal nature of damage also influences the post-failure response of the material, that is, its ability to sustain loading after a crack has appeared. For example, a material model could predict that the material near a crack loses all strength and therefore acts like a fluid, or it could retain strength in the direction parallel to the crack. By formulating a material model within a thermodynamic framework, the interaction between damage, deformation, and mechanical force emerges in a consistent way. When the damage increases incrementally at a material point, it decreases the free energy while increasing the entropy, leaving the internal energy unchanged. This tends to raise the temperature while reducing the nonlocal bond forces. The spectrum of possible post-failure responses presents opportunities for modelers to make simulations more realistic in applications. However, such response is not totally arbitrary, because the way that damage affects the free energy at a material point is constrained by the dissipation inequality, which is a consequence of the Second Law of Thermodynamics.The use of state-based material models increases the types of material response that can be represented, including the interaction of bond damage with the forces in the bonds. In state-based modeling, an increase in the damage at one bond can affect the forces in all the other bonds connected to the same material point. A naive approach to implementing damage can have unintended consequences, resulting in "creating energy" in contradiction to the dissipation inequality. For example, the seemingly obvious approach of simply omitting a broken bond from the integral expression for dilatation can end up increasing the hydrostatic stress. This can lead to numerical instability and potentially nonphysical results in simulations. Developers of peridynamic material models should take these issues into account, to help avoid such practical difficulties in applications. In addition to the necessary theoretical background, this talk will cover recent progress on the implementation of damage to ensure consistency with the thermodynamic principles and avoid instability.

Abstract ID Keynote Lecture V

PERIDYNAMICS FOR SIZE-DEPENDENT FRACTURE BEHAVIOR OF QUASI-BRITTLE MATERIALS

Erdogan Madenci

University of Arizona

Keywords: Peridynamics, size-effect, quasi-brittle, fracture

The transition from toughness-controlled to strength-controlled fracture with changing specimen size, known as the size effect (SE), is a key feature of quasi-brittle materials. This study investigates the size-dependent fracture behavior of quasi-brittle materials using Bond-Based Peridynamics (BB-PD). It combines a bilinear PD constitutive model with a three-dimensional stochastic field to represent material heterogeneity, a spatial attenuation kernel, and a discretized micro-modulus function. A fractal-based framework is employed to quantify the size effect, providing a consistent interpretation of the scaling behavior across different specimen sizes. The model is validated against two experimental studies involving three-point bending tests on geometrically scaled notched concrete beams under both Mode I and mixed-mode loading conditions. The simulations accurately reproduce the experimentally observed peak loads, post-peak softening behavior, and kinked crack paths. In addition, simulations are conducted for multiple specimen sizes under flexural loading to evaluate the influence of structural dimensions on crack evolution and nominal strength. The PD results successfully reproduce the experimental results from three-point bending tests on notched graphite beams.

Abstract ID Keynote Lecture VI

DAMAGE AND FRACTURE IN SOLIDS: ALTERNATIVE REGULARIZATIONS, DISCRETIZATION TECHNIQUES, AND A LOCALIZING GRADIENT-DAMAGE IMPLEMENTATION WITH MESH CUTTING

Pedro Areias

IDMEC, Instituto Superior Técnico

Keywords: gradient-enhanced damage; localizing damage; phase-field fracture; adaptive remeshing; Steiner-point-free cutting

With rate-independent constitutive models, once strain softening begins, local damage models lose mesh objectivity: solutions localize into bands of vanishing width, dissipate no energy, and follow the mesh. Three decisions determine a failure simulation: the regularization that restores a length scale, the discretization that carries the crack, and the software framework that hosts both. We compare crack-band rescaling, integral nonlocal averaging, implicit gradient enhancement through a screened-Poisson equation, its transient variants that grow the interaction, recent localizing models that contract it and bound the band, phase-field formulations, their cohesive variants, and the thick level set. We weigh extended finite elements, embedded discontinuities, cracking particles, peridynamics, and eigenerosion against specialized adaptive remeshing, whose cost is state transfer between non-nested meshes. Published implementations of the localizing family target ABAQUS and MATLAB; our finite-strain code SimPlas couples the model to the Steiner-point-free tetrahedral cutter of Areias and Soeiro, a stand-alone library based on many-to-many relations: eleven templates subdivide any marked-edge set, one global diagonal rule renders every cut conforming a priori, and parent-pair provenance makes the transfer of displacement and nonlocal strain exact. The verification and benchmark programme runs from one-dimensional band narrowing to three-dimensional mixed-mode fracture, against published.

Abstract ID 277

BRIDGING PHASE-FIELD AND PERIDYNAMIC CORROSION MODELING VIA A CONVERGENT NONLOCAL KKS EXTENSION

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Keywords: nonlocal phase-field, KKS model, corrosion, peridynamics, Allen–Cahn/Cahn–Hilliard system, well-posedness, nonlocal-to-local convergence, interaction horizon

We propose a nonlocal extension of the Kim–Kim–Suzuki (KKS) phase-field corrosion model that unifies classical gradient-based phase-field formulations with nonlocal, horizon-based theories used in peridynamics. The key idea is to replace local gradient terms in the free energy by integral interaction terms defined over a finite horizon, thereby introducing an intrinsic length scale directly into the model. By differentiating the resulting nonlocal free energy in an appropriate Hilbert-space setting, we obtain a coupled nonlocal Allen–Cahn equation for the phase-field and a nonlocal Cahn–Hilliard-type equation for the concentration, where the conserved dynamics are formulated as a gradient flow in a metric induced by the inverse nonlocal operator (the natural analogue of the classical H^{-1} structure). We establish well-posedness of the coupled system via Galerkin approximations, uniform energy estimates, and compactness arguments, and we prove convergence to the classical local KKS model as the interaction horizon tends to zero under suitable kernel scaling and regularity assumptions. Numerical experiments based on an explicit time-stepping scheme and finite-difference-style discretization of the nonlocal operator on a two-dimensional pitting corrosion benchmark illustrate the impact of nonlocality and confirm the predicted nonlocal-to-local convergence.

Abstract ID 279

PERIFIT: AN OPEN-SOURCE PYTHON PACKAGE FOR SURFACE CORRECTION IN PERIDYNAMICS

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Keywords: Peridynamics, surface correction, bond-based peridynamics, state-based peridynamics, correspondence model, linear peridynamic solid, nonlocal mechanics, nodal influence weights, operator matching, open-source software

Peridynamic models suffer from a well-known surface effect caused by the truncation of nonlocal neighborhoods near free surfaces, boundaries, cracks, and voids. This truncation distorts the discrete operators, reduces accuracy, and may prevent convergence even under mesh refinement. While the problem is well recognized, many existing correction strategies are formulation-specific, computationally expensive, geometry-dependent, or difficult to integrate into practical simulations.

This work presents a unified surface correction framework for three-dimensional peridynamics covering bond-based peridynamics, the ordinary state-based linear peridynamic solid model, and the non-ordinary state-based correspondence model. The approach introduces optimized nodal influence weights that are computed in a load-independent preprocessing step and applied symmetrically to all bonds. The weights are determined by matching truncated discrete operators to their analytical full-horizon counterparts on a polynomial test space. The procedure preserves pairwise reciprocity and global symmetry, does not alter the constitutive law or horizon size, and requires neither ghost nodes nor coupling to classical continuum mechanics.

To clarify the origin of the surface effect in different formulations, a one-dimensional modal analysis is developed for the governing, derivative, and energy operators. The analysis reveals distinct truncation signatures across the three model classes and identifies the dominant mechanism in the correspondence model as a first-moment defect, which produces a spurious force under constant stress. These findings motivate model-specific operator-matching blocks within a common optimization framework.

The method is implemented in an open-source Python package, perifit, which provides a complete workflow for weight computation, diagnostics, mesh cleaning, and export to several peridynamic solver formats. Numerical studies on a three-dimensional bar under uniaxial tension show that the uncorrected formulations do not converge under horizon refinement, whereas the corrected models exhibit monotonic error reduction, with the largest improvements observed for the correspondence model.

The results show that optimized nodal influence weights provide a practical and formulation-aware route to substantially improve the accuracy and robustness of bond-based and state-based peridynamic simulations.

Abstract ID 280

MODELING SIZE EFFECTS IN PLATES USING A COSSERAT-ENHANCED PERIDYNAMIC CORRESPONDENCE FRAMEWORK

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Keywords: Cosserat, size effects, elasticity, stress regularization

Classical continuum theory lacks an intrinsic length scale, which prevents it from capturing the size-dependent material behaviour observed in experiments on micro-scale structures. Such effects, which are well documented in the work of Fleck and Hutchinson, indicate that the material response depends on an internal length scale associated with microstructural mechanisms. Nonlocal formulations, such as peridynamics, introduce a characteristic length through the horizon. However, in peridynamics formulations, the horizon plays a dual role as both a physical and numerical parameter, which complicates its interpretation, particularly in the context of localization and instability issues. In this study, a correspondence-based peridynamics formulation enhanced by a simplified Cosserat model is proposed to introduce an additional intrinsic material length scale. The formulation was implemented within a non-ordinary state-based peridynamic framework and applied to selected plate problems, including bending and notched configurations. The results show that the proposed model recovers the classical elastic response as the characteristic length tends to zero, whereas finite values of the characteristic length lead to a clear size-dependent behaviour. In particular, an increase in the bending stiffness and regularization of the stress fields near the stress concentrators were observed. The introduction of Cosserat kinematics enables the development of couple stresses and modifies both the displacement and stress distributions. The results further demonstrate that the model response is governed by the ratio of the characteristic length to the horizon radius, which reflects the interplay between the intrinsic material length and peridynamic horizon. The influence of the characteristic length becomes more pronounced for smaller horizon sizes, whereas for larger horizons, the response approaches that of the classical formulation. This highlights the need to distinguish between numerical and material length scales in peridynamics models. The present study constitutes the first step towards the development of a consistent Cosserat-enhanced peridynamic framework, providing a basis for future extensions to more advanced material behaviours, including elastoplasticity.

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Abstract ID 281

PERIDYNAMIC FORMULATION OF INTERFACIAL THERMAL RESISTANCE

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Keywords: Peridynamics; interfacial thermal resistance; thermal potential equivalence; series impedance; heterogeneous materials.

The inherent challenge in peridynamic modelling of interfacial thermal resistance (ITR) arises from the geometric incompatibility between the macroscopic idealization of a zero-thickness interface and the physical reality of a finite volumetric interaction zone. Existing approaches typically suffer from empirical smearing of temperature jumps, explicit geometric tracking of discrete interfaces, or constraint formulations that require costly per-step iteration and artificial stabilization. To address these limitations, we present a constitutive series-impedance model within the bond-based peridynamic framework, which fundamentally conceptualizes ITR as an intrinsic material property to decouple geometric integration from constitutive behavior. This model leads to the unified closed-form micro-conductivity representation that rigorously distinguishes the volume-inherent resistive properties of the interaction zone from the physical Kapitza resistance. Through the analysis on integration symmetry and exact residual, we demonstrate that this formulation derived for planar interface remains valid for the interfaces with arbitrary shapes, with the geometric deviation strictly bounded by second-order residuals. Additionally, this constitutive treatment introduces negligible computational overhead while preserving the stability characteristics of the explicit time integration for the bulk material system. Comprehensive numerical tests corroborate the first-order convergence of the formulation and its proficiency in accurately capturing sharp temperature discontinuities traversing intricate microstructural configurations. Simulations of randomly reinforced composites successfully capture the effects of size and shape of the micro-inclusions, demonstrating the capability of the present peridynamic model to simulate heat transfer in heterogeneous materials.

Abstract ID 282

FORCE-HEAT EQUIVALENCE ENERGY DENSITY PRINCIPLE AND ITS APPLICATIONS TO THE CHARACTERIZATION OF MATERIAL PROPERTIES UNDER EXTREME CONDITIONS

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Keywords: Force-Heat Equivalence Energy Density Principle; extreme conditions; mechanical/physical properties; theoretical quantitative characterization

The demand for expanding the service conditions of materials has become increasingly intense. The mechanical/physical properties of materials under diverse and wide-range extreme conditions have become a core issue of concern in various fields, and there is an urgent need to establish the ability to predict the performance of materials under such conditions. Focusing on the major needs of the country, aiming at the advanced materials and structures that have a wide application prospect in national strategic equipment, focusing on their mechanical behavior, strength theory and characterization methods under diverse and wide-range extreme conditions, the author originally proposed a new theory that could quantitatively characterize the effect of temperature on the mechanical/physical properties of materials - the Force-Heat Equivalence Energy Density Principle (Li's principle of energy equivalence). Based on this principle, a series of material failure criteria suitable for extreme conditions in a wide range of diversity are proposed. And for the first time, established a series of theoretical quantitative characterization models for the mechanical/physical properties (fracture strength, yield strength, ultimate strength, fatigue strength, creep life, buckling strength, hardness, melting point, band gap width, electrical breakdown strength, and exciton energy, etc.) of various material systems, including inorganic non-metallic, metallic, polymeric, and composite materials, without any fitting parameters. These models cover a wide spectrum of quantitative correlations including temperature, acoustic field, optical field, electric field, magnetic field, irradiation, microwave, pressure, strain rate, and size, etc. Aiming at the persistent challenge that several key properties of materials under extreme conditions are difficult to obtain, especially in situ and non-destructively, a series of high-efficiency, low-cost, nondestructive measurement and in situ monitoring technologies for material properties under extreme conditions in a wide range (including thermal, acoustic, optical, electrical, magnetic, irradiation, high pressure, etc.) have been developed based on the Li's principle of energy equivalence.

Abstract ID 283

GENERALISED PHASE FIELD MODELLING OF FRACTURE IN GYROID STRUCTURES: NUMERICAL AND EXPERIMENTAL INSIGHTS USING ADDITIVELY MANUFACTURED PLA SPECIMENS

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Keywords: Cohesive phase field model, Finite Element Method (FEM), Triply Periodic Minimal Surfaces (TPMS), Gyroid structures, Additive Manufacturing (AM)

This study presents a three-dimensional cohesive generalized phase-field approach to model and validate quasi-static fracture processes in Gyroid lattice structures. By incorporating linear, hyperbolic, and exponential softening laws, the model extends beyond classical AT1 and AT2 formulations, enhancing flexibility in simulating material degradation. These laws were calibrated through tensile tests on 3D-printed flat specimens made of Polylactic Acid (PLA) bars, showing strong agreement with numerical force–displacement curves and crack patterns. After establishing the accuracy of the model in two-dimensional tests, the study progressed to three-dimensional structures by examining the fracture behavior of Triply Periodic Minimal Surface (TPMS) geometries, focusing on the Gyroid due to its well-documented mechanical advantages. Single Gyroid unit cells and 2x2x2 clusters were fabricated using generic PLA material on an Ultimaker S5 3D printer. Subsequently, compression and tensile tests were performed using a DEBEN microtensile testing stage. To enable a detailed visual comparison with the numerical simulations, each experimental test was recorded from three complementary angles—vertical, horizontal, and isometric—capturing the full structural response under both loading conditions and geometrical configurations. This multi-angle visual dataset facilitated a precise frame-by-frame assessment against the simulated results, offering valuable insights into crack initiation, propagation trajectories, and overall deformation behavior. The mechanical response observed in the printed specimens was then reproduced and analyzed through three-dimensional simulations, conducted using the developed generalized phase-field model. This approach ensured consistent evaluation between experimental and computational outcomes across all tested configurations. The numerical implementation was developed using the open-source library GPFEniCS, offering a robust environment for solving coupled variational problems in fracture mechanics. To meet the demanding computational requirements of large-scale 3D simulations, all analyses were conducted on the high-performance computing facilities at CINECA. This setup enabled the integration of multiple softening laws and complex boundary conditions while preserving numerical efficiency and modelling flexibility. Quantitative comparisons between simulations and experiments were carried out, focusing on load–displacement curves and qualitative assessments of fracture morphologies and deformation modes. The results confirm the model's capacity to accurately capture failure mechanisms in additively manufactured Gyroid lattices. Furthermore, the modelling framework developed herein is highly extensible, providing a strong basis for the future inclusion of additional physical and mechanical phenomena—such as residual stresses, toughening mechanisms, micron-scale effects—as well as the analysis of alternative TPMS architectures like Primitive, Diamond, and I-WP geometries.

Abstract ID 284

AN OPTIMIZATION-BASED ALGORITHM FOR SURFACE AND BOUNDARY CORRECTIONS IN BOND-BASED PERIDYNAMICS

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Keywords: Peridynamics, Boundary-induced softening, Surface correction, Optimization, Bond-based

Peridynamics (PD), as a nonlocal continuum theory, is widely used for the modeling of fracture and evolving discontinuities [1]. However, in bounded domains, the truncation of interaction horizons near free surfaces, cracks, and voids leads to a loss of neighbors, causing artificial surface softening and inconsistencies in derivative and energy operators that persist under discretization refinement [2].In this work, the effects of horizon truncation are analyzed and isolated, highlighting their impact on the accuracy of PD discretizations. To overcome these limitations, a novel surface correction strategy fully formulated within the PD framework is proposed. The method restores full-horizon behavior without altering the horizon radius or bond topology by introducing optimized nodal influence weights, with symmetric scaling of bond interactions. The nodal weights are computed through a preprocessing optimization procedure that enforces consistency between truncated- and full-horizon operators [3]. The resulting algorithm is simple to integrate into existing bond-based PD codes and does not require ghost particles, variable horizons, or reference solutions from classical continuum mechanics. Numerical benchmarks in one and two dimensions, including dynamic fracture simulations, show that the proposed approach reduces boundary-induced softening, improves energy consistency, and accelerates convergence. In addition, the analytical evaluation of calibration targets over full-horizons enhances the accuracy of volume integration in the interior domain [3].The method is computationally efficient, straightforward to implement, and performs reliably across different geometries and discretizations. These features make it a promising algorithmic contribution to peridynamics, with potential extensions to state-based formulations and relevance for advanced computational approaches to fracture and interface problems. This work is supported by Sapienza Ateneo Progetti Grandi (CUP: B83C24007070005), and PROGETTO MUSICS - FISA-2023-00099 (CUP: B83C25000810001).

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Abstract ID 285

AN ANISOTROPIC HEAT TRANSFER PERIDYNAMIC FRAMEWORK FOR MELT POOL GEOMETRY PREDICTION IN METAL ADDITIVE MANUFACTURING

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Keywords: Anisotropic material, peridynamics, heat transfer, phase change, melt pool morphology

In metal additive manufacturing, melt pool geometry serves as a critical indicator of part quality and process stability. Under laser irradiation, Marangoni flow within the melt pool induces an effectively orthotropic heat transfer behavior, which significantly affects melt pool morphology [1]. To accurately simulate this phenomenon, this study develops an anisotropic heat-transfer model based on bond-based peridynamics (BB-PD) [2]. Consequently, a micro-conductivity formulation is derived, and an enthalpy-based peridynamic model for solid-liquid phase change is further formulated [3]. By incorporating a Gaussian-exponential volumetric laser heat source model, a complete peridynamic framework for melt pool morphology prediction is established. The proposed framework is validated through a series of examples and comparisons with finite element results, demonstrating its correctness and robustness. Finally, single-track melt pool simulations are performed and compared with experimental measurements, showing that the proposed method can accurately predict melt pool geometric characteristics. Notably, the framework captures melt pool geometry without explicitly resolving fluid dynamics. This work provides a foundation for the future development of anisotropic thermo-mechanically coupled peridynamic models for additive manufacturing

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Abstract ID 286

PERIDYNAMIC MODELING OF FATIGUE CRACK INITIATION IN ADDITIVELY MANUFACTURED INCONEL 718: COMPETITION BETWEEN SURFACE ROUGHNESS AND INTERNAL DEFECTS

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Keywords: Peridynamic, Surface roughness, High cycle fatigue, Internal porosity, Additive manufacturing

Fatigue failure remains a critical concern for the structural integrity of engineering components, particularly in the aerospace industries, where components are subjected to prolonged cyclic loading. As fatigue cracks typically initiate at or near the surface due to stress concentrations or material defects under high-cycle fatigue conditions, understanding surface- and defect-driven damage mechanisms is essential for accurate life prediction. Accurate prediction of fatigue crack initiation is essential for ensuring safety and optimizing design, particularly in the high-cycle fatigue regime where nucleation dominates fatigue life. In this study, a Peridynamic framework is employed to simulate the evolution of fatigue damage in additively manufactured Inconel 718, building upon the work of Stewart Silling et al. [1]. Cyclic loading conditions are applied to simulate crack initiation, and a cumulative damage-based formulation is adopted to predict fatigue life. The effect of maximum surface valley depth on fatigue life is systematically analyzed, and the numerical results are validated against experimental data under high-cycle fatigue conditions [2], showing good agreement. The findings confirm that surface roughness plays a significant role in governing the nucleation-dominated fatigue regime. Furthermore, the model is extended to investigate the combined effects of surface roughness and internal porosity. The results indicate that the dominant damage mechanism depends on the spatial interaction between defects, with a transition from surface-dominated to pore-dominated behavior occurring when pores are located within a critical distance from the free surface. The findings show that the peridynamic approach provides consistent predictions of fatigue life compared to experimental observations. The aim of this work is to verify the potential of Peridynamics as a robust and unified tool for fatigue assessment and lifecycle prediction in defect-sensitive materials. This approach offers significant potential for application in safety-critical engineering systems. The authors believe that this framework can support the design of additively manufactured components, which often exhibit inherent surface roughness and internal defects that are difficult to eliminate through post-processing. Therefore, accurate prediction of as-built surface topography and defect interaction effects is essential for achieving the desired performance and reliability

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Abstract ID 287

COUPLING A PERIDYNAMIC CORROSION MODEL WITH AN AGENT-BASED CELL MODEL TO STUDY THE INTERACTION BETWEEN MAGNESIUM IMPLANT BIODEGRADATION AND BONE REGENERATION

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Keywords: Biodegradable Magnesium Implants, Peridynamic Corrosion Modelling, Nonlocal Nernst-Planck-Poisson System, Agent Based Cell Modelling, Osteogenic Response

Biodegradable magnesium implants have attracted considerable attention in orthopaedic applications due to their favourable mechanical properties and their potential to actively support bone regeneration [1]. However, the interaction between magnesium degradation and the osteogenic response remains insufficiently understood. Experimental studies, both in vitro and in vivo, are costly, time-consuming, and often yield discrepant results or raise new questions.To complement these experiments and to systematically analyse (a) the degradation behaviour in the presence of bone cells on the one hand and (b) changes in cellular activity and bone formation under varying electrochemical conditions on the other hand, we are developing a fully coupled, multiphysics and multiscale computational model based on the nonlocal Nernst–Planck–Poisson model (NNPP) derived by Hermann et al. [2]. The model is currently capable of describing diffusion, electromigration, and chemical reactions within a single nonlocal framework, allowing for the prediction of ion species concentrations. The effective interface diffusivity coefficient in the diffusive corrosion layer (DCL) depends on the magnesium ion concentration and the total material loss, while the diffusivity in the liquid and solid phases is a constant material parameter of the model.Based on these quantities, we establish a strong coupling with the agent-based cell model (ABM) of Jalil et al. [3], which describes how magnesium ions and pH regulate mesenchymal stem cell (MSC) proliferation, differentiation, migration, and apoptosis in vitro. Instead of prescribing these quantities externally, the ABM directly receives magnesium concentrations and pH values from the NNPP model.In turn, the output of the ABM influences the constitutive model of the DCL diffusivity through geometric blocking effects caused by cells being recruited to and adhering at the implant surface.Solving this multiphysics and multiscale model in a monolithic manner using a fully implicit backward Euler scheme, combined with a Newton method where the Jacobians are obtained via automatic differentiation, is computationally challenging and expensive. The strong nonlinear coupling between electrochemical transport and cellular dynamics, together with the wide range of relevant time and length scales, leads to a stiff system that necessitates fine temporal and spatial discretisations, but at the same time holds high potential for GPU parallelisation.We will present the current status, discuss numerical challenges, and show first investigations how local pH and magnesium ion concentrations influence the osteogenic response and how bone regeneration affects the magnesium implant degradation.

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Abstract ID 289

FAILURE ANALYSIS OF COMPOSITE BEAM BASED ON PERIDYNAMICS THEORY

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Keywords: Timoshenko Beam, Composite Beam, Layer-wise Beam

Peridynamics (PD) is a non-local continuum mechanics theory that describes long-range forces between material points through integral equations. By overcoming the limitations of traditional differential equations in handling discontinuity problems, it is well-suited for analyzing material fracture, damage, and multi-physics field coupling. In this study, a mathematical model for composite beam structures was established based on peridynamics theory, and a damage model was constructed using the maximum strain energy density criterion. The model was validated through the bending failure of sandwich and laminate composite beam structures, successfully accomplishing crack initiation, propagation, and arrest phenomena in alternating soft and hard materials. A key advantage of this model is its ability to visualize two-dimensional damage evolution within a one-dimensional framework, significantly reducing computational time and modeling costs.

Abstract ID 290

PERIDYNAMIC MODELING OF NON-UNIFORM DEGRADATION IN BIORESORBABLE SCREWS

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Keywords: peridynamics, bioabsorbable magnesium implants, pitting corrosion

Bioabsorbable magnesium-based fixation screws offer temporary mechanical support during bone healing while avoiding secondary removal surgery, but their clinical use is limited by the difficulty of predicting degradation in physiological environments. In particular, Mg alloys often corrode through irregular and localized patterns that are difficult to represent with conventional moving-boundary methods. This work presents a peridynamic computational framework for simulating the degradation of Mg-alloy screws immersed in a biomimetic electrolyte. Corrosion is described as anodic dissolution at the evolving solid-liquid interface, coupled with diffusion of released metal ions in the surrounding liquid. Thanks to its nonlocal formulation, peridynamics naturally handles the progressive recession of the interface without explicit surface tracking or remeshing. The model extends the FFT-accelerated PeriFast/Corrosion formulation by introducing a space- and time-dependent corrosion current density. The current law is written as the product of a spatial distribution and a temporal decay function, enabling both uniform corrosion and pitting-like degradation to be treated within the same framework. In the non-uniform case, localized current-density peaks are randomly distributed over a background value and are interpreted as mesoscale effects of microstructural defects or local anodic sites. Differently from geometrical pitting approaches, pits are not prescribed in the initial geometry but emerge when the evolving wetted surface intersects regions of higher current density. The framework is applied to the 60-day degradation of an M2 Mg-10Gd screw in an a-MEM-based medium. Parameters are selected from literature data and calibrated against experimental volume-loss measurements. Simulations reproduce the main degradation regimes and allow comparison of uniform and pitting-like corrosion through volume loss, magnesium-ion concentration, and surface roughness indicators. Results show that localized current peaks accelerate material loss and produce more irregular concentration and roughness patterns. A differential pitting scenario further demonstrates how heterogeneous bone environments can be represented through region-dependent current distributions in simulations.

Abstract ID 292

A PERIDYNAMIC VISCOELASTIC-PLASTIC MODEL FOR ICE APPLICABLE ACROSS WIDE RANGES OF STRAIN RATES

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Keywords: Peridynamics, Ice model, Viscoelastic-plastic model, Strain rate effects

Ice exhibits diverse mechanical responses, including elasticity, viscosity, ductility, and brittleness, that are highly dependent on strain rates [1]. To address the challenge of characterizing such complex mechanical behavior using Peridynamics, a viscoelastic-plastic constitutive model for ice was developed in this study. Under the framework of ordinary state-based peridynamics (OSBPD), an elastoplastic model based on the Drucker-Prager yield criterion was formulated and a viscoelastic model [2] composed of two Maxwell models in parallel was established. An implementation framework was proposed for the viscoelastic-plastic model, with the incorporation of a rate-dependent damage formulation [3] to construct a comprehensive ice constitutive model. Benchmark tests covering low, intermediate, and high strain rate ranges were conducted to validate the proposed model. Numerical results show excellent agreement with existing experimental results, effectively capturing ice deformation characteristics, crack propagation patterns, and ice load variations. The results further indicate the capability of the proposed model to reproduce ice mechanical behavior across wide ranges of strain rates and its potential for simulating ice-structure interaction under complex polar conditions.

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Abstract ID 301

AN EFFICIENT BOND-WISE COMPUTATIONAL FRAMEWORK WITH A LOW-RANK INCREMENTALLY UPDATED PRECONDITIONED SOLVER FOR FRACTURE SIMULATIONS IN PERIDYNAMICS

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Keywords: Peridynamics; Fracture simulation; Low-rank; Preconditioned solver

Fracture simulation in peridynamics using implicit schemes is computationally expensive due to stiffness evolution caused by bond breakage and repeated solution of evolving large algebraic systems. To address this challenge, we propose a bond-wise computational framework that integrates the stiffness matrix assembly and update with a fast solver tailored to evolving algebraic systems during crack propagation. In this framework, each bond is treated as a basic computational unit with a rank-one stiffness contribution, so fracture driven by bond breakage can be described as a sequence of low-rank modifications to the global stiffness matrix. Leveraging this observation, a low-rank incrementally updated preconditioned solver is developed for this framework. The solver updates an initial preconditioner using the Sherman-Morrison-Woodbury formula, while an incremental factorization is introduced to reduce the computational overhead caused by cumulative bond breakage. Analyses show that this updating strategy preserves the eigenvalue clustering of the preconditioned system, ensuring stable and efficient convergence, and the corresponding complexity analyses are provided. As an application, the proposed framework is employed to simulate quasi-static fracture in bond-based peridynamics. Numerical experiments show that the simulated crack patterns are consistent with experimental observations, confirming the reliability and high computational efficiency of the framework.

Abstract ID 302

MIXED SCHEME ABOUT ROM/FOM WITH SPACE-ADAPTIVE PARTITIONING STRATEGY FOR QUASI-STATIC PERIDYNAMIC FRACTURE SIMULATION

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Keywords: Peridynamics; Reduced-order model; Proper orthogonal decomposition; Space-adaptive strategy; Fracture simulation

In this paper, we present a mixed reduced-order/full-order model (ROM/FOM) scheme based on space-adaptive partitioning strategy for peridynamics (PD) to efficiently simulate brittle fractures. Generally, the drastical displacement mutation occurs around the crack tip and path, resulting in the ROM more sensitive to high-fidelity snapshots, and even leading to failure of ROM. To overcome this difficulty, the entire computational domain is partitioned into two types of regions: the damage regions are simulated using full-order PD solver, while the sub-system over remaining regions is projected onto low-dimensional subspaces obtained by the proper orthogonal decomposition (POD) method. The domain partitioning is adaptively performed based on bond-breakage data and no a priori knowledge of cracks is required. Besides, a modified reduced subspace that satisfy homogeneous boundary conditions is constructed. By developing a specific linear combination of POD bases plus particular solution containing only boundary data, the reduced systems are free of boundary degrees of freedom while still enforcing boundary constraints. Several benchmark tests and numerical examples are conducted to demonstrate the successful implementation of fracture simulations for three distinct loading scenarios and various fracture patterns using the proposed method. Moreover, this mixed ROM/FOM approach achieves a significant improvement in computational efficiency due to greatly dimension reduction while maintaining almost the same accuracy compared to the full-order PD model.

Abstract ID 303

OPERATOR-PRESERVING SURFACE CORRECTION FOR PROJECTED VISCOUS PERIDYNAMIC FLOW VIA TENSOR GENERALIZED MOVING LEAST SQUARES AND POLYNOMIAL BOUNDARY EXTRAPOLATION

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Keywords: Peridynamics, Surface correction, GMLS, Navier–Stokes, Meshfree methods, Viscous flow

Peridynamic fluid formulations based on projected bond interactions are attractive because they retain a particle-neighbour structure closer to peridynamic solid mechanics than meshfree reconstructions of classical derivatives. In the projected viscous formulation of Zhao et al., viscous forces are carried through bondwise projected velocity differences over a finite horizon. This structure is useful for future moving-boundary and fluid-structure interaction settings, but it is vulnerable to the classical peridynamic surface effect: near a no-slip wall, the horizon is truncated, polynomial reproduction is lost, and first-order wall errors can dominate the solution.This work develops an operator-preserving surface-effect correction that repairs this truncation error without replacing the original bond-projection operator by a classical derivative reconstruction, such as Peridynamics Differential Operator methods. The method separates two error sources that are usually coupled. The tensor Generalized Moving Least Squares (GMLS) correction minimally perturbs the bond weights so that truncated near-wall families satisfy the required polynomial reproducing conditions. In full symmetric horizons, it returns the original bond-projection kernel up to quadrature and conditioning tolerance. A manufactured polynomial boundary condition, polyBC, then assigns fictitious wall-node values by fitting a local quadratic wall-normal profile through nearby fluid nodes while enforcing no-slip at the true wall surface. Thus, GMLS repairs the operator-side truncation error, while polyBC repairs the boundary-data error. The two components are complementary. In ablation studies on Poiseuille flow, a manufactured Stokes annulus, and 3D elliptical-pipe flow, using only GMLS or only polyBC reduces the error constant but does not restore the observed second-order trend. The combined correction recovers rates consistent with second-order convergence on the analytical wall-bounded benchmarks, with error reductions of approximately 26 - 139 times at the reference resolutions. Additional tests then probe behavior beyond the divergence-free wall-benchmark setting: a non-divergence-free manufactured flow verifies the projected viscous limit with its dilatational contribution, an acoustic standing wave reproduces the predicted projected-operator decay ratio, and a passive-scalar transport problem checks that the polyBC wall extrapolation transfers to scalar advection-diffusion-reaction dynamics. A backward-facing-step test further indicates practical robustness: uncorrected configurations fail to reach steady state, whereas the corrected configurations converge in the present weakly compressible PD-NS formulation. The result is a fluid-side surface treatment that retains the bond-projection structure of the underlying PD operator while correcting the leading wall inconsistency introduced by horizon truncation. For fluid-structure interaction, the present method should be viewed as a foundation rather than a complete coupling: the corrected near-wall weights are generally pairwise asymmetric, so conservative interface exchange still requires a separate reconciliation of kinematic compatibility, force and torque balance, and interface work as future studies.

Abstract ID 304

PHASE-FIELD PERIDYNAMICS FOR BRITTLE FRAGMENTATION WITH LARGE DEFORMATIONS

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Keywords: Peridynamics, Brittle Fragmentation, Finite Deformations, Dynamic Fracture, Phase-Field Peridynamics

The simulation of fragmentation in brittle structures under dynamic loading is a particularly challenging task in computational mechanics. Cracks propagate at high velocities, multiple crack surfaces nucleate at unforeseen locations, and elastic waves released by the initial fracture trigger further breaks along the structure. Such phenomena are difficult to capture with classical numerical methods and require a formulation that resolves finite deformations and arbitrary crack topologies in a consistent way. Peridynamics offers a promising approach as a nonlocal continuum formulation, in which interactions between material points within a finite horizon are considered. Among the established formulations, the correspondence formulation is particularly attractive, since it directly incorporates classical hyperelastic constitutive laws and avoids the surface effects of the bond-based and ordinary state-based formulations. Its zero-energy modes can be eliminated by a bond-associated quadrature point approach. However, this stabilization is only partially compatible with the traditional peridynamic fracture model based on bond deletion. As bonds are progressively removed, the approximation of the deformation gradient degenerates and the shape tensor may even become singular. The kinematic approximation then breaks down in exactly those regions in which multiple cracks form, which is the regime of greatest interest for fragmentation problems. To overcome this limitation, a novel phase-field peridynamics framework is presented. Instead of an instantaneous bond deletion, the energetic contribution of each bond is degraded continuously through a bond-specific phase-field parameter. The damage evolution is derived from an energy-based variational principle and ensures thermodynamic consistency with Griffith's fracture theory. A kernel-dependent normalization constant is introduced such that the total crack dissipation matches the energy release rate per unit crack area for general spherical kernel functions. Since the bonds are no longer deleted, the shape tensor remains invertible and the bond-associated kinematic approximation stays accurate even under significant damage. To reduce the computational cost of the higher-order quadrature, an adaptive variant of the framework selectively activates the bond-associated stabilization only where a local non-uniformity indicator or the presence of damage requires it. In the talk, the framework is demonstrated on challenging three-dimensional fragmentation problems at finite deformations, showcasing the stability and accuracy of the proposed approach.

Abstract ID 307

A DILATATION-ENHANCED DAMAGE MODEL FOR THE FAST CONVOLUTION-BASED METHOD PERIDYNAMICS

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Keywords: Peridynamics; Fast convolution-based method; Damage model; Fracture; Nonlocal dilatation

The fast convolution-based method (FCBM) significantly accelerates peridynamic (PD) simulations by leveraging the convolutional structure of integral operators. To preserve this convolutional formulation and enable efficient FFT-based acceleration, damage evolution must be formulated at the nodal level rather than at the bond level. However, existing node-based damage models either do not distinguish between tension and compression, positive and negative shear, or require computationally expensive nonlocal deformation gradients. In this work, a dilatation-enhanced damage model that is tension/compression-aware is introduced for the fast convolution-based peridynamic (FCBM-PD) framework to simulate fracture in quasi-brittle materials under complex loading. In addition to the strain energy density, the model employs the nonlocal dilatation as an intrinsic measure of volumetric deformation, enabling natural discrimination between tensile and compressive states that may lead to damage or not. Dilatation is computed directly from intermediate variables, avoiding the need for strain decomposition based on the nonlocal deformation gradient and the associated risk of zero-energy modes. The proposed model preserves the convolutional structure of FCBM-PD for all its versions, bond-based, state-based, and correspondence models, maintaining high computational efficiency. The model is validated with several benchmark problems, encompassing both quasi-static and dynamic scenarios, in 2D and 3D. The results demonstrate that the proposed method accurately captures crack initiation and propagation under tensile, compressive, shear, and mixed-mode loadings. Convergence studies confirm numerical robustness, and computational performance analysis demonstrates potential for large-scale, high-resolution simulations of fracture and damage. The model is implemented and validated within the FCBM- bond-based (BBPD), ordinary state-based (OSBPD), and correspondence models in the non-ordinary state-based (NOSBPD) formulations, in 2D and 3D, demonstrating its general applicability.

Abstract ID 308

PERIDYNAMICS WITH STRAIN GRADIENT ELASTICITY FOR MICROSTRUCTURAL SIZE EFFECT

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Keywords: peridynamics, strain gradient elasticity, micro structure, size effect

Experimental observations at micro- and nano-scales have revealed pronounced size-dependent behavior in materials and structures, particularly in MEMS and NEMS applications. These effects arise from the interaction between intrinsic material length scales and structural dimensions. This study presents an ordinary state-based peridynamic (PD) model coupled with strain gradient elasticity (PDSG) to account for size-dependent mechanical behavior. This approach combines the nonlocal Peridynamic theory with the strain gradient elasticity theory, enabling multiscale analysis of materials with discontinuities. The formulation transforms the Navier-type strain gradient displacement equations into their integral peridynamic form which remains valid in the presence of discontinuities such as cracks, defects, and material interfaces. Numerical simulations of cracked and uncracked nano-films under tensile loading demonstrate that increasing the internal length scale parameter leads to reduced displacement responses, consistent with expected size-dependent stiffening effects. The integration of peridynamics and strain gradient elasticity provides a robust computational framework for modeling materials exhibiting size effects and damage phenomena.

Abstract ID 310

INTEGRATION OF PERIDYNAMICS INTO THE FLOATING FRAME OF REFERENCE APPROACH FOR THE STUDY OF FRACTURE IN MULTIBODY SYSTEMS

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Keywords: Peridynamics; flexible multibody dynamics; floating frame of reference; component mode synthesis; crack propagation

Multibody dynamic (MBD) analyses are widely used to study mechanical systems composed of interconnected bodies undergoing large displacements and rotations. Recent work by the authors introduced the integration of peridynamics (PD) into MBD frameworks to capture structural deformation and nonlinear phenomena such as crack initiation and propagation. However, the computational cost associated with this approach limits its applicability to realistic materials and long-duration simulations. This work adapts two existing formulations aimed at overcoming the computational limitations arising from the different time scales associated with rigid-body motion and fracture. Both formulations are based on a floating frame of reference (FFR) formulation, enabling the separation of rigid motion from elastic deformation. For cases involving small deformations, a component mode synthesis (CMS) reduction strategy is employed to reduce the model order and suppress high-frequency response, allowing larger integration time steps while preserving accuracy and numerical stability. For problems involving large nonlinear deformations or fracture, an FFR formulation without reduction is adopted. The proposed approaches are assessed through numerical simulations of a slider-crank mechanism and compared with a previously developed formulation, demonstrating substantial gains in computational efficiency. In addition, a landing gear application illustrates the potential of the proposed methods for realistic engineering systems. These developments constitute an important step towards a hybrid multibody–peridynamic framework capable of efficient structural analysis and progressive failure prediction in complex mechanical systems.

Abstract ID 311

PERIDYNAMIC MODELING OF BRAIN TISSUE

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Keywords: Soft materials, Hyperelasticity, Indentation, Evolving discontinuities

Brain tissue is among the most challenging materials to model because of its ultrasoft mechanical behavior and biphasic nature. During brain surgery, the relatively rapid evolution of the phenomenon allows the tissue to be approximated as a nearly incompressible hyperelastic medium, commonly described through strain-energy functions based on principal stretches (Ogden-type constitutive laws) [1]. Conventional numerical methods, however, face difficulties in handling evolving discontinuities, such as those produced by a scalpel cutting through cerebral tissue. Peridynamics [2], which is formulated through integro-differential equations, is naturally capable of modeling the initiation and propagation of discontinuities without requiring additional tracking or failure criteria. In particular, the non-ordinary state-based formulation enables the straightforward incorporation of classical constitutive models into the peridynamic framework. Numerical instabilities associated with zero-energy modes can be effectively mitigated using stabilization techniques, such as the bond-associated stabilization method [3]. In our previous work, we showed that analyses of nearly incompressible materials within this peridynamic framework may exhibit artificial overstiffening, similar to volumetric locking phenomena in finite element methods. To address this issue, we proposed the selective bond-associated stabilization approach, which accurately captures the response of nearly incompressible materials while preserving numerical stability and avoiding overstiffening [4]. In the present work, this approach is applied to the modeling of brain tissue through the incorporation of Ogden-type hyperelastic constitutive laws within the peridynamic framework. This enables the model to capture the strain stiffening associated with the progressive alignment of axonal fiber networks and the asymmetric response in compression and tension resulting from the biphasic nature of gray and white matter. The proposed formulation is further validated through numerical simulations of representative problems involving cortical indentation and the evolution of discontinuities in brain tissue. This work represents a first step toward the comprehensive modeling of brain-scalpel interaction during surgical cutting procedures.

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Abstract ID 313

THEORETICAL MODEL FOR CHARACTERIZING THE CONFINING PRESSURE-DEPENDENT COMPRESSIVE STRENGTH OF ROCK MATERIALS

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Keywords: Confining pressure-dependent; Compressive strength; Rock materials; Theoretical model

Deep rocks are subjected to high confining pressures in complex geological environments, and their compressive strength exhibits a significant nonlinear increase with rising confining pressure. Accurate, economical, and rapid determination of rock compressive strength is essential for deep rock engineering. Based on the Force-Heat Equivalence Energy Density Principle, considering the equivalence between the strain energy and the work done by confining pressure. This study establishes a theoretical model to characterize the confining pressure-dependent compressive strength of rock materials without fitting parameters. The model quantitatively predicts rock compressive strength under various confining pressures using only the compressive strength data at zero and any other confining pressures. This study provides theoretical guidance for the quantitative characterization of rock compressive strength and has significant practical value for the stability design, prediction, and monitoring of deep rock engineering.

Abstract ID 314

INVESTIGATION OF STATIC AND DYNAMIC FRACTURE BEHAVIORS IN ORTHOTROPIC FUNCTIONALLY GRADED COMPOSITE LAMINATES VIA OSPD

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Keywords: Ordinary state-based peridynamics, Functionally graded composite laminates, Stress intensity factors, Nonlocal interaction integral, Crack propagation

Orthotropic functionally graded composite laminates offer tailored mechanical performance for advanced engineering applications, but accurate fracture characterization under coupled material heterogeneity and anisotropy remains a critical challenge. This work presents an ordinary state-based peridynamic (OSPD) approach to investigate static fracture parameters and dynamic crack propagation in orthotropic functionally graded materials (FGMs). Built upon peridynamic differential operators, a nonlocal interaction integral formulation that accounts for both material gradient and orthotropy is established to extract mixed-mode stress intensity factors (SIFs) and crack opening displacements. Two crack growth criteria, the prototype microelastic brittle bond failure criterion and the maximum circumferential stress criterion, are implemented and comparatively evaluated for mode-I and mixed-mode fracture problems. The proposed framework is validated through multiple benchmark cases against reference solutions from the finite element method, extended finite element method and extended wavelet Galerkin method. Numerical results confirm that the developed nonlocal integral delivers path-independent and stable SIF estimations. SIF magnitudes are governed by the combined effects of crack length and material gradient, and high material gradients induce pronounced asymmetric crack tip fields and non-symmetric crack propagation. Fiber orientation dominates the crack growth direction, while material property distribution regulates propagation velocity and stability. The two failure criteria exhibit complementary advantages in automatic crack evolution simulation and crack inclination prediction respectively. This study provides a reliable numerical tool and theoretical insights for fracture assessment of advanced FGM composite structures.

Abstract ID 319

FATIGUE CRACK PROPAGATION IN A RAILWAY STRUCTURE USING PERIDYNAMICS

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Keywords: Fatigue, Peridynamics, Submodeling, Computational fatigue analysis, Freight wagon

Accounting for fatigue is vital in designing dynamically loaded structures, as it is the primary cause of most in-service mechanical failures. Under a damage tolerance philosophy, predicting crack paths and propagation rates is essential for optimizing maintenance schedules and extending component life. Peridynamics, a non-local continuum mechanics theory [1], offers a natural approach to simulating fatigue cracking, effectively mitigating the computational limitations of traditional methods [2]. This work characterizes peridynamic fatigue models and assesses their applicability to large-scale engineering projects by analyzing the SMARTWAGONS freight wagon bogie frame.

To achieve this, an in-house two-dimensional MATLAB program is developed. The models are first rigorously validated for accuracy and computational efficiency against exact analytical solutions, finite element (FE) simulations, and experimental data. Subsequently, a hybrid FE-peridynamic submodeling approach is employed to analyze fatigue on the freight wagon's body shells.

The peridynamic models demonstrate an excellent ability to accurately predict complex crack trajectories. While some discrepancies are observed in predicting crack growth rates under mixed-mode loading, the hybrid submodeling approach proved highly successful. It successfully delivers critical insights into crack initiation, path evolution, and propagation within critical high-stress regions of the wagon, demonstrating the strong industrial potential of peridynamic fatigue analysis for practical applications.

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Abstract ID 320

NEW PERIDYNAMIC KERNELS FOR STABLE GENERAL ANISOTROPIC MATERIALS

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Keywords: Peridynamics, Anisotropy, Material stability, Elasticity, Diffusion

In peridynamic [1] material modelling, the simplicity of bond-based and ordinary state-based models is often the main motivation for their adoption in fracture applications. However, when compared to correspondence models, their use is mainly limited to isotropic materials, or to materials with specific material symmetries. To model such materials, the calibration with classical elasticity tensor is needed, yielding a direction dependent micromodulus [2]. For the requirement of material stability (in classical elasticity, the strong ellipticity condition), in bond-based peridynamics a sufficient condition is the positiveness of the micromodulus [1]. Typical peridynamic kernels in the literature, under the mentioned calibration procedures fail to ensure such condition, resulting in conditional stability, for specific materials. In the current work, we discuss other possibilities for ensuring stable material models, proposing an unconditionally stable kernel for anisotropic materials in peridynamics. Its application to diffusion and elasticity is discussed while emphasis is also put on the modelling of multiphysics problems. We illustrate our proposed models and compare them with results obtained using other kernels, resorting to simple static and modal analyses, employing a straightforward meshfree discretization.

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