



SCHOOL
FOR ADVANCED
STUDIES
LUCCA

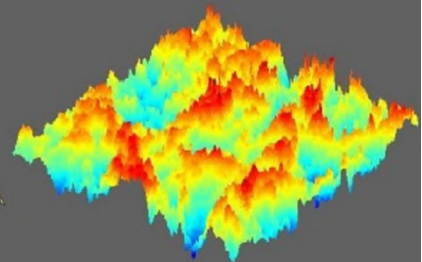
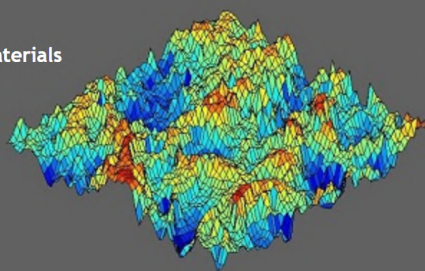


SAN FRANCESCO
2013 2023

MUSAM
TEN-YEAR IMPACT REPORT
2013 – 2023

MUSAM

MUSAM - Multi-scale Analysis of Materials



Preface

This report summarizes the key facts and figures of the research unit MUSAM on Multi-scale Analysis of Materials, founded in 2013 with the mission to strengthen the IMT (Institutions, Markets, Technologies) School for Advanced Studies Lucca on quantitative methods.

Sincere thanks go to the research staff, from PhD students to assistant professors, along with visiting researchers, who animated the unit with their dedication and passion and made a continuous effort to integrate training and research. The activities have always been conceived and developed within an international perspective, with a continuously growing network of collaborations Worldwide, which are gratefully acknowledged.

Although frontier research was always the primary vocation, the impact of the unit can be appreciated also in relation to the knowledge and technology transfer dimensions, as proved by the several industrial collaborations established through joint activities and doctoral projects.

Hence, this report aims at setting a milestone to highlight the research contributions of MUSAM on the wide spectrum of computational methods and experimental techniques for materials, and to serve as inspiration for the activities of the years to come, to be addressed with a renewed impulse and commitment.

Lucca, November 9, 2023

Prof. Marco Paggi

(MUSAM, Research Unit Director)

1 The research unit: people and activities

The research unit has been directed by Prof. Marco Paggi since its foundation in 2013, when he joined the IMT School for Advanced Studies Lucca from Politecnico di Torino, with the mission to strengthen the technological area of the school. **MUSAM –Multi-scale Analysis of Materials–** (<http://musam.imtlucca.it/>) was conceived as an **interdisciplinary research unit** integrating **computational and experimental mechanics, numerical analysis and materials science** to address frontier research problems in modelling, simulation and testing of natural and artificial physical systems. Hinging on the development of new computational methods, applications covered a wide range of technological problems, with notable industrial collaborations at the regional, national and international levels.

From 2015 to 2019, Dr. Andrea Bacigalupo joined the unit as an assistant professor, bringing his competences on micromechanics and homogenization theory. After his leave to University of Genova, where he became associate and then full professor, Dr. Pietro Lenarda joined the research unit as assistant professor in 2020, after a previous experience at the Italian Institute of Technology in Genova, covering the topics of biomechanics and coupled problems in solids and fluids. Dr. Andrea Mola joined in 2021 the unit from Scuola Internazionale Superiore di Studi Avanzati (SISSA) as assistant professor, with specific competences on numerical analysis, model order reduction techniques and computational fluid dynamics. Dr. Maria Rosaria Marulli joined the unit as assistant professor in 2023, working on contact and fracture mechanics for advanced materials, adhesives and for applications of mechanics to archaeology and cultural heritage. In the period 2020-2022, Prof. Fabrizio Davì, full professor at Università Politecnica delle Marche, joined the unit for a sabbatical leave.



Prof. Marco Paggi (since 2013)
Computational mechanics



Dr. Andrea Mola (since 2021)
Numerical analysis &
Computational fluid dynamics



Dr. Pietro Lenarda (since 2020)
Biomechanics & Coupled problems



Dr. Maria Rosaria Marulli (since 2023)
Contact & fracture mechanics for
advanced materials and cultural heritage



Prof. Andrea Bacigalupo (2015-2019)
Micromechanics & homogenization

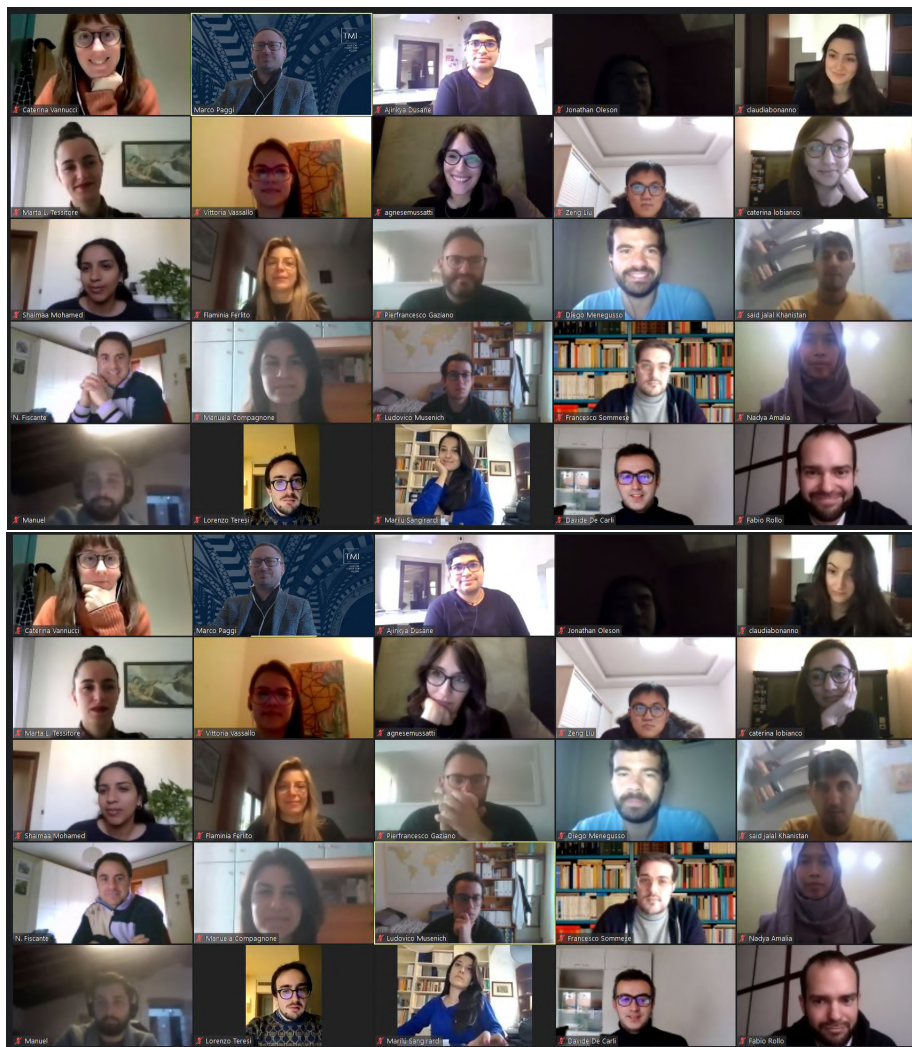


Prof. Fabrizio Davì (2020-2022)
On sabbatical leave from
Università Politecnica delle Marche

Professors and assistant professors

Professors and assistant professors of the research unit have contributed to the **interdisciplinary PhD programmes of the IMT School** (PhD in Institutions, Markets and Technologies; PhD in Systems Science; PhD in Management of Digital Transformation), delivering core courses on numerical methods (Numerical Analysis, Numerical Methods for the Solution of Partial Differential Equations, Reduced

Order Models with Applications), advanced courses on computational mechanics (Computational Contact and Fracture Mechanics, Computational Fluid Dynamics, Advanced Topics of Computational Mechanics, Micromechanics), interdisciplinary courses on enabling digital technologies (Enabling Digital Technologies, Principles of Digital Twins, Digital Twins for Health, Computer-Aided Engineering for Virtual Prototyping and Advanced Manufacturing Solutions) and on soft skills (Fundamentals of Intellectual Property and Management of Research, Fundamentals of Academic Entrepreneurship). During the A.Y. 2019/20, the courses were delivered online due to the pandemic emergency and this was a great opportunity to open them to externals, registering a wide participation of PhD students from many universities worldwide (55 participants for the course on Numerical Methods for the Solution of Partial Differential Equations; 86 participants for the course on Computational Contact and Fracture Mechanics).

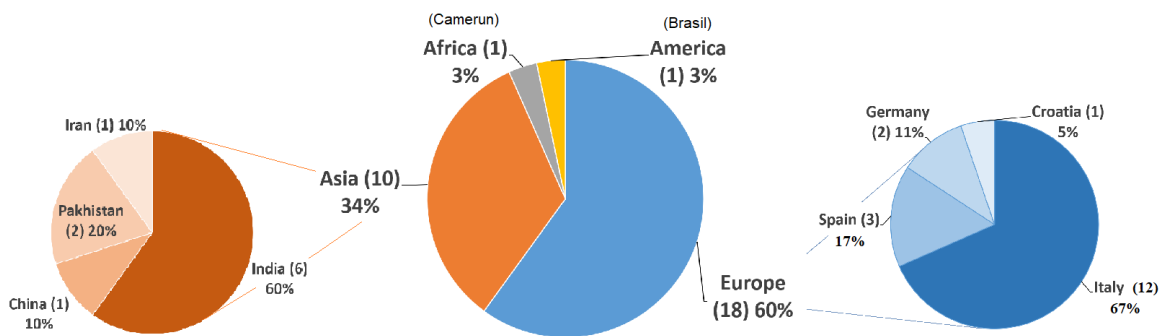


Some participants to the lectures delivered online during the A.Y. 2019/20, open to externals

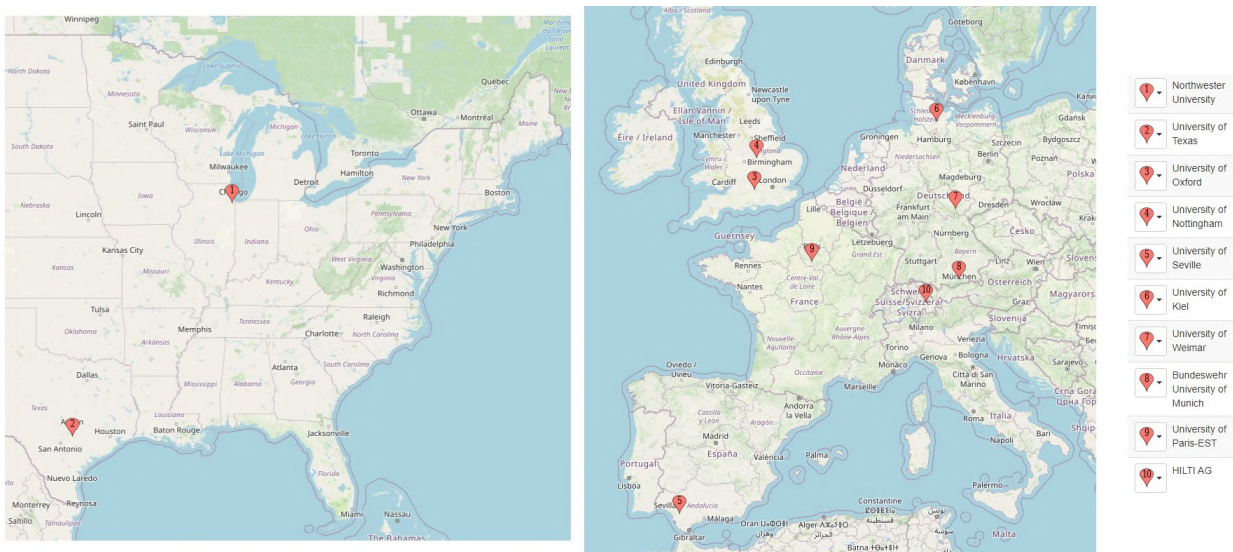
Over the years, the research staff has been complemented by a considerable number of **post-doc researchers and research collaborators** (5 female, 10 male), primarily recruited on research projects funded by regional, national or international grants (see Sec. 5). The cumulative duration of the contracts of the **15 recruited researchers** amounts to over 26 years, which corresponds to an average duration of 1.7 years per contract. After the experience at the IMT School, all the researchers had a placement in other universities or private research centres. Notably, among them, Dr. Francesca Fantoni has been appointed tenure-track assistant professor at the University of Brescia (Italy) and Dr. Pattabhi Budarapu reached the position of associate professor at the Indian Institute of Technology

Bhubaneswar (India).

The majority of the research staff consisted in **30 PhD students** (8 female, 22 male), worldwide recruited and supervised by members of the research unit (see Sec. 5): 25 recruited on the PhD programmes of the IMT School for Advanced Studies Lucca from the 29th to the 39th PhD cycles (7 for the PhD in Institutions, Markets, Technology; 15 for the PhD in Systems Science; 3 for the PhD in Management of Digital Transformation) and 5 came from other institutions for their visiting periods (University of Weimar, University of Girona, Bundeswehr University Munich, University of Rijeka, University of Torino). Almost all the supervised students experienced a visiting period abroad from 1 to 6 months in prestigious universities and industrial research centres (see the map below), significantly contributing to the expansion of the network of international collaborations. Over 11 alumni, 7 are having careers in academia and 4 in private research centres, both in Italy and abroad.



Nationality of incoming PhD students across continents



Sites for the visiting periods of the PhD students

Visiting professors and visiting scholars have also animated the research unit with **72 seminars** since 2014 (see Sec. 6), and evidence of their quality comes from the fact that many of them have been recipient of prestigious grants by the European Research Council (2 ERC Advanced Grants 2014-19 & 2022-27 at Davide Bigoni, 1 ERC Consolidator Grant 2018-23 and 1 ERC Proof of Concept Grant 2020-22 at Gianluca Fiori, 1 ERC Starting Grant 2022-27 at Diego Misseroni, 1 ERC Starting Grant 2022-27 at Antonio Papangelo, 1 ERC Starting Grant 2023-28 at Emilio Martinez Paneda). The 1st workshop of the interdisciplinary project on Scientific Computing coordinated by Prof. Marco Paggi that was held in Lucca in December 2022, involving 5 of the Italian schools for advanced studies in Italy, has also seen the presentations of researchers recipient of 7 ERC grants.

2 Scientific impact

The research unit made a progress on a wide range of **quantitative methods of computational mechanics**. New theories and the related implementation in research codes allowed to model and simulate frontier problems in solid mechanics and fluid dynamics governed by partial differential equations. Advances on the Finite Element Method (FEM) have regarded new solvers for coupled problems, phase field fracture theories, mixed formulations, solid shells, and interface finite elements. The Boundary Element Method (BEM) has also been originally developed for tribological applications, also in conjunction with FEM to enable multi-scale simulations, and for computational fluid dynamics to efficiently solve fluid flows governed by a potential. At a smaller scale, Molecular Dynamics has been specialized to simulate fracture in Silicon and Graphene, integrating the technique with FEM for multiscale computations. Advances on computational and asymptotic homogenization theories have regarded the identification of Cauchy and higher order continua for coupled problems, and the technique has also been integrated with phase field for multiscale computations of fracture. The Smoothed Particle Hydrodynamics software SPHERA has also been extended to address hydrodynamic lubrication problems. Reduced Order Models have been employed for MD simulations and in conjunction with computational fluid dynamics.

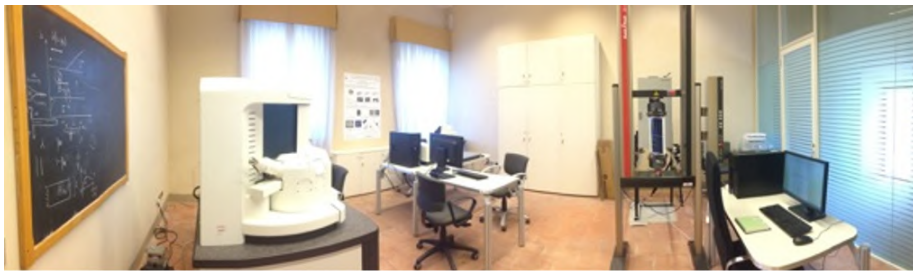
Applications Methods	Tribology	Renewable energies & electronics	Smart & metamaterials	Biomechanics	Adhesives	Aerospace & naval sectors	Paper sector	Building sector, infrastructures
FEM (coupled problems)								
FEM (phase field)								
FEM (mixed formulations)								
FEM (solids shells)								
FEM (interface elements)								
BEM								
MD & multiscale methods								
Homogenization								
SPH								
ROM								

Research contribution on computational methods and related applications

In addition to the computational research, the **experimental laboratory MUSAM-Lab** <https://www.imtlucca.it/en/ricerca/laboratori/musam-lab>, whose equipment has been entirely purchased thanks to the funds by the European Research Council (ERC StG CA2PVM, ERC PoC PHYSIC),

provided an excellent environment to test and validate the developed computational models and establish collaborations with national and international companies on advanced testing of materials. The laboratory is registered on the portal Cantieri 4.0 of Tuscany Region <http://www.cantieri40.it/i40/dettagli/dettagliOverviewLaboratorio.php?quale=1031> and among the laboratories for technology transfer of the National Competence Centre on Industry 4.0 ARTES4.0 <https://www.artes4.it/-/musam-lab>.

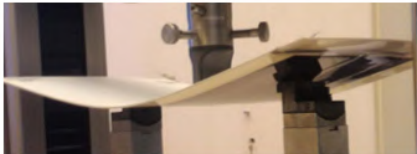
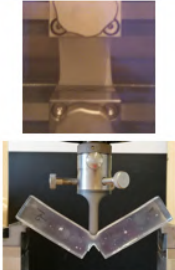

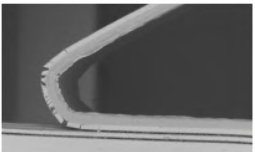

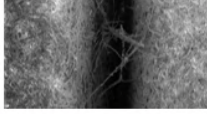
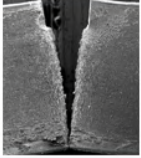
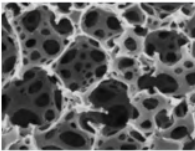
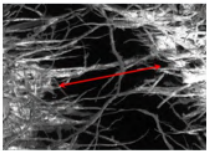
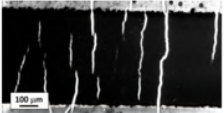
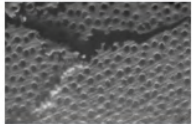
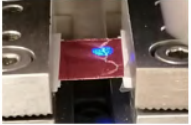
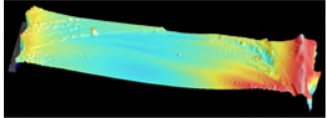
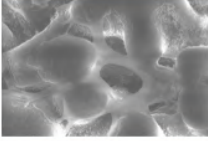
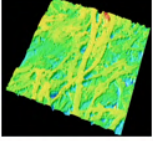
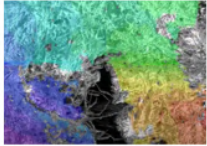
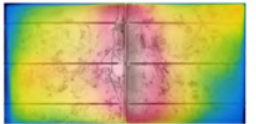
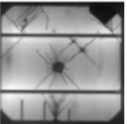
The available instruments allow testing a wide range of materials across different scales of observation, combining in situ material testing and advanced image analysis techniques (Digital Image Correlation, confocal imaging, SEM imaging). The range of materials tested is therefore quite wide, from those used in photovoltaics, to any kind of polymers, adhesives, porous materials, biomaterials, and cellulose-based materials (paperboard, paper tissue, Aluminum-paper laminates).



The experimental laboratory MUSAM-Lab

The proposed computational and experimental methods have seen a significant amount of applications across several fields, including tribology, materials for renewable energy (photovoltaics and hydrogen technologies), electronics, smart and metamaterials, biomechanics, adhesive technologies, aerospace and naval sectors, paper sector, building sector and infrastructures. A cloud figure collecting the most frequent keywords of international journal publications is shown below, along with an overview of research contributions on computational methods and experimental techniques, and related applications.

Funding on a competitive basis has been received from the Tuscany Region, the Italian Ministry of University and Research, and from the European Commission (see Sec. 9), attracting over **9.5 million Euro of funds (over 2.4 million Euro to the IMT School), in addition to 320,000 Euro from companies** for commissioned R&D activities to co-fund research positions.

Applications Methods	Materials for photovoltaics & electronics	Porous materials & biomaterials	Polymers & adhesives	Cellulose materials
Mechanical testing w/ or w/o climatic chamber (component scale)				
Peeling tests				
In situ mechanical testing (with SEM)				
In situ m echanical testing (with confocal profilometer)				
Confocal profilometry				
Digital Image Correlation				
Electroluminescence & thermal imaging				

Experimental techniques and type of materials tested in the MUSAM-Lab

- GIAN Course on Computational fracture mechanics for photovoltaic reliability, Indian Institute of Technology Delhi, May 2019, New Delhi.
- PRO Winter School of the NewFrac Marie Curie ITN Project, 7-11 February 2022, IMT School for Advanced Studies Lucca.

Beside the dissemination and advanced training to the scientific community, the members of the research unit have been actively engaged in **public outreach**. Meetings with invited entrepreneurs and open to citizens were organized in 2017 to provide concrete examples of innovation (Aperitivi delle Idee). During all the editions of the Night of Researchers in Lucca, the staff of the research unit has organized visits to the MUSAM-Lab with demonstration of the experimental tests, hands-on activities for children, and also seminars and conferences, see e.g. <https://www.youtube.com/watch?v=sasiuxdtqNY>. Dr. Andrea Mola has also been engaged in 2023 on an initiative of dissemination for students, see the recorded lesson on <https://www.youtube.com/watch?v=2KeUqAa4BI8>. A list of articles published on international and national press mentioning MUSAM and TV interviews is collected in Sec. 8.

In terms of **knowledge and technology transfer**, the research unit collaborated with several national and international companies: Robert Bosch GmbH (Renningen, Germany), Lucart s.p.A. (Porcari, Italy), ToolsPole (Tallinn, Estonia), Nemesys s.r.l. (Pontedera, Italy), Sigma Ingegneria s.r.l. (Lucca, Italy), LUCENSE scarl (Lucca, Italy), CROMOLOGY Italia s.p.a. (Porcari, Italy), Tacchificio Villa Cortese S.r.l. (Villa Cortese, Italy), Euro Inn Advisory s.r.l. (Correggio, Italy), CIEFFEPI s.r.l. (Pistoia, Italy), Applied Materials Italia s.r.l. (Olmi di S. Biagio di Callalta, Italy), Jabil, Industrial and Energy (San Petersburg, Florida, USA). The participation by Prof. Paggi to the technical group of the Task 13 of the International Energy Agency led to two important reports for companies and stakeholders of the photovoltaic sector.

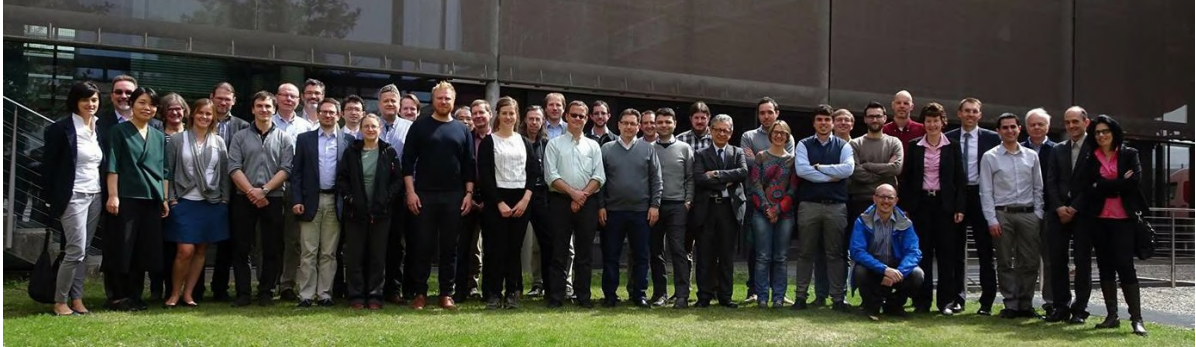
One Italian patent resulted from research (Impianto di laminazione di celle solari in silicio e processo realizzato con tale impianto, Inventors: M. Paggi, F. Biancalani, C. Borri, I. Berardone, S. Olalekan Ojo; Owner: Scuola IMT Alti Studi Lucca; Priority number: 102018000006351; Priority date: 15/06/2018; Grant date: 03/07/2020). M. Paggi and F. Biancalani founded on April 4, 2019 the innovative start-up and university spin-off TREE-TOWER srl, which won the 3rd place at the StartCup Toscana competition in 2019.



Some group photos at conferences organized in Lucca (from top to bottom: Euromech Colloquium 575, GIMC-GMA conference, Workshop Expanding Horizons)




Some group photos at seasonal schools organized by research unit members (top: CISM course; bottom: GIAN course)



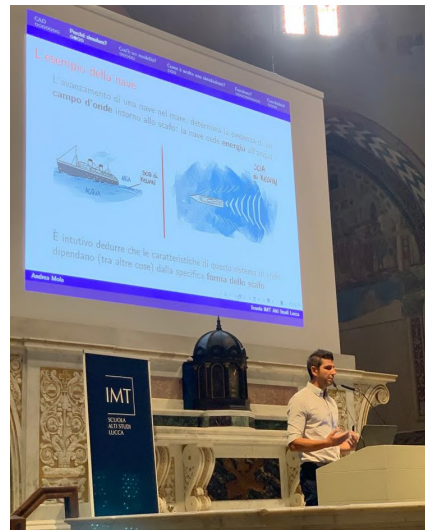
IEA INTERNATIONAL ENERGY AGENCY
PHOTOVOLTAIC POWER SYSTEMS PROGRAMME



PVPS

IEA PVPS Task 13 Meeting, 27-29 March 2017 
SUPSI, CH-6952 Canobbio (Lugano), Switzerland

Some group photos at plenary meetings of the Technical Group of the Task 13 of the International Energy Agency (Top: Amsterdam; bottom: Lugano)



Some photos at the Night of Researchers and at public events open to students in Lucca

4 Awards and recognitions

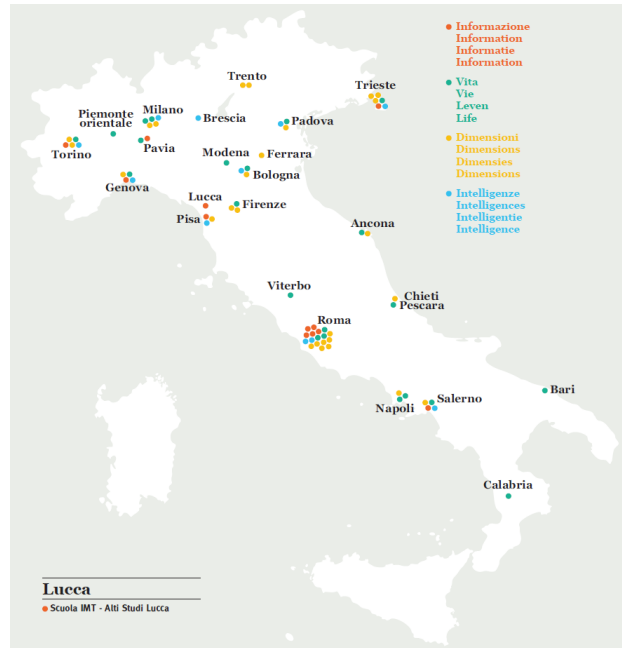
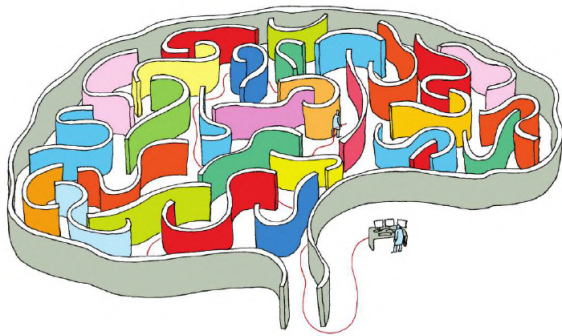
Marco Paggi was interviewed in **Cartaditalia n. 3 (2017)** dedicated to New frontiers of Italian Scientific Research, an issue published by the Italian Cultural Institute of Brussels and focusing on the new frontiers of science. It gave the floor to young under-40 Italian researchers who worked in the departments and laboratories of universities all around the world. The issue offered a detailed and up-to-date overview of the main areas of interest of contemporary scientific investigation, together with a true map of major Italian research centres.

n.3
2017

RIVISTA DI CULTURA ITALIANA CONTEMPORANEA
REVUE DE CULTURE ITALIENNE CONTEMPORAINE
TIJDSCHRIFT VOOR HEDERDAAGSE ITALIANSE CULTUUR
JOURNAL OF CONTEMPORARY ITALIAN CULTURE

Cartaditalia

Nuove frontiere della ricerca scientifica italiana
Nouvelles frontières de la recherche scientifique italienne
Nieuwe grenzen van het Italiaans wetenschappelijk onderzoek
New frontiers of Italian Scientific Research



The cover of the issue n. 3 of Cartaditalia (left), containing the interview to Marco Paggi, with Scuola IMT included in the map of research centres focusing on new frontiers of science (right)

Marco Paggi has also been included in the **World's Top 2% Scientists List** from 2020 to 2023, see <http://dx.doi.org/10.17632/btchxktzyw.2>, <http://dx.doi.org/10.17632/btchxktzyw.3>, <http://dx.doi.org/10.17632/btchxktzyw.4>, <http://dx.doi.org/10.17632/btchxktzyw.6>.

The alumni Pietro Lenarda and Pavan Kumar Asur Vijaya Kumar received the **best PhD thesis awards** on Mechanics of Materials by the Italian Group of Mechanics of Materials of the Italian Association of Theoretical and Applied Mechanics, editions 2018 (P. Lenarda, Modeling and simulation of a class of nonlinear coupled reaction-diffusion problems for green applications, Committee: D. Bigoni, R. Massabò, R. Paroni) and 2023 (P.K.A.V. Kumar, Cohesive and variational methods for fracture mechanics in statics and fatigue, Committee: D. Addressi, L. Deseri, S. de Miranda).

The **spin-off company TREE-TOWER srl** won the **3rd place** at the **StartCup Toscana** competition in 2019.

5 Researchers that animated the research unit

Post-doctoral researchers and research collaborators

- Dr. Claudia Borri, post-doc from 03/02/2014 to 31/08/2018 supported on the ERC StG CA2PVM project, afterwards post-doc at the National Research Council (Florence, Italy)
- Dr.-Ing. Pattabhi R. Budarapu, post-doc from 02/03/2015 to 28/02/2017 supported on the ERC StG CA2PVM project, afterwards assistant and associate professor at the Indian Institute of Technology (Bhubaneswar, India)
- Dr. Lorenzo Morini, post-doc from 18/01/2016 to 17/12/2016 supported on the ERC StG CA2PVM project, afterwards Marie Curie researcher at Cardiff University (Cardiff, UK)
- Dr. Ing. Francesca Fantoni, post-doc from 01/03/2016 to 28/02/2017 supported on the ERC StG CA2PVM project, afterwards tenure-track assistant professor at University of Brescia (Brescia, Italy)
- Dr. Ing. Irene Berardone, post-doc from 01/03/2016 to 30/11/2017 supported on the ERC StG CA2PVM project, afterwards post-doc at the University of Bologna (Bologna, Italy) and then researcher at Accenture (Milano, Italy)
- Dr. Ing. Saheed Olalekan Ojo, post-doc from 15/03/2016 to 30/11/2017 supported on the ERC StG CA2PVM project, afterwards post-doc at the University of Limerick (Limerick, Ireland)
- Dr. Ing. Mariacristina Gagliardi, post-doc from 18/11/2016 to 30/11/2017 supported on the ERC StG CA2PVM project and research collaborator from 01/02/2018 to 15/09/2019 supported on the PROPAIN project from Regione Toscana, afterwards post-doc at CNR Nano (Pisa, Italy)
- Dr. Gianluca Del Frate, post-doc from 01/08/2018 to 17/02/2019 supported on the GlycoG-Lab 4.0 project from Regione Toscana, afterwards researcher at Menarini Ricerche S.P.A. (Pisa, Italy)
- Dr. Fabio Montisci, post-doc from 15/06/2019 to 15/09/2020 supported on the GlycoG-Lab 4.0 project from Regione Toscana, afterwards post-doc at University of Cambridge (Cambridge, UK)
- Ing. Davide Carminati, research collaborator from 15/02/2019 to 14/02/2020, afterwards responsible for the R&D dept. of Tacchificio Villa Cortese S.R.L. (Milano, Italy)
- Dr. Ing. Hamed Zarei Mahmoodabadi, post-doc supported by Robert BOSCH GmbH from 01/05/2019 to 30/04/2020, and then post-doc from 01/07/2022 to 30/06/2024 supported on the NEXTPAPER4.0 project by Regione Toscana and Lucense scarl.
- Dr. Francesco Biancalani, joint post-doc with AXES research unit from 01/09/2018 to 31/12/2028, afterwards CEO of TREE-TOWER S.R.L. and post-doc at Politecnico di Torino (Torino, Italy).
- Ing. Simone Sommovigo, research collaborator supported by Ne.m.e.sys S.R.L. from 01/03/2023 to 28/02/2024.
- Dr. Ing. Maria Rosaria Marulli, post-doc from 01/06/2021 to 30/10/2023, then assistant professor at the IMT School for Advanced Studies Lucca
- Dr. Ing. Jacopo Bonari, post-doc from 01/06/2021 to 14/06/2023, then researcher at the German Aerospace Center (Munich, Germany)

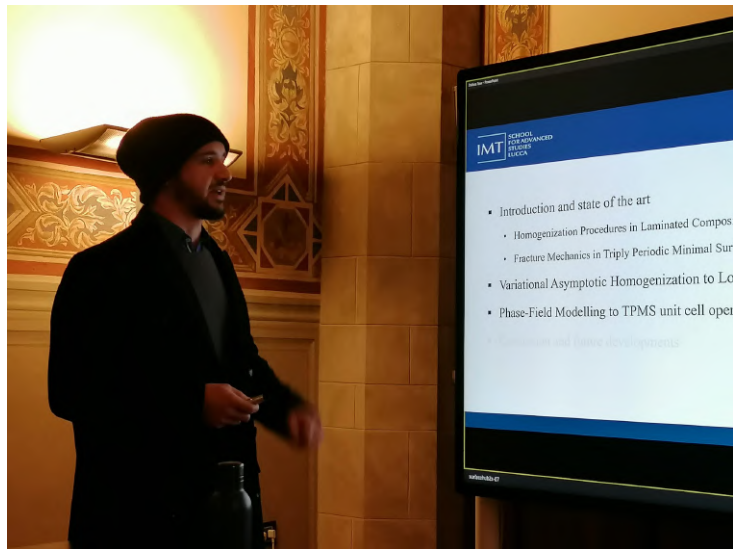


Dr. Francesca Fantoni during a seminar at IMT Lucca in 2019 (left); Prof. Pattabhi Budarapu in his office at the Indian Institute of Technology Bhubaneswar, India, 2023 (right)

Alumni

- Pietro Lenarda, PhD in Institutions, Markets and Technologies, 29th cycle, visiting scholar at the University of Oxford (UK); afterwards post-doc at the Italian Institute of Technology, Genoa.
- Valerio Carollo, double PhD degree in Institutions, Markets and Technologies, Curriculum in Computational Mechanics, 30th cycle, and in Industrial Engineering at University of Seville (Spain), afterwards post-doc at the University of Trento and now researcher at Marshall Aerospace (Cambridge, UK)
- Paolo Cinat, PhD in Institutions, Markets and Technologies, Curriculum in Computational Mechanics, 30th cycle; afterwards post-doc at the National Research Council Florence, and now researcher at Leonardo (Camaione, Italy)
- Vigneswaran Govindarajan, PhD in Institutions, Markets and Technologies, 30th cycle, visiting scholar at the University of Weimar (Germany); now technical director of the ING Europtech Private Limited (Chennai, India)
- Rosaria Del Toro, PhD in Institutions, Markets and Technologies, 31st cycle, visiting scholar at the University of Kiel (Germany); afterwards post-doc at Scuola Superiore Sant'Anna and now post-doc at University of Chieti-Pescara
- Nicola Dardano, PhD in Institutions, Markets and Technologies, 32nd cycle; afterwards researcher in an engineering company in Pisa
- Teresa Guillen Hernandez, double PhD degree in Institutions, Markets and Technologies, 32nd cycle, and in Industrial Engineering at University of Seville (Spain); afterwards post-doc at the University of Seville (Spain)
- Jacopo Bonari, PhD in Systems Science, 33rd cycle, visiting scholar at the Bundeswehr University Munich (Germany); afterwards post-doc at the IMT School and now researcher at the German Aerospace Center, Munich
- Maria Rosaria Marulli, PhD in Systems Science, 33rd cycle, visiting scholar at the Bundeswehr University Munich (Germany) and at the University of Seville (Spain); afterwards post-doc and now assistant professor at the IMT School

- Pavan Asur Vijaya Kumar, PhD in Systems Science, 34th cycle, visiting at scholar the University of Seville (Spain) at the University Paris-EST (France); afterwards post-doc at the Technical University of Wien (Austria)
- Deison Teixeira Preve, PhD in Systems Science, 34th cycle, visiting scholar at the University of Nottingham (UK); afterwards post-doc at the University of Udine



Some photos taken at PhD defence ceremonies

PhD students (on track)

- Francis John, PhD in Systems Science, 34th cycle, visiting scholar at HILTI AG, Schaan (Liechtenstein).
- Rakesh Tota Kumar, PhD in Systems Science, 35th cycle.
- Angel de Jesus Valverde Gonzalez, double PhD degree in Systems Science, 35th cycle, and in Industrial Engineering at University of Seville (Spain), visiting scholar at The University of Texas at Austin (USA).
- Karthik Ambikakumari Sanalkumar, double PhD degree in Industrial Engineering at University of Seville (Spain) and in Systems Science at IMT Lucca, 36th cycle.
- Ajinkya Dusane, PhD in Systems Science, 36th cycle, visiting scholar at Northwestern University (Evanston, USA).
- Zeng Liu, double PhD degree in Systems Science, 36th cycle, and in Industrial Engineering at University of Seville (Spain).
- Luca Cattarossi, PhD in Management of Digital Transformation, co-funded by ToolsPole, 38th cycle.
- Alice Bertolini, PhD in Management of Digital Transformation, co-funded by LUCART S.P.A., 38th cycle.
- Mohadeseh Fallah Yakhdanim, PhD in Systems Science, Track in Computational Mechanics, 38th cycle.
- René Thierry Djoumessi, PhD in Systems Science, Track in Computational Mechanics, 38th cycle.
- Mazhar Shehzad, PhD in Systems Science, Track in Computational Mechanics, 38th cycle.
- Gabriel Cassese, PhD in Systems Science, Track in Computational Mechanics, 39th cycle.
- Syed Muhammad Zubair Shah Bukhari, PhD in Systems Science, Track in Computational Mechanics, 39th cycle.
- Lorenzo Pasquetti, PhD in Management of Digital Transformation, co-funded by Ne.m.e.sys S.R.L., 39th cycle.

Visiting PhD students

- Giusi Sorrentino, PhD student at University of Torino (Torino, Italy), 2022.
- Ivana Pranjić, PhD student at University of Rijeka (Rijeka, Croatia), 2021.
- Nora Hagemeyer, PhD student at Bundeswehr University Munich (Munich, Germany), 2018.
- Adria Quintanas Corominas, PhD student at the University of Girona (Girona, Spain), 2018.
- Navid Valizadeh, PhD student at the University of Weimar, (Weimar, Germany), 2017.

Visiting Professors and Researchers

- Fabrizio Davì, Full Professor at Università Politecnica delle Marche, on sabbatical leave at IMT Lucca (A.Y. 2020-21 & 2021-22).
- Andrea Amicarelli, Visiting Scholar in 2018-20, Researcher at Ricerca sul Sistema Energetico RSE spa (Milano, Italy).
- Diego Misseroni, Visiting Professor in 2017-18, Assistant Professor at the University of Trento (Trento, Italy).
- Davide Bigoni, Visiting Professor in 2015-17 & 2019-23, Full Professor at the University of Trento (Trento, Italy).
- Pattabhi R. Budarapu, Visiting Professor in 2017, Assistant Professor at the Indian Institute of Technology (Bhubaneswar, India).
- Mauro Corrado, Visiting Professor in 2014 & 2017, Associate Professor at Politecnico di Torino and Marie Curie Fellow at the Ecole Polytechnique Fédérale de Lausanne (Lausanne, Switzerland).
- Francesca Fantoni, Visiting Researcher in 2019, Assistant Professor at the University of Brescia (Brescia, Italy).
- Alessio Gizzi, Visiting Researcher in 2015-18, Associate Professor at the Università Campus Bio-Medico di Roma (Roma, Italy).
- Dario Piga, Visiting Professor in 2017, Assistant Professor at Scuola Universitaria Professionale della Svizzera italiana (SUPSI) (Lugano, Switzerland).
- Alexander Popp, Visiting Professor in 2017, Full Professor at Bundeswehr University Munich (Munich, Germany).
- José Reinoso, Visiting Professor in 2014-18 & in 2023, Associate Professor at the University of Seville (Seville, Spain).
- Antonis Vakis, Visiting Professor in 2017, Associate Professor at the University of Groningen (Groningen, The Netherlands).



Some photos of visiting professors

6 Organized seminars

– 2014 –

1. Mauro Corrado, An XFEM strategy to analyse the scale-slenderness-reinforcement failure mode transitions in RC beams, 27/02/2014.
2. Davide Bigoni, Configurational forces in elastic structures, 17/03/2014.
3. José Reinoso, Advanced nonlinear three-dimensional finite element shell formulations for composite structures, 20/03/2014.
4. Vladislav Mantic, Prediction of Initiation and Growth of Cracks in Composites. A Coupled Stress and Energy Criterion of the Finite Fracture Mechanics, 14/07/2014.
5. Gianluca Fiori, Graphene-based solar cells, 11/09/2014.

– 2015 –

6. Alessio Gizzi, Theoretical and numerical modeling of nonlinear electromechanics with applications to biological active media, 20/02/2015.
7. Pattabhi Budarapu, Multiscale modelling of fracture, 17/04/2015.
8. Lorenzo Morini, Analysis of interfacial crack problems using the weight functions technique, 22/04/2015.
9. Davide Bigoni, Folding and faulting of an elastic continuum, 16/06/2015.
10. Elio Sacco, An interface damage model accounting for the confinement effect, 18/11/2015.
11. Roman Pohrt, Rough spheres in elastic contact - problem solving in the lazy way, 25/09/2015.
12. Francesca Fantoni, Crack growth as a standard dissipative system, 26/10/2015.
13. Lorenzo Morini, Multiscale asymptotic homogenization analysis of thermo-diffusive composite materials, 26/11/2015.

– 2016 –

14. Danila Aita, Limit and Nonlinear Elastic Analyses of Masonry Structures: an overview, 26/02/2016.
15. Riccardo Barsotti, Structures that disapprove linearity: membranes, masonry structures, beams in contact with rough surfaces, 26/02/2016.
16. Paolo Valvo, Analytical solutions for modelling delamination of composite laminates: from elastic interface models to discontinuous cohesive laws, 26/02/2016.
17. Marco Celli, George Vander Voort, Arrigo Borin, Seminar on Metallic and ceramic materials with applications to paper industry, 26/05/2016.
18. Andrea Piccaluga, Alessandra Patrono, Nicola Redi, Giuliano Gorini, Innovative Entrepreneurship in Universities: from the Idea to the Business Plan, 16/06/2016.
19. José Reinoso, Phase field modelling of fracture: recent theoretical developments and applications, 20/07/2016.

– 2017 –

20. Nicola Menga, The contact mechanics of elastic and viscoelastic thin layers, 06/04/2017.

21. Davide Bigoni, Folding and faulting of continua: statics and dynamics, 04/05/2017.
22. Philipp Weissgraeber, Finite Fracture Mechanics: linking strength of materials and fracture mechanics to study crack initiation, 24/07/2017.
23. Antonis Vakis, Ocean Grazer: A Novel Ocean Energy Extraction and Storage Device, 18/09/2017.
24. Alexander Popp, Contact and interface modeling in nonlinear solid mechanics using mortar finite element methods, 17/10/2017.
25. Alexander Popp, New contact algorithms for nonlinear beam finite elements and their application to stent graft modeling, 24/10/2017.

– 2018 –

26. Camilla Coletti, Scalable van der Waals heterostacks for optoelectronics, 23/01/2018.
27. Andreas Almqvist, Modelling and simulation of tribological processes, 15/02/2018.
28. Davide Bigoni, The dynamics of a shear band, 22/02/2018.
29. José Reinoso, Novel computational models for failure analysis shells: smeared-based crack and delamination models, 23/02/2018.
30. Davide Bigoni, Numerical and experimental proof of the destabilization paradox by using a new flutter machine, 04/06/2018.
31. Diego Misseroni, Cracking me softly - the mechanics of hyperelastic Kirigami structures, 09/07/2018.
32. Andrea Amicarella, Mathematical models, numerical formulations and High Performance Computing applications of a mesh-less Computational Fluid Dynamics code for free-surface flows, fluid-structure interactions and granular flows, 20/07/2018.

– 2019 –

33. Gianni Royer Carfagni, Structured phase field models, 11/02/2019.
34. Samuel Forest, Micromorphic vs. strain and stress gradient continuum theories, 25/02/2019.
35. Fabrizio Scarpa, Auxetics and Shape Morphing Mechanical Metamaterials, 25/02/2019.
36. Francesca Fantoni, Crack tracking algorithms based on a viscous regularization of the quasi-static 3D fracture propagation problem, 11/03/2019.
37. Steven Moseley, Carsten Peters, Drilling in reinforced concrete: An overview, 17/04/2019.
38. José Reinoso, Phase field methods of fracture in heterogeneous media and structures: a combined bulk-interface-like crack method, 10/09/2019.
39. Chiara Cappelli, Fully Atomistic Multiscale Approaches for the Computational Spectroscopy of Complex Systems: Status and Perspectives, 23/07/2019.
40. Davide Bigoni, Structures loaded with a force acting along a line, or 'the Reut's column problem', 18/10/2019.
41. Laura Longo, Grinding stones, Tribology and Starchy Food. The Recipe for Homo sapiens Evolutionary Success, 19/12/2019.

– 2020 –

42. Luca Deseri, Instabilities Across the Scales: the Case of Cells, 14/02/2020.
43. Riccardo Cavuoto, Hydroxyapatite Ceramics: Hierarchical Porosity and Mechanical Characterisation, 03/02/2020.
44. Davide Bigoni, Metamaterials and Instabilities in Extreme Elastic Materials, 15/02/2020.
45. Davide Bigoni, Shear bands, metamaterials, flutter and other stories, 27/07/2020.
46. José Reinoso, Biomimetic interfaces and crack-arresters: routes towards improved fracture performances, 05/10/2020.
47. José Reinoso, Phase field methods for crack modeling in fibre long reinforced composite structures at different scales, 05/10/2020.

– 2021 –

48. Ivan Fumagalli, Simulation and control of fluid dynamics systems in moving geometries, 17/02/2021.
49. Andrea Mola, Reduced Order Models and Parameter Space Reduction for Parameterized Partial Differential Equations Problems in Industrial Engineering, 19/02/2021.
50. Michele Ciavarella, Multiscale models in tribology, 08/04/2021.
51. Antonio Papangelo, Modelling soft adhesive contact under shear loads, 09/04/2021.

– 2022 –

52. Fabrizio Davì, Scintillating crystals as continua with microstructure: Basic facts and non deformable crystals, 17/02/2022.
53. Fabrizio Davì, Scintillating crystals as continua with microstructure: Deformable crystals and elasto-mechanoluminescence, 18/02/2022.
54. Davide Bigoni, Leonardo da Vinci, Galileo Galilei and Structural Mechanics, 03/03/2022.
55. Giusi Sorrentino, A history carved in stones: multi-scale approaches for surface texture analysis, 04/04/2022.
56. Emilio Martinez Paneda, Chemo-mechanics phase field modelling of hydrogen embrittlement, Li-Ion battery degradation and corrosion damage, 23/06/2022.
57. Daniela Addressi, Multiscale FE procedures for heterogeneous damaging materials, 23/06/2022.
58. Davide Bigoni, Material instabilities for architected materials, 02/11/2022.
59. Julien Yvonnet, Multiscale fracture modeling in heterogeneous materials: recent challenges, 14/11/2022.

– 2023 –

60. Pere Juarez Vives, Learning Agility in Higher Education Institutions. The INSPIREO® Method from University of Barcelona, 16/01/2023.
61. Catalin Picu, Strength and toughness of network materials: damage accumulation and controlling structural parameters, 15/03/2023.
62. Jaan-Willem Simon, Multiscale modeling of paper – How to get from network to sheet level, 19/04/2023.

63. Davide Bigoni, Strange oscillatory instabilities in elastic structures, 12/05/2023.
64. Victor A. Eremeev, Surface/interfacial antiplane waves in media with surface energy and imperfect contact, 17/05/2023.
65. Alessio Gizzi, Mathematical and computational modeling of active soft tissue electrophysiology, 06/06/2023.
66. Daniele Bianchi, Integration of numerical homogenization and finite element analysis for topological optimization of 3D printed devices, 07/06/2023.
67. André Ferreira Costa Vieira and Joana Costa Vieira, FEM as a tool for optimizing the operating conditions of the tissue paper embossing and perforation processes, 21/06/2023.
68. Debiao Meng, Complex system modeling and design optimization considering uncertainty, 27/06/2023.
69. Davide Bigoni, Solids from cohesionless matter, 18/07/2023.
70. Gustav Marin, Impact of paperboard deformation and damage mechanisms on packaging performance, 19/07/2023.
71. Artem Kulachenko, Unveiling paper mysteries with micromechanical simulations, 20/09/2023.
72. Sigma Ingegneria SRL, MARMOREAL: application of photogrammetry and Virtual Reality for the digitalization and visualization of assets in the stone market, MUSAM & LYNX joint seminar, 07/11/2023.



Some photos taken during seminars

7 Scientific publications

International journal publications (indexed in SCOPUS)

– 2014 –

1. J. Reinoso and M. Paggi. A consistent interface element formulation for geometrical and material nonlinearities. *Computational Mechanics*, 54(6):1569–1581, 2014. ISSN 01787675. doi:[10.1007/s00466-014-1077-2](https://doi.org/10.1007/s00466-014-1077-2)
2. M. Paggi, R. Pohrt, and V.L. Popov. Partial-slip frictional response of rough surfaces. *Scientific Reports*, 4, 2014c. ISSN 20452322. doi:[10.1038/srep05178](https://doi.org/10.1038/srep05178)
3. M. Paggi, I. Berardone, A. Infuso, and M. Corrado. Fatigue degradation and electric recovery in silicon solar cells embedded in photovoltaic modules. *Scientific Reports*, 4, 2014b. ISSN 20452322. doi:[10.1038/srep04506](https://doi.org/10.1038/srep04506)

– 2015 –

4. V. Gade, N. Shiradkar, M. Paggi, and J. Opalewski. Predicting the long term power loss from cell cracks in pv modules. Institute of Electrical and Electronics Engineers Inc., 2015. ISBN 9781479979448. doi:[10.1109/PVSC.2015.7355665](https://doi.org/10.1109/PVSC.2015.7355665)
5. M. Paggi and Q.-C. He. Evolution of the free volume between rough surfaces in contact. *Wear*, 336-337:86–95, 2015. ISSN 00431648. doi:[10.1016/j.wear.2015.04.021](https://doi.org/10.1016/j.wear.2015.04.021)
6. F. Spertino, A. Ciocia, P. Di Leo, R. Tommasini, I. Berardone, M. Corrado, A. Infuso, and M. Paggi. A power and energy procedure in operating photovoltaic systems to quantify the losses according to the causes. *Solar Energy*, 118:313–326, 2015. ISSN 0038092X. doi:[10.1016/j.solener.2015.05.033](https://doi.org/10.1016/j.solener.2015.05.033)
7. C. Borri and M. Paggi. Topological characterization of antireflective and hydrophobic rough surfaces: Are random process theory and fractal modeling applicable? *Journal of Physics D: Applied Physics*, 48(4), 2015. ISSN 00223727. doi:[10.1088/0022-3727/48/4/045301](https://doi.org/10.1088/0022-3727/48/4/045301)
8. A. Infuso and M. Paggi. Computational modeling of discrete mechanical systems and complex networks: Where we are and where we are going. *Frontiers in Materials*, 2, 2015. ISSN 22968016. doi:[10.3389/fmats.2015.00018](https://doi.org/10.3389/fmats.2015.00018)
9. I. Berardone, S. Kajari-Schröder, R. Niepelt, J. Hensen, V. Steckenreiter, and M. Paggi. Numerical modelling and validation of thermally-induced spalling. volume 77, pages 855–862. Elsevier Ltd, 2015. doi:[10.1016/j.egypro.2015.07.121](https://doi.org/10.1016/j.egypro.2015.07.121)
10. A. Bemporad and M. Paggi. Optimization algorithms for the solution of the frictionless normal contact between rough surfaces. *International Journal of Solids and Structures*, 69-70:94–105, 2015. ISSN 00207683. doi:[10.1016/j.ijsolstr.2015.06.005](https://doi.org/10.1016/j.ijsolstr.2015.06.005)
11. M. Paggi and A. Sapora. An accurate thermoviscoelastic rheological model for ethylene vinyl acetate based on fractional calculus. *International Journal of Photoenergy*, 2015(252740), 2015. ISSN 1110662X. doi:[10.1155/2015/252740](https://doi.org/10.1155/2015/252740)
12. M. Paggi and J. Reinoso. An anisotropic large displacement cohesive zone model for fibrillar and crazing interfaces. *International Journal of Solids and Structures*, 69-70:106–120, 2015. ISSN 00207683. doi:[10.1016/j.ijsolstr.2015.04.042](https://doi.org/10.1016/j.ijsolstr.2015.04.042)
13. M. Corrado and M. Paggi. Nonlinear fracture dynamics of laminates with finite thickness adhesives. *Mechanics of Materials*, 80(PB):183–192, 2015. ISSN 01676636. doi:[10.1016/j.mechmat.2014.07.012](https://doi.org/10.1016/j.mechmat.2014.07.012)

14. O. Saheed Olalekan, S. Grivet-Talocia, and M. Paggi. Model order reduction applied to heat conduction in photovoltaic modules. *Composite Structures*, 119:477–486, 2015. ISSN 02638223. doi:[10.1016/j.compstruct.2014.09.008](https://doi.org/10.1016/j.compstruct.2014.09.008)
15. A. Bacigalupo and M.L. De Bellis. Auxetic anti-tetrachiral materials: Equivalent elastic properties and frequency band-gaps. *Composite Structures*, 131:530–544, 2015. ISSN 02638223. doi:[10.1016/j.compstruct.2015.05.039](https://doi.org/10.1016/j.compstruct.2015.05.039)

– 2016 –

16. P.R. Budarapu, B. Javvaji, V.K. Sutrar, D.R. Mahapatra, M. Paggi, G. Zi, and T. Rabczuk. Lattice orientation and crack size effect on the mechanical properties of graphene. *International Journal of Fracture*, 203(1-2):81–98, 2017b. ISSN 03769429. doi:[10.1007/s10704-016-0115-9](https://doi.org/10.1007/s10704-016-0115-9)
17. B. Javvaji, P.R. Budarapu, V.K. Sutrar, D.R. Mahapatra, M. Paggi, G. Zi, and T. Rabczuk. Mechanical properties of graphene: Molecular dynamics simulations correlated to continuum based scaling laws. *Computational Materials Science*, 125:319–327, 2016. ISSN 09270256. doi:[10.1016/j.commatsci.2016.08.016](https://doi.org/10.1016/j.commatsci.2016.08.016)
18. S.O. Ojo and M. Paggi. A 3d coupled thermo-visco-elastic shear-lag formulation for the prediction of residual stresses in photovoltaic modules after lamination. *Composite Structures*, 157:348–359, 2016a. ISSN 02638223. doi:[10.1016/j.compstruct.2016.08.036](https://doi.org/10.1016/j.compstruct.2016.08.036)
19. M. Paggi, M. Corrado, and I. Berardone. A global/local approach for the prediction of the electric response of cracked solar cells in photovoltaic modules under the action of mechanical loads. *Engineering Fracture Mechanics*, 168:40–57, 2016b. ISSN 00137944. doi:[10.1016/j.engfracmech.2016.01.018](https://doi.org/10.1016/j.engfracmech.2016.01.018)
20. C. Borri and M. Paggi. Topology simulation and contact mechanics of bifractal rough surfaces. *Proceedings of the Institution of Mechanical Engineers, Part J: Journal of Engineering Tribology*, 230(11):1345–1358, 2016. ISSN 13506501. doi:[10.1177/1350650116641017](https://doi.org/10.1177/1350650116641017)
21. V. Carollo, M. Paggi, and A. Rossani. A two parameter elasto-plastic formulation for hardening pressure-dependent materials. *Mechanics Research Communications*, 77:1–4, 2016. ISSN 00936413. doi:[10.1016/j.mechrescom.2016.07.009](https://doi.org/10.1016/j.mechrescom.2016.07.009)
22. J. Reinoso, M. Paggi, and P. Areias. A finite element framework for the interplay between delamination and buckling of rubber-like bi-material systems and stretchable electronics. *Journal of the European Ceramic Society*, 36(9):2371–2382, 2016a. ISSN 09552219. doi:[10.1016/j.jeurceramsoc.2016.01.002](https://doi.org/10.1016/j.jeurceramsoc.2016.01.002)
23. P. Lenarda and M. Paggi. A geometrical multi-scale numerical method for coupled hygro-thermo-mechanical problems in photovoltaic laminates. *Computational Mechanics*, 57(6):947–963, 2016. ISSN 01787675. doi:[10.1007/s00466-016-1271-5](https://doi.org/10.1007/s00466-016-1271-5)
24. C. Borri, M. Paggi, J. Reinoso, and F.M. Borodich. Adhesive behaviour of bonded paper layers: Mechanical testing and statistical modelling. *Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science*, 230(9):1440–1448, 2016. ISSN 09544062. doi:[10.1177/0954406215612502](https://doi.org/10.1177/0954406215612502)
25. J. Reinoso, M. Paggi, and R. Rolfes. A computational framework for the interplay between delamination and wrinkling in functionally graded thermal barrier coatings. *Computational Materials Science*, 116:82–95, 2016c. ISSN 09270256. doi:[10.1016/j.commatsci.2015.08.031](https://doi.org/10.1016/j.commatsci.2015.08.031)
26. M. Paggi and P. Wriggers. Node-to-segment and node-to-surface interface finite elements for fracture mechanics. *Computer Methods in Applied Mechanics and Engineering*, 300:540–560, 2016. ISSN 00457825. doi:[10.1016/j.cma.2015.11.023](https://doi.org/10.1016/j.cma.2015.11.023)

27. S.O. Ojo and M. Paggi. A thermo-visco-elastic shear-lag model for the prediction of residual stresses in photovoltaic modules after lamination. *Composite Structures*, 136:481–492, 2016b. ISSN 02638223. doi:[10.1016/j.compstruct.2015.10.023](https://doi.org/10.1016/j.compstruct.2015.10.023)
28. R. Jones, F. Chen, S. Pitt, M. Paggi, and A. Carpinteri. From nasgro to fractals: Representing crack growth in metals. *International Journal of Fatigue*, 82:540–549, 2016. ISSN 01421123. doi:[10.1016/j.ijfatigue.2015.09.009](https://doi.org/10.1016/j.ijfatigue.2015.09.009)
29. M. Gagliardi. Novel biodegradable nanocarriers for enhanced drug delivery. *Therapeutic Delivery*, 7(12):809–826, 2016. ISSN 20415990. doi:[10.4155/tde-2016-0051](https://doi.org/10.4155/tde-2016-0051)
30. A. Bacigalupo, L. Morini, and A. Piccolroaz. Overall thermomechanical properties of layered materials for energy devices applications. *Composite Structures*, 157:366–385, 2016c. ISSN 02638223. doi:[10.1016/j.compstruct.2016.07.048](https://doi.org/10.1016/j.compstruct.2016.07.048)
31. A. Bacigalupo and M. Lepidi. High-frequency parametric approximation of the floquet-bloch spectrum for anti-tetrachiral materials. *International Journal of Solids and Structures*, 97–98: 575–592, 2016. ISSN 00207683. doi:[10.1016/j.ijsolstr.2016.06.018](https://doi.org/10.1016/j.ijsolstr.2016.06.018)
32. A. Bacigalupo, L. Morini, and A. Piccolroaz. Multiscale asymptotic homogenization analysis of thermo-diffusive composite materials. *International Journal of Solids and Structures*, 85–86:15–33, 2016b. ISSN 00207683. doi:[10.1016/j.ijsolstr.2016.01.016](https://doi.org/10.1016/j.ijsolstr.2016.01.016)
33. A. Bacigalupo and L. Gambarotta. Simplified modelling of chiral lattice materials with local resonators. *International Journal of Solids and Structures*, 83:126–141, 2016. ISSN 00207683. doi:[10.1016/j.ijsolstr.2016.01.005](https://doi.org/10.1016/j.ijsolstr.2016.01.005)
34. A. Bacigalupo, G. Gnecco, M. Lepidi, and L. Gambarotta. Design of acoustic metamaterials through nonlinear programming. *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 10122 LNCS:170–181, 2016a. ISSN 03029743. doi:[10.1007/978-3-319-51469-7_14](https://doi.org/10.1007/978-3-319-51469-7_14)

– 2017 –

35. V. Carollo, J. Reinoso, and M. Paggi. A 3d finite strain model for intralayer and interlayer crack simulation coupling the phase field approach and cohesive zone model. *Composite Structures*, 182:636–651, 2017b. ISSN 02638223. doi:[10.1016/j.compstruct.2017.08.095](https://doi.org/10.1016/j.compstruct.2017.08.095)
36. S.O. Ojo, P.R. Budarapu, and M. Paggi. A nonlocal adaptive discrete empirical interpolation method combined with modified hp-refinement for order reduction of molecular dynamics systems. *Computational Materials Science*, 140:189–208, 2017a. ISSN 09270256. doi:[10.1016/j.commatsci.2017.08.022](https://doi.org/10.1016/j.commatsci.2017.08.022)
37. J. Reinoso, A. Arteiro, M. Paggi, and P.P. Camanho. Strength prediction of notched thin ply laminates using finite fracture mechanics and the phase field approach. *Composites Science and Technology*, 150:205–216, 2017a. ISSN 02663538. doi:[10.1016/j.compscitech.2017.07.020](https://doi.org/10.1016/j.compscitech.2017.07.020)
38. S.O. Ojo, S.O. Ismail, M. Paggi, and H.N. Dhakal. A new analytical critical thrust force model for delamination analysis of laminated composites during drilling operation. *Composites Part B: Engineering*, 124:207–217, 2017b. ISSN 13598368. doi:[10.1016/j.compositesb.2017.05.039](https://doi.org/10.1016/j.compositesb.2017.05.039)
39. P. Lenarda, M. Paggi, and R. Ruiz Baier. Partitioned coupling of advection–diffusion–reaction systems and brinkman flows. *Journal of Computational Physics*, 344:281–302, 2017. ISSN 00219991. doi:[10.1016/j.jcp.2017.05.011](https://doi.org/10.1016/j.jcp.2017.05.011)
40. F. Fantoni, A. Bacigalupo, and M. Paggi. Multi-field asymptotic homogenization of thermo-piezoelectric materials with periodic microstructure. *International Journal of Solids and Structures*, 120:31–56, 2017. ISSN 00207683. doi:[10.1016/j.ijsolstr.2017.04.009](https://doi.org/10.1016/j.ijsolstr.2017.04.009)

41. M. Paggi and J. Reinoso. Revisiting the problem of a crack impinging on an interface: A modeling framework for the interaction between the phase field approach for brittle fracture and the interface cohesive zone model. *Computer Methods in Applied Mechanics and Engineering*, 321: 145–172, 2017. ISSN 00457825. doi:[10.1016/j.cma.2017.04.004](https://doi.org/10.1016/j.cma.2017.04.004)
42. P.R. Budarapu, J. Reinoso, and M. Paggi. Concurrently coupled solid shell-based adaptive multiscale method for fracture. *Computer Methods in Applied Mechanics and Engineering*, 319:338–365, 2017c. ISSN 00457825. doi:[10.1016/j.cma.2017.02.023](https://doi.org/10.1016/j.cma.2017.02.023)
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8 MUSAM on headlines

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3. Da Leonardo alla stampa 3D: è il magico mondo dei materiali. Il Tirreno Lucca, 27/09/2019.
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5. La Scuola IMT vola a Catania per il Premio Innovazione. StampToscana, 31/10/2019.
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7. Pandemia, il futuro delle imprese Oggi webinar di IMT e Artes 4.0. Il Tirreno Lucca, 23/07/2020.
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15. Città Future - Un laboratorio per le indagini sui materiali. La Nazione Lucca, 09/11/2022.
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20. Università e imprese dialogano sulla ricerca - Dalla medicina alla green economy. Università e imprese a braccetto. La Nazione Lucca, 24/02/2023.
21. Ciclo di seminari su materiali innovativi. La Nazione Lucca, 07/03/2023.
22. IMT, rivoluzione hi-tech Materiali più efficienti per trasporti e biomedica. La Nazione Lucca, 22/04/2023.
23. Nuovi materiali "tuttofare" studiati a IMT. Il Tirreno Lucca-Pistoia-Montecatini, 26/04/2023.
24. Il packaging del futuro IMT e Lucense uniscono le forze nel segno della sostenibilità. La Nazione.it, 04/07/2023.

25. Alleanza tra IMT e Lucense per gli imballaggi "verdi". Il Tirreno Lucca-Pistoia-Montecatini, 04/07/2023.
26. IMT e Lucense studiano il packaging del futuro - Il packaging del futuro. IMT e Lucense uniscono le forze nel segno della sostenibilità. La Nazione Lucca, 04/07/2023.

TV interviews

1. Dottorandi da tutto il mondo a Lucca per frequentare la NewFrac Pro School, scuola di alta formazione finanziata dalla Commissione Europea e organizzata da IMT. Intervista al professor Marco Paggi. TG NOI TV, 10/02/2022, http://195.110.133.122/media/20220210/20220210-noi_tv-tg_noi_1330-154305837m.mp4
2. 27 dottorandi in arrivo da diversi paesi frequentano la IMT. Intervista a Marco Paggi, Professore Scuola IMT. TG NOI TV, 09/02/2022, http://195.110.133.122/media/20220210/20220210-noi_tv-tg_noi_1330-154305837m.mp4

9 Funded research projects

European Research Council & Marie Skłodowska-Curie actions

- 2012-2017 – ERC Starting Grant 2012 CA2PVM "Multi-scale and multi-physics computational approach to design and durability of photovoltaic modules", granted by the European Research Council (1483980 Euro, 60 months, PI: Marco Paggi).
- 2016-2018 – ERC Proof of Concept 2016 PHYSIC "PHotovoltaic with SuperIor Crack resistance", granted by the European Research Council (149500 Euro, 18 months, PI: Marco Paggi).
- 2020-2024 - Marie Skłodowska-Curie Innovative Training Network (H2020 MSCA-ITN) "New strategies for multifield fracture problems across scales in heterogeneous systems for Energy, Health and Transport - NEWFRAC", granted by the European Research Executive Agency (GA 861061), (3359824.20 Euro; 250904.88 Euro for IMT, 48 months, resp. research unit: Marco Paggi).
- 2023-2027 - Research unit, Marie Skłodowska-Curie Staff Exchanges (HORIZON-MSCA-2021-SE-01) "Ductility and Fracture Toughness analysis of functionally graded materials - DIAGONAL", granted by the European Research Executive Agency (GA 101086342), (184000 Euro, 46000 Euro for IMT, 48 months, resp. research unit: Marco Paggi).

Italian Ministry of University and Research

- 2018-2020 – MIUR-DAAD Joint Mobility Program 2017 "Multi-scale modeling of friction for large scale engineering problems". The project, in collaboration with Prof. Dr.-Ing. A. Popp (Bundeswehr Universität Munich) is granted by the Italian Ministry of Education, University and Research (MIUR), and the Deutscher Akademischer Austausch Dienst (DAAD), (40000 Euro, 20000 Euro for IMT, 24 months, PI: Marco Paggi).
- 2019-2023 - Research Project of National Interest (PRIN 2017) "XFAST-SIMS: Extra fast and accurate simulation of complex structural systems", granted by the Italian Ministry of Education, University and Research (GA 20173C478N) (877560 Euro, 131588 Euro for IMT, 36 months, resp. research unit: Marco Paggi).
- 2022-2023 - PRO3 joint programme of the Italian Schools for Advanced Studies, "Scientific computing for natural sciences, social sciences, and applications: methodological and technological development" (595800 Euro, 63300 Euro for IMT, 24 months, resp. res. unit: Marco Paggi).
- 2024-2026 - Research Project of National Interest (PRIN PNRR 2022) "ROMEU: Reduced Order Models for Environmental and Urban flows" (224734 Euro, 36251 Euro for IMT, resp. res. unit: Andrea Mola).

Tuscany Region

- 2018-2019 – POR FSE 2014/2020. PROPAINTE "Intelligent design of innovative functionalized paints", Regione Toscana, (54000 Euro, PI: Marco Paggi).
- 2018-2020 – POR FESR 2014/2020, action 1.1.5 sub-action a1 - Call 1, Strategic Projects of Research and Development. "GlycoG-Lab 4.0" (2500575 Euro, 125065 Euro for IMT, 24 months, resp. research unit: Marco Paggi).
- 2022-2024 – Fondo per lo Sviluppo e la Coesione della Regione Toscana, NEXTPAPER4.0 "Next Generation Paper and Packaging" (60000 Euro, 24 months, PI: Marco Paggi).

Industrial contracts supporting research personnel

- 01/01/2019-31/12/2019 – Project "Effect of roughness on adhesion of surfaces", 1 year post-doc supported by Robert BOSCH GmbH (50,000 Euro).
- 01/01/2019-31/12/2019 – Project "Optimization and efficiency of heel factory's production techniques", 1 year research collaborator supported by Tacchificio Villa Cortese S.R.L. (54,280 Euro).
- 01/03/2023-28/02/2024 - Project "Study of materials, devices and production processes along the hydrogen supply chain", 1 year research collaborator supported by Ne.m.e.sys S.R.L. (20,650 Euro)
- A.Y. 2022/23-2024/25 – Project "Paper mill sludge: new valorization opportunities", PhD position in Management of Digital Transformation co-funded by LUCART S.P.A. and PNRR (60,000 Euro).
- A.Y. 2022/23-2024/25 – Virtual prototyping methods for calculating the performance of sails and load-bearing hydrodynamic appendages of high-performance yachts, PhD position in Management of Digital Transformation co-funded by ToolsPole and PNRR (60,000 Euro).
- A.Y. 2023/24-2025/26 – Development of new technologies for the hydrogen supply chain: simulation methods aimed at the industrialization of devices for the production, storage and use of hydrogen, PhD position in Management of Digital Transformation co-funded by Ne.m.e.sys S.R.L. and PNRR (75,000 Euro).

Indicator	Key figures
Supervised PhD students	25
Best PhD thesis awards	2
Visiting PhD students	5
Recruited post-doc and research collaborators	15
Visiting professors and researchers	12
PhDs and post-docs co-funded by companies	6
Number of publications	185
% of publications with international coauthors	49%
% of publications coauthored by PhD students	35%
Organized seminars	72
Organized conferences, workshops and schools	7
Articles on newspapers mentioning MUSAM	26
TV interviews and youtube videos	4
Total attracted funds	9.8 MEuro
Projects' funds at IMT Lucca	2.6 MEuro
Industrial contracts supporting research staff	320 kEuro
Patents	1
Spin-offs	1