SEAS, 29 Oxford St., Cambridge, MA, USA
gbordiga@seas.harvard.edu
giovannibordiga.com
Google Scholar Profile
Publons Profile
ORCID Profile
GiovanniBordiga
GiovanniBordiga

Giovanni Bordiga

Curriculum Vitae

Research interests

Mechanical intelligence · Inverse design · Differentiable physics · Optimization · Mechanical metamaterials · Material instabilities · Wave propagation · Homogenization theory

Education

Nov. 2016 – Apr. 2020 **PhD in Solid and Structural Mechanics**,
Doctoral School of Civil, Environmental, and Mechanical Engineering,
University of Trento (Italy),
Curriculum: Modeling and Simulation

- **PhD Thesis:** *"Homogenization of periodic lattice materials for wave propagation, localization, and bifurcation"*,
  Advisors: Andrea Piccolroaz and Davide Bigoni,
  Evaluation Commitee: Basile Audoly and Pedro M. Reis,
  Final grade: *Cum Laude*.

Sep. 2014 – Oct. 2016 **MSc in Civil Engineering**,
Department of Civil, Environmental, and Mechanical Engineering,
University of Trento (Italy),
Curriculum: Structures

- **MSc Thesis:** *"Micromechanical modeling of masonry"* (in Italian),
  Advisor: Davide Bigoni,
  Final grade: *110/110 Cum Laude*.

Sep. 2011 – Sep. 2014 **BSc in Civil Engineering**,
Department of Civil, Environmental, and Mechanical Engineering,
University of Trento (Italy)

- **BSc Thesis:** *"Non-uniform torsion of thin-walled open cross-section beams"* (in Italian),
  Advisor: Massimiliano Gei,
  Final grade: *110/110 Cum Laude*.

Research experience

Sep. 2021 – Present **Postdoctoral Researcher**,
Harvard School of Engineering and Applied Sciences,
Harvard University (US),
Advisors: Katia Bertoldi

- Development of a differentiable simulation framework for automating the design of flexible mechanical metamaterials with target dynamic responses.
- Inverse design of flexible mechanical metamaterials for shape morphing, nonlinear wave guiding, energy focusing, shock mitigation, and cloaking of nonlinear waves.

May 2020 – Aug. 2021 **Postdoctoral Researcher**,
Department of Civil, Environmental, and Mechanical Engineering,
University of Trento (Italy),
Advisors: Andrea Piccolroaz and Davide Bigoni

- Homogenization of elastic lattices prestressed by circulatory (follower) forces demonstrating the existence of hypoelastic continuum materials displaying flutter instability at the macroscale.
- Analytical and numerical investigation of tensile buckling in periodic lattice materials endowed with sliding constraints.

Nov. 2016 – Apr. 2020 **PhD Student in Solid and Structural Mechanics**,
Department of Civil, Environmental, and Mechanical Engineering,
University of Trento (Italy),
Advisors: Andrea Piccolroaz and Davide Bigoni

- Analytical and numerical investigation of the free and forced dynamic response of Rayleigh-beam lattices leading to sharp frequency-dependent wave localization.
- Modeling and tuning of the prestress state in a lattice domain to realize dynamic interfaces designed for total reflection, negative refraction, and wave channeling.
- Development of static and dynamic homogenization methods for beam lattices prestressed by conservative and non-conservative positional forces.
- Analytical and numerical analysis of macroscopic and microscopic bifurcations in prestressed anisotropic lattices and their connection to shear bands formation and short-wavelength instabilities.

Publications

Peer-reviewed journals

[8] A. S. Meeussen, **G. Bordiga**, A. X. Chang, B. Spoettling, K. P. Becker, L. Mahadevan, K. Bertoldi, "Textile Hinges Enable Extreme Properties of Kirigami Metamaterials". In: *Adv. Funct. Mater.* (2024), p. 2415986. DOI: 10.1002/adfm.202415986.

[7] **G. Bordiga**, E. Medina, S. Jafarzadeh, C. Bösch, R. P. Adams, V. Tournat, K. Bertoldi, "Automated Discovery of Reprogrammable Nonlinear Dynamic Metamaterials". In: *Nat. Mater.* 23.11 (2024), pp. 1486–1494. DOI: 10.1038/s41563-024-02008-6.

[6] A. Kotikian, A. A. Watkins, **G. Bordiga**, A. Spielberg, Z. S. Davidson, K. Bertoldi, J. A. Lewis, "Liquid Crystal Elastomer Lattices with Thermally Programmable Deformation via Multi-Material 3D Printing". In: *Adv. Mater.* (2024), p. 2310743. DOI: 10.1002/adma.202310743.

[5] **G. Bordiga**, D. Bigoni, A. Piccolroaz, "Tensile Material Instabilities in Elastic Beam Lattices Lead to a Bounded Stability Domain". In: *Philos. Trans. R. Soc. Math. Phys. Eng. Sci.* 380.2231 (2022), p. 20210388. DOI: 10.1098/rsta.2021.0388. (Cover article).

[4] **G. Bordiga**, A. Piccolroaz, D. Bigoni, "A Way to Hypo-Elastic Artificial Materials without a Strain Potential and Displaying Flutter Instability". In: *J. Mech. Phys. Solids* 158 (2022), p. 104665. DOI: 10.1016/j.jmps.2021.104665.

[3] **G. Bordiga**, L. Cabras, A. Piccolroaz, D. Bigoni, "Dynamics of Prestressed Elastic Lattices: Homogenization, Instabilities, and Strain Localization". In: *J. Mech. Phys. Solids* 146 (2021), p. 104198. DOI: 10.1016/j.jmps.2020.104198.

[2] **G. Bordiga**, L. Cabras, D. Bigoni, A. Piccolroaz, "Free and Forced Wave Propagation in a Rayleigh-beam Grid: Flat Bands, Dirac Cones, and Vibration Localization vs Isotropization". In: *Int. J. Solids Struct.* 161 (2019), pp. 64–81. DOI: 10.1016/j.ijsolstr.2018.11.007.

[1] **G. Bordiga**, L. Cabras, A. Piccolroaz, D. Bigoni, "Prestress Tuning of Negative Refraction and Wave Channeling from Flexural Sources". In: *Appl. Phys. Lett.* 114.4 (2019), p. 041901. DOI: 10.1063/1.5084258. (Editor's Pick).

In conference proceedings

[3] **G. Bordiga**. "In-Plane Floquet-Bloch Waves in Elastic Grids and Prestress Tuning of Structured Interfaces". In: *RAMSS2019 - Recent Advances in Mechanics of Solids and Structures*. Trento, 2019. URL: http://rgdoi.net/10.13140/RG.2.2.15758.82244.

[2] **G. Bordiga**. "Free and Forced Wave Propagation in a Rayleigh-beam Grid: Flat Bands, Dirac Cones, and Vibration Localization vs Isotropization". In: *ESMC2018 - 10th European Solid Mechanics Conference*. Bologna, 2018. URL: http://rgdoi.net/10.13140/RG.2.2.24679.09126.

[1] **G. Bordiga**. "Micromechanical Modelling of Masonry". In: *CERMODEL2017*. Trento, 2017.

Software

[2] **G. Bordiga**. *DifFlexMM: Differentiable Flexible Mechanical Metamaterials*. Bertoldi Group, 2024. URL: https://github.com/bertoldi-collab/DifFlexMM.

[1] **G. Bordiga**. *Simulation and Design of Shape-Morphing LCE Lattices*. Bertoldi Group, 2024. URL: https://github.com/bertoldi-collab/morphing-lattices.

Conference presentations

Sep. 9–11, 2024 **SMASIS2024**, Atlanta, GA (US),
Automated design of flexible mechanical metamaterials with reprogrammable wave functionalities
G. Bordiga, E. Medina, S. Jafarzadeh, C. Bösch, V. Tournat, K. Bertoldi

Sep. 9–11, 2024 **SMASIS2024**, Atlanta, GA (US),
Mechanical metamaterial 'brain' for fully analog control of a mobile robot
C. Bösch, **G. Bordiga**, C. McCann, S. Jafarzadeh, J. Wilt, M. Yuen, Y. Jin, A. Fichtner, K. Bertoldi

Jul. 3–4, 2024 **DynaMetaFlex**, *Workshop on "Nonlinear dynamics of flexible mechanical metamaterials"*, Laboratoire d'Acoustique de l'Université du Mans, Institut d'Acoustique – Graduate School, CNRS, Le Mans Université, Le Mans, (France),
Teaching reprogrammable dynamics to material structures
G. Bordiga, E. Medina, S. Jafarzadeh, C. Bösch, V. Tournat, K. Bertoldi

Oct. 8–11, 2023 **SES2023**, Minneapolis, MN (US),
Inverse-design of nonlinear mechanical metamaterial cloaks
G. Bordiga, J. Argaud, V. Tournat, K. Bertoldi

Mar. 5–10, 2023 **APS2023**, Las Vegas, NV (US),
Manipulating energy flows with non-periodic mechanical metamaterials
G. Bordiga, E. Medina, V. Tournat, K. Bertoldi

Oct. 16–19, 2022 **SES2022**, College Station, TX (US),
Non-periodic design discovery for optimal dynamic responses in flexible mechanical metamaterials
G. Bordiga, E. Medina, V. Tournat, K. Bertoldi

Jul. 4–8, 2022 **ESMC2022**, *11th European Solid Mechanics Conference*, Galway (Ireland),
Non-hyper-elastic materials from follower prestress states reveal flutter instability in elastic lattices. (Invited talk)
G. Bordiga, A. Piccolroaz, D. Bigoni

Mar. 14–18, 2022 **APS2022**, Chicago, IL (US),
Architected metamaterials for routing nonlinear mechanical pulses
G. Bordiga, E. Medina, V. Tournat, K. Bertoldi

Invited talks & seminars

Mar. 31, 2025 **Seminar**, *Center for Fluid Mechanics Seminar*, Brown University, Providence, RI (US),
Automating the discovery of nonlinear architected materials.
G. Bordiga

Jul. 25, 2024 **Seminar**, *Seismology and Wave Physics Lab*, ETH, Zürich (Switzerland),
Teaching reprogrammable dynamics to material structures.
G. Bordiga

Jun. 13, 2024 **Seminar**, *Laboratory for Intelligent Probabilistic Systems*, Princeton University, Princeton, NJ (US),
Teaching reprogrammable dynamics to material structures.
G. Bordiga

Jul. 4–8, 2022 **ESMC2022**, *11th European Solid Mechanics Conference*, Galway (Ireland),
Non-hyper-elastic materials from follower prestress states reveal flutter instability in elastic lattices.
G. Bordiga, A. Piccolroaz, D. Bigoni

Mentoring

At Bertoldi Lab, Harvard University

Sep., 2024 – Jun., 2025 **Stijn de Bruin**, *Master student*, **TU Delft (Netherlands)**,
Project: *Encoding dynamic bifurcations in mechanical metamaterials*

Sep., 2024 – Jan., 2025 **Antoine Fondeur**, *Master student*, **MINES Paris – PSL (France)**,
Project: *Inverse design of magneto-mechanical metamaterials for reprogrammable static and dynamic responses*

Sep., 2024 – Jan., 2025 **Jian Zhimo**, *PhD student*, **Tsinghua University (China)**,
Project: *Mechanical metamaterials for sensing and control*

Sep., 2023 – Sep., 2024 **Tom Vreugdenhil**, *Master student*, **TU Delft (Netherlands)**,
Thesis: *Dynamic metamaterials for reprogrammable underactuated robotics*

Sep., 2023 – Dec., 2024 **Carlos Peréz García**, *Master student*, **University Carlos III of Madrid (Spain)**,
Project: *Magneto-mechanical metamaterials for reprogrammable stress-strain response and energy absortion*

Feb.–Sep., 2023 **Jean-Gabriel Argaud**, *Master student*, **MINES Paris – PSL (France)**,
Project: *Cloaking in nonlinear mechanical metamaterials*

Jul.–Dec., 2022 **Cyrill Bösch**, *PhD student*, **ETH (Switzerland)**,
Project: *Mechanical metamaterial 'brain' enables fully analog robotic control*

Sep., 2022–present **Audrey Watkins**, *PhD student*, **Harvard University (US)**,
Project: *Nonlinear waves in multistable metamaterials for mechanical computing*

Feb.–Sep., 2022 **Ben Spoettling**, *Master student*, **ETH (Switzerland)**,
Thesis: *Automated design and discovery of shape-morphing metamaterials*

Teaching experience

2018–2020 **Teaching assistant**,
Department of Civil, Environmental, and Mechanical Engineering,
University of Trento (Italy),
Course: *Structural Dynamics*

- 40+ students.
- Material: Created interactive Mathematica notebooks to teach the dynamics of single and multi-degree-of-freedom systems, modal analysis, free and forced vibrations of elastic beams.
- Graded: oral exams.

2019–2020 **Lecturer and tutor**,
Department of Civil, Environmental, and Mechanical Engineering,
University of Trento (Italy),
Course: *Solids and Structural Mechanics*

- 80+ students, 20 hours of lectures, and 5 hours of tutoring activities.
- Taught: De Saint Venant theory and exercises, Principle of Virtual Work for statically indeterminate structures, structural symmetries, frame structures.
- Graded: written and oral exams.

2018–2019 **Lecturer and tutor**,
Department of Civil, Environmental, and Mechanical Engineering,
University of Trento (Italy),
Course: *Solids and Structural Mechanics*

- 80+ students, 20 hours of lectures, and 20 hours of tutoring activities.
- Taught: De Saint Venant theory and exercises, Principle of Virtual Work for statically indeterminate structures, Mohr's circles, elastic beam theory, frame structures.
- Graded: written and oral exams.

2017–2018 **Lecturer and tutor**,
Department of Civil, Environmental, and Mechanical Engineering,
University of Trento (Italy),
Course: *Solids and Structural Mechanics*

- 80+ students, 30 hours of lectures, and 30 hours of tutoring activities.
- Taught: De Saint Venant theory and exercises, Mohr's circles, failure and yield criteria (Von Mises, Tresca, Mohr-Coulomb, Rankine, Drucker-Prager), Principle of Virtual Work for statically indeterminate structures, elastic beam theory.
- Graded: written and oral exams.

Peer reviews

- Journal of the Mechanics and Physics of Solids
- Science Advances
- Advanced Engineering Materials
- International Journal of Solids and Structures
- European Journal of Mechanics - A/Solids
- Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences
- Computer Methods in Applied Mechanics and Engineering
- Journal of Elasticity
- Mechanics of Materials
- Journal of Sound and Vibration
- Meccanica
- Journal of Mechanics of Materials and Structures

Events & Conferences service

Sep. 9–11, 2024 **SMASIS2024**, *Special Symposium: Embodying Physical Computing and Mechano-Intelligence*, Atlanta, GA (US)
Served as: Session chair.

Jul. 22, 2024 **Git + GitHub Workshop: Version control for scientists**, Harvard SEAS, Cambridge, MA (US)
Served as: Organizer and presenter.

Jul. 29, 2022 **Git + GitHub Workshop: Version control for scientists**, Harvard SEAS, Cambridge, MA (US)
Served as: Organizer.

Sep. 27, 2019 **Researchers' night**, Trento (Italy)
Served as: Co-organizer and presenter for the Solid and Structural Mechanics exhibition stand.

Jun. 6–7, 2019 **RAMSS2019 — Recent Advances in Mechanics of Solids and Structures**, Trento (Italy)
Served as: Conference assistant.

Sep. 28, 2018 **Researchers' night**, Trento (Italy)
Served as: Co-organizer and presenter for the Solid and Structural Mechanics exhibition stand.

Jul. 2–6, 2018 **ESMC2018 — 10th European Solid Mechanics Conference**, Bologna (Italy)
Served as: Co-organizer for conference program.

Sep. 29, 2017 **Researchers' night**, Trento (Italy)
Served as: Co-organizer and presenter for the Solid and Structural Mechanics exhibition stand.

Awards & Honors

2017 Graduation Award for Merit, University of Trento (Italy)
2016 University Scholarship for Merit, Italian government, INPS
2015 University Scholarship for Merit, Italian government, INPS
2015 Graduation Award for Merit, University of Trento (Italy)
2014 University Scholarship for Merit, Italian government, INPS
2013 University Scholarship for Merit, Italian government, INPS
2012 University Scholarship for Merit, Italian government, INPS

Entrepreneurial experience

Apr.–May, 2024 **Blueprint**, *By The Engine Tough Tech startup accelerator*, Cambridge, MA (US)
Startup: *PFX: Programmable Fluids for X*, Turning metafluids into a passive pressure-regulating device for hypertension treatment.
Team: Adel Djellouli, Giovanni Bordiga, and Katia Bertoldi.

Community activities

Jun.–Aug., 2024 **Beach volleyball tournament**, *Harvard Rhino League*, Cambridge, MA (US)
Role: Team captain for the Bertoldi Lab (Championship winner).

Jun.–Aug., 2023 **Beach volleyball tournament**, *Harvard Rhino League*, Cambridge, MA (US)
Role: Team captain for the Bertoldi Lab (Championship winner).

Skills

Programming

Scientific computing	Wolfram Language	*Highly specialized*	Python	*Highly specialized*
	MATLAB	*Advanced*	R	*Intermediate*
Markup	LaTeX	*Highly specialized*	Markdown	*Advanced*
	HTML/CSS	*Basic*		
Others	Java	*Advanced*	C/C++	*Intermediate*
	Javascript	*Advanced*	Bash	*Intermediate*
	Android	*Basic*	SQLite	*Basic*

Application software

Modeling & Simulation	Mathematica	*Highly specialized*	COMSOL	*Advanced*
	ABAQUS	*Intermediate*	SAP2000	*Intermediate*
CAD	AutoCAD	*Highly specialized*	SketchUp	*Advanced*
IDE	VSCode	*Highly specialized*	IntelliJ IDEA	*Advanced*
	Android Studio	*Intermediate*		
Graphics	Inkscape	*Advanced*	GIMP	*Intermediate*
Others	Git	*Advanced*	GitHub	*Advanced*
	Zotero	*Advanced*		

Operating systems

Linux	*Highly specialized*	Windows	*Advanced*
Android	*Advanced*	MacOS	*Intermediate*

Languages

- **Italian:** Native language
- **English:** Professional proficiency

Last update: April 7, 2025