Dr. Ornella Mattei

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Research interests

Space-time microstructures and field patterns; Inverse problems; Bounds on the overall properties of composites; Variational methods for time-dependent problems; Characterization of truss structures under tension.

Education

2016	**PhD in Methods and Mathematical Models for Engineering**, University of Brescia, Italy.
2012	**Master Degree in Civil Engineering**, University of Brescia, Italy.
2010	**Bachelor Degree in Civil Engineering**, University of Brescia, Italy.

Professional Appointments

2019-	**Assistant Professor**, Department of Mathematics, San Francisco State University, USA.
2018-2019	**Postdoctoral Research Associate**, Department of Mathematics, University of Utah, USA.
2017-2018	**Associate Instructor**, Department of Mathematics, University of Utah, USA.
2016-2018	**Visiting Postdoctoral Scholar**, Department of Mathematics, University of Utah, USA.
2013-2016	**PhD Candidate**, Department of Civil, Environmental, Architectural Engineering and Mathematics, University of Brescia, Italy.

Grants, Awards and Fellowships

- **PIC Math Program**, Spring semester 2024, a program of MAA and SIAM funded by the NSF grant DMS-1722275;
- **SFSU ORSP Small Grant** for the project *Billiard Tables and Space-time Composites*, January - May, 2023, $14,000;
- **NSF Grant** (Principal Investigator) DMS-2008105 for the project *RUI: Time-dependent composites and inverse problems*, August 2020-July 2023, $165,000;
- **2020 PUMP (Preparing Undergraduates through Mentoring towards Phds) Grant** for the project *Wave propagation in dynamic materials* September 2020 -May 2021, funded by

the NSF grant DMS-1916494 (PI: Jordan Schettler, San José State University, Co-PI: Cynthia Flores, CSU Channel Islands);

- **2019 AWM Travel Grant** to participate in the *Workshop New trends and challenges in the mathematics of optimal design*, June 10-14, 2019, Isaac Newton Institute for Mathematical Sciences, Cambridge, UK, funded by the Association for Women in Mathematics, USA;
- **2018 Early Career Travel Award** to participate in the *SIAM Conference on Mathematical Aspects of Materials Science*, July 9-13, 2018, Portland, Oregon, USA, funded by the National Science Foundation, USA;
- **2018 Outstanding Postdoc Award**, funded by the Department of Mathematics, University of Utah, USA;
- **Fellowship** to participate in the *6th Midwest Women in Mathematics Symposium*, April 7, 2018, Purdue University, West Lafayette, Indiana, USA, funded by the National Science Foundation;
- **Fellowship** to participate in the IMA Workshop in *Liquid Crystals, Metamaterials, Transformation Optics, Photonic Crystals, and Solar Cells*, February 27 - March 2, 2018, funded by the Institute for Mathematics and its Applications (IMA), Minneapolis, Minnesota, USA;
- **Fellowship** to participate in the IMA Workshop in *Novel Optical Materials*, March 13-17, 2017, funded by the Institute for Mathematics and its Applications (IMA), Minneapolis, Minnesota, USA;
- **Fellowship** to participate in the IMA Annual Thematic Program in *Mathematics and Optics*, September 2016-December 2016, funded by the Institute for Mathematics and its Applications (IMA), Minneapolis, Minnesota, USA;
- **Fellowship** to participate in the Alghero Summer School on *Elastic Metamaterials: From Theory to Applications*, May 22-29, 2016, Alghero, Italy, funded by LIA Coss&Vita, Italy & France;
- **Scholarship** to participate in the CISM-ECCOMAS International Summer School on *Modelling, Simulation and Characterization of Multi-Scale Heterogeneous Materials*, September 28-October 2, 2015, Udine, Italy, funded by CISM, Italy;
- **Scholarship** to participate in the *Workshop on Interdisciplinary Mathematics*, May 8-10, 2015, Williamsport, Pennsylvania, USA, funded by PennState University, USA;
- **PhD scholarship** for the academic years 2013/2014, 2014/2015, 2015/2016 funded by the University of Brescia, Italy.

Visits

11/2021	**Visiting Faculty** (1 week) at the Department of Mathematics, University of Utah, USA. Collaborator: Graeme W. Milton;
8/2021	**Visiting Faculty** (1 week) at the Department of Mathematics, University of Utah, USA. Collaborator: Graeme W. Milton;
1/2020	**Visiting Faculty** (1 week) at the Department of Mathematics, KAIST, Daejeon, South Korea. Collaborator: Mikyoung Lim;
1/2020	**Visiting Faculty** (1 week) at the Department of Mechanical Engineering, Technion, Israel. Collaborator: Gal Shmuel;

7/2019	**Visiting Faculty** (2 weeks) at the Department of Mathematics, KAIST, Daejeon, South Korea. Collaborator: Mikyoung Lim;
7/2017	**Visiting Postdoctoral Scholar** (2 weeks) at the Department of Mathematics, KAIST, Daejeon, South Korea. Collaborator: Mikyoung Lim;
9/2016-12/2016	**Visiting Postdoctoral Scholar** (3 months) at the Institute for Mathematics and its Applications (IMA), Minneapolis, Minnesota, USA;
1/2015-6/2015	**Visiting PhD student** (6 months) at the Department of Mathematics, University of Utah, USA. Advisor: Graeme W. Milton;
11/2013	**Visiting PhD student** (3 weeks) at the Department of Applied Mathematics and Theoretical Physics, University of Cambridge, UK. Advisor: John R. Willis.

Teaching Experience

San Francisco State University (Principal Instructor):

- **Math 376-Ordinary Differential Equations I**, Fall 2021, Fall 2022, and Fall 2023.
- **Math 460-Mathematical Modeling**, Fall 2020, Fall 2021, Fall 2022, Spring 2023.
- **Math 477/777-Partial Differential Equations**, Spring 2020, Spring 2021, Spring 2022.
- **Math 226-Calculus I**, Fall 2019 and Spring 2020.
- **Math 245-Elementary Differential Equations and Linear Algebra**, Fall 2019 and Fall 2020.

University of Utah (Principal Instructor):

- **Math 2250-Differential Equations and Linear Algebra**, Spring 2019.
- **Math 3150-PDEs for Engineers**, Spring 2018 and Fall 2018.
- **Math 1060-Trigonometry**, Fall 2017 and Spring 2018.

Undergraduate Mentoring Experience

Advisor for Senior Applied Math Projects (San Francisco State University):

- *Band diagrams for space-time laminates*, Paulina Svensson, Spring and Fall 2023;
- *Modeling surface effects on football falls*, Kevin Wu, Spring and Fall 2023;
- *Bounds on the response of viscoelastic composites with continuous relaxation times in the time domain*, Angelika Torrella, Spring 2021 and Fall 2021;
- *Mathematical models for economic growth*, Omar Torres, Spring 2021 and Fall 2021;
- *Bounds on the response of viscoelastic composites in the time domain*, Enri Refunjol, Fall 2021;
- *Eshelby problem in 2D for an arbitrary inclusion subject to an arbitrary fa-field loading*, Enri Refunjol, Spring 2021;

- *Energy conservation in dynamic composites*, Jenna Hooper, Fall 2021;
- *Wave propagation in functionally graded time-modulated materials*, Jenna Hooper, Spring 2021;
- *On modeling the spread of coronavirus*, Jackie Luu, Fall 2020 and Spring 2021;
- *Bounds on the effective response of isotropic viscoelastic composites in time*, Ryan Krieger, Fall 2020;
- *Active chiral fluids*, Ryan Krieger, Spring 2020;
- *On bounding the effective properties of viscoelastic composites in time*, Henry Guerrero-Duarte, Spring 2020 and Fall 2020;
- *Wave propagation in functionally graded spatio-temporal materials*, Timothy Wolfe, Fall 2019 and Spring 2020.

Advisor for Research Undergraduate Projects (San Francisco State University):

- *Fractional Fourier Transform*, Miriam Sanchez and Angela Perez, Spring 2023;
- *Bounds on the response of viscoleastic composites with continuous spectrum*, Jairo Martinez and Jessica Matthews, Summer 2022;
- *Energy conservation in dynamic composites*, Jenna Hooper, Summer 2021;
- *Wave propagation in functionally graded spatio-temporal materials*, Jenny Diaz, Summer 2020.

Co-advisor for Bachelor's theses (University of Brescia, Italy):

- *Analytic solutions for the stress state due to bending in sandwich beams: effects of the deformability of the core* (in Italian), P. Bossini, 2014. Advisor: L. Bardella;
- *Application of the Newmark model to the analysis of timber-concrete composite beams characterized by variable stud spacing and concentrated loads* (in Italian), G. Pretti, 2014. Advisor: L. Bardella.

Graduate Mentoring Experience

Advisor for Master's theses:

- *Bounds on the response of 3D-printed materials with a viscoelastic phase*, Charlie McMenomy, 2023;
- *Comparison of Billiard Problem and Wave Propogation in Space-Time Microstructures*, Darcy Brunk, 2023;
- *Analysis on the PT-symmetry and Eigenvalues of Field Patterns*, Jamey Hollis, 2022.

Mentor for independent studies:

- *Functionally graded temporal composites*, Yashleen Sharma, Spring 2023;
- *Spatio-temporal composites*, Darcy Brunk, Spring 2022;
- *Partial Differential Equations*, Charlie Mcmenomy, Spring 2022;
- *Partial Differential Equations*, Jamey Hollis, Summer 2021.

Outreach Experience

- **Women in STEM Panel**, PacificSTEM, March 27, 2021 (online);
- **CSU STEM-NET Virtual Café 10.1**, October 7, 2020 (online);
- **Research Preview Seminar**, *The Mathematics of Materials Science*, April 27, 2020, Department of Mathematics, SFSU, USA;
- **Research Preview Seminar**, *Research topics in the Mathematics of Materials Science*, November 20, 2020, Department of Mathematics, SFSU, USA;
- **Undergraduate Colloquium**, *The Mathematics of Rainbows*, January 23, 2019, Department of Mathematics, University of Utah, USA;
- **Undergraduate Colloquium**, *The Mathematics of Rainbows*, November 29, 2018, Department of Mathematics, University of Utah, USA;
- **Undergraduate Colloquium**, *Waves in strings*, November 29, 2017, Department of Mathematics, University of Utah, USA;

Service as an organizer

- **Minisymposium organizer** (together with Kshiteej Deshmukh), 10th International Congress on Industrial and Applied Mathematics, Waseda University, Tokyo, Japan, August 20-25, 2023.
- **Chair committee** for the planning of the May 12 Celebration of Women in Mathematics event, hosted by the Mathematical Sciences Research Institute, Berkeley, May 12, 2022-2024.
- **Organizer** (together with Hélène Barcelo, Hajer Bahouri, Mihaela Ifrim, Julia Plavnik) of the May 12 Celebration of Women in Mathematics event, hosted by the Mathematical Sciences Research Institute, Berkeley, May 12, 2021. (online event)
- **Minisymposium organizer** (together with Aaron Welters, Robert Viator and Christian Kern), 2020 SIAM Conference on Mathematical Aspects of Materials Science, May 24-29, 2021, Bilbao, Spain. Minisymposium: *Frontiers in nonreciprocity, metamaterials, and non-symmetric effective tensors.* (online event)
- **Minisymposium organizer** (together with Aaron Welters and Elena Cherkaev), 11th International Conference of Electrical, Transport, and Optical Properties on Inhomogeneous Media, July 16-20, 2018, Krakow, Poland. Minisymposium: *Herglotz-Nevanlinna Function Theory and its Applications.*
- **Minisymposium organizer** (together with Aaron Welters), 2018 SIAM Conference on Mathematical Aspects of Materials Science, July 9-13, 2018, Portland, Oregon, USA. Minisymposium: *Applications of Herglotz-Nevanlinna Function Theory to Electromagnetics, Composites, and Dirichlet-to-Neumann maps.*
- **Local organizing committee member** of the International Symposium IUTAM 2012: *Fracture phenomena in nature and technology*, July 1-5, 2012. University of Brescia, Italy.

Service as a reviewer

- **Manuscript Reviewer** for the Proceedings of the Royal Society A, the Journal of the Mechanics and Physics of Solids, and the European Journal of Mechanics A/Solids, Mathematics, Laser & Photonics Reviews, Mechanics Research Communications, ASME Journal of Heat Transfer, Physical Review B .
- **Grant Reviewer** for the National Science Foundation, Division of Mathematical Sciences, 2022.

Service as a committee member

San Francisco State University

- College of Science & Engineering:
  - **WISE (Women in Science and Engineering) Scholarships Committee**, Fall 2020.
- Department of Mathematics:
  - **Thesis Supervising Committee**, Calvin Chen, Summer 2021; Kyle Bradach, Spring 2022; Connor Loehde-Woolard, Spring 2023; Lekha Patil, Summer 2023;
  - **Equity and Diversity Committee**, Fall 2020 - to date;
  - **Curriculum Committee**, Fall 2020 - to date;
  - **Student Success Committee**, Spring 2020 - to date;
  - **Scholarships Committee**, Spring 2020.

Service as an advisor

- Faculty Advisor for the **SFSU SIAM (Society for Industrial and Applied Mathematics) Student Chapter**;
- **Pacific Math Alliance** mentor;
- **Association of Women in Mathematics** mentor;
- **Coach** for SCUDEM (SIMIODE Challenge Using Differential Equations Modeling): 1 team in Fall 2020, 4 teams in Fall 2021 (one outstanding award), 2 teams in Fall 2022.

Invited Seminars

1. **Department Colloquium**, October 12, 2022, San Jose State University, USA;
2. **M*A*T*H Colloquium**, February 9, 2022, Sonoma State University, USA (online);
3. **Department Colloquium**, February 18, 2021, Humboldt State University, USA (online);
4. **Waves Seminar**, October 29, 2020, UC Merced, USA (online);
5. **Applied Mathematics Seminar**, January 8, 2020, KAIST, Daejeon, South Korea;
6. **Mechanical Engineering Seminar**, January 15, 2020, Technion, Israel.
7. **Applied Mathematics Seminar**, September 11, 2017, University of Utah, USA;
8. **Applied Mathematics Seminar**, July 18, 2017, KAIST, Daejeon, South Korea;
9. **IMA Annual Program Seminar**, November 16, 2016, IMA, University of Minnesota, USA;
10. **Geomechanics Seminar**, October 7, 2016, University of Minnesota, USA;
11. **Applied Mathematics Seminar**, April 13, 2015, University of Utah, USA.

Invited Talks at Conferences

Upcoming:

1. **2024 Joint Mathematical Meetings**, JMM 2024, Minisymposium: *Mathematical modeling of complex materials systems*, January 3-5, 2024, San Francisco, USA;
2. **2024 Joint Mathematical Meetings**, JMM 2024, Minisymposium: *Women, Art, and Mathematics: Mathematics in the Literary Arts and Pedagogy in Creative Settings*, January 3-5, 2024, San Francisco, USA;
3. **10th International Congress on Industrial and Applied Mathematics**, Minisymposium: *Waves in complex and multiscale media*, August 20-25, 2023, Waseda University, Tokyo, Japan;
4. **VI AMMCS International Conference**, Minisymposium: *Recent Advances in the Theory and Applications of Wave Propagation*, August 14 - 18, 2023, Waterloo, Ontario, Canada.

Past:

1. **Workshop series on Waves in Time-Varying Media**, May 3-5, 2023, New York, USA;
2. **The First CSU Mathematical Conference**, California State University, Northridge, November 11–12, 2022, Northridge, California;
3. **MetaMat Webinar Series**, November 1, 2022, Imperial College, London, UK;
4. **2022 International Workshop on Multiscale Innovative Materials and Structures**, September 29 - October 1, 2022, Cetara, Italy;
5. **12th International Conference on Elastic, Electrical, Transport, and Optical Properties of Inhomogeneous Media**, ETOPIM 12, July 4- July 8, 2022, Besancon, France;
6. **19th U.S. National Congress on Theoretical and Applied Mechanics**, June 19-24, 2022 Austin, Texas, USA;
7. **Workshop on Herglotz-Nevanlinna functions and their applications to dispersive systems and composite materials**, May 23-27, 2022, CIRM, Marseille, France.
8. **SIAM TX/LA Conference**, Minisymposium: *Advances in theory and applications of composite materials*, November 5-7, 2021, South Padre Island, Texas, USA.
9. **Workshop series on Waves in Time-Varying Media**, Session: *Theory and Fundamental Concepts of Time-Varying Media*, March 31, 2021, Imperial College, UK (online);
10. **SIAM Conference on Mathematical Aspects of Materials Sciences**, Minisymposium: *Soft materials: patterns, instabilities, and controlled deformations*, May 24-29, 2021, Bilbao, Spain (online);
11. **SIAM Conference on Mathematical Aspects of Materials Science**, Minisymposium: *Variational Models: Theory, Computations, and Applications to Materials*, May 24-29, 2021, Bilbao, Spain (online);
12. **14th World Congress on Computational Mechanics WCCM & ECCOMAS 2020**, January 11-15, 2021, Paris, France (online);
13. **Workshop on Herglotz-Nevanlinna Theory Applied to Passive, Causal and Active Systems**, October 6-11, 2019, Banff International Research Station for Mathematical Innovation and Discovery, Banff, Alberta, Canada;
14. **Workshop on Topology and broken symmetries: from driven quantum matter to active metamaterials**, July 1-3, 2019, Utrecht, The Netherlands;

15. **Workshop on Non-reciprocal and Topological Wave Phenomena in Solids and Fluids**, May 29-31, 2019, University of Missouri in Columbia, MO, USA;

16. **55th Annual Technical Meeting of the Society of Engineering Science**, October 10-12, 2018, Leganés, Madrid, Spain;

17. **11th International Conference of Electrical, Transport, and Optical Properties on Inhomogeneous Media**, July 16-20, 2018, Krakow, Poland;

18. **SIAM Conference on Mathematical Aspects of Materials Science**, July 9-13, 2018, Portland, Oregon, USA;

19. **10th European Solid Mechanics Conference**, July 2-6, 2018, Bologna, Italy;

20. **Summer School on Waves and Particles in Random Media: Theory and Applications**, May 21-25, 2018, Colorado State University, USA;

21. **Applied Mathematics, Modeling and Computational Science Conference AMMCS2017**, August 20-25, 2017, Waterloo, Canada;

22. **The Mathematics of Metamaterials and Materials Workshop**, August 9, 2016, Snowbird, Utah, USA;

23. **XIII Continuum Models Discrete Systems, CMDS Investigators Workshop: At the Frontiers of Computation and Materials**, May 16, 2015, Snowbird, Utah, USA;

24. **Workshop on Interdisciplinary Mathematics**, May 8-10, 2015, Williamsport, Pennsylvania, USA.

Other presentations

1. **SIAM Wasatch Student Chapters Conference**, April 6, 2019, Utah State University, Logan, USA;

2. **24th International Congress of Theoretical and Applied Mechanics**, August 21-26, 2016, Montréal, Canada;

3. **22th Congress of the Italian Association of Theoretical and Applied Mechanics**, September 14-17, 2015, Genova, Italy;

4. **4th International Conference on Material Modeling**, May 27-29, 2015, Berkeley, California, USA;

5. **11th World Congress on Computational Mechanics**, July 20-25, 2014, Barcelona, Spain.

Posters

1. **Workshop on New trends and challenges in the mathematics of optimal design**, June 10-14, 2019, Isaac Newton Institute for Mathematical Sciences, Cambridge, UK;

2. **IMA Workshop on Liquid Crystals, Metamaterials, Transformation Optics, Photonic Crystals, and Solar Cells**, February 27-March 2, 2018, Minneapolis, Minnesota, USA;

3. **IMA Workshop on Novel Optical Materials**, March 13-17, 2017, Minneapolis, Minnesota, USA.

Publications

Articles on my work:

1. **Introducing a suitable spatial geometry that could lead to stable time-modulated materials**, Alane Lim, AIP Scilight, February 10, 2023. DOI: https://doi.org/10.1063/10.0017341.

2. **Guiding Stress with Cable Networks and the Spider Web Problem**. G. Bouchitté, O. Mattei, G.W. Milton, P. Seppecher. SIAM News, October 2020 issue;

3. **New Horizons in the Study of Waves in Space-time Microstructures**. O. Mattei, G.W. Milton. SIAM News, Volume 50/Issue 9 (November 2017).

Book Chapters:

1. **Bounds for the response of viscoleastic composites under antiplane loadings in the time domain**. O. Mattei, G.W. Milton. In *Extending the Theory of Composites to Other Areas of Science*, Edited by G.W. Milton, Milton and Patton Publishing (produced by BookBaby.com), 2016. ISBN: 978-1483569192.

Papers published in peer-reviewed journals:

1. **Determining the volume fraction in 2-phase composites and bodies using time varying applied fields**. O. Mattei, G.W. Milton, M. Putinar, 2023. *J. Mech. Phys. Solids* 175, 105292, DOI: https://doi.org/10.1016/j.jmps.2023.105292.

2. **An extremal problem arising in the dynamics of two-phase materials that directly reveals information about the internal geometry**. O. Mattei, G.W. Milton, M. Putinar, 2023. *Comm. Pure Appl. Math.* 76 (10), 2372-2409, DOI: http://doi.org/10.1002/cpa.22082.

3. (Editor's Pick) **On the effects of suitably designed space microstructures in the propagation of waves in time modulated composites**. O. Mattei. V. Gulizzi, 2023. *Appl. Phys. Lett.* 122, 061701. DOI: https://doi.org/10.1063/5.0132899

4. **The obstacle problem in masonry structures and cable nets**. A. Amendola, O. Mattei, G.W. Milton, P. Seppecher, 2023. *Proc. R. Soc. A.* 479: 20220229. DOI: http://doi.org/10.1098/rspa.2022.0229.

5. **Limit analysis of strut nets**. A. Amendola, A. Fortunato, F. Fraternali, O. Mattei, G.W. Milton, P. Seppecher, 2023. *Journal of Mathematics and Mechanics of Solids* 28(8):1760-1775. DOI: https://doi.org/10.1177/10812865221136814.

6. **Explicit analytic solution for the plane elastostatic problem with a rigid inclusion of arbitrary shape subject to arbitrary far-field loadings**. O. Mattei, M. Lim, 2021. *Journal of Elasticity*, 144, 81-105. DOI: https://doi.org/10.1007/s10659-021-09828-6.

7. **On the forces that cable webs under tension can support and how to design cable webs to channel stresses**. G. Bouchitté, O. Mattei, G.W. Milton, P. Seppecher, 2019. *Proc. R. Soc. A*, 475. DOI: https://doi.org/10.1098/rspa.2018.0781.

8. **Field patterns: A new type of wave with infinitely degenerate band structure**. O. Mattei, G.W. Milton, 2017. *Europhys. Lett.* 120(5), 54003. DOI: https://doi.org/10.1209/0295-5075/120/54003;

9. **Field patterns without blowup**. O. Mattei, G.W. Milton, 2017. *New J. Phys.* **19** 093022. DO1: https://doi.org/10.1088/1367-2630/aa847d;

10. **Field patterns: A new mathematical object**. G.W. Milton, O. Mattei, 2017. *Proc. R. Soc. A* 20160819. DOI: http://dx.doi.org/10.1098/rspa.2016.0819;

11. **Bounds for the overall properties of composites with time-dependent constitutive law**. O. Mattei, A. Carini, 2017. *Eur. J. Mech. A-Solid*, 61, 408–419. DOI: http://dx.doi.org/10.1016/j.euromechsol.2016.10.015;

12. **A structural model for plane sandwich beams including transverse core deformability and arbitrary boundary conditions**. O. Mattei, L. Bardella, 2016. *Eur. J. Mech. A-Solid* 58, 172-186. DOI: http://dx.doi.org/10.1016/j.euromechsol.2016.01.015;

13. **Variational formulations for the linear viscoelastic problem in the time domain**. A. Carini, O. Mattei, 2015. *Eur. J. Mech. A-Solid*, 54, 146–159. DOI: http://dx.doi.org/10.1016/j.euromechsol.2015.05.007;

14. **On explicit analytic solutions for the accurate evaluation of the shear stress in sandwich beams with a clamped end**. L. Bardella, O. Mattei, 2014. *Compos. Struct.* 12, 157-168. DOI: http://dx.doi.org/10.1016/j.compstruct.2014.01.044;

15. **Corrigendum to "On explicit analytic solutions for the accurate evaluation of the shear stress in sandwich beams with a clamped end".** L. Bardella, O. Mattei, 2014. *Compos. Struct.* 116, 849. DOI: http://dx.doi.org/10.1016/j.compstruct.2014.05.010.

Papers in preparation

1. **On bounding the response in time of viscoelastic composites with a void phase**. O. Mattei, C. McMenomy (Master's student).

2. **Universal features of directional and complete gaps in spatio-temporal laminates**. O. Mattei, P. Svensson (undergraduate student).

PhD thesis:

1. **On bounding the effective response of viscoelastic composites in the time domain: The variational approach and the analytic method**. O. Mattei, 2016.