

# Mattia Cenedese

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## APPOINTMENT HISTORY

Postdoctoral researcher at ETH Zürich (Switzerland)	October 2021 - Present
Scientific assistant I at ETH Zürich (Switzerland)	September 2017 - September 2021
Research scientist at Politenico di Milano (Italy)	May - August 2017

## EDUCATION

Ph.D. in Mechanical Engineering at ETH Zürich (Switzerland)	June 2021
▷ Thesis title: <i>A geometric approach to nonlinear mechanical vibrations: from analytic to data-driven methods</i>	<a href="#">[link]</a>
▷ Supervisor: Prof. Dr. George Haller	
▷ Co-supervisor: Prof. Dr. Melih Eriten	
M.Sc. in Mechanical Engineering at Politecnico di Torino (Italy)	December 2017
▷ Final score: 110 <i>cum laude</i> / 110	
M.Sc. in Mechanical Engineering at Politecnico di Milano (Italy)	December 2016
▷ Final score: 110 <i>cum laude</i> / 110	
▷ Thesis title: <i>Smart periodic structures: from wave propagation to electromechanical design</i>	<a href="#">[link]</a>
▷ Supervisor: Prof. Dr. Francesco Braghin	
▷ Co-supervisor: Prof. Dr. Laura Gastaldi	
Enrolled in <i>Alta Scuola Politecnica</i> , XI Cycle	November 2014 - June 2016
▷ Final project: <i>IntegraGreen: integration of additive manufacturing and conventional processes in view of green and sustainable development</i>	<a href="#">[link]</a>
▷ Supervisors: Prof. Dr. Luca Settineri, Prof. Dr. Bianca Maria Colosimo, Prof. Luca Iuliano, Dr. Paolo Priarone, Leonardo Napoli	
Laurea in Mechanical Engineering at Politecnico di Milano (Italy)	September 2014
▷ Final score: 110 <i>cum laude</i> / 110	
▷ Equivalent to a B.Sc.	

## PROFESSIONAL TRAINING & SKILLS

### Workshops & summer schools

- ▷ *Effective High-Performance Computing & Data Analytics with GPUs*, July 19-30, 2021, organized by the Swiss National Supercomputing Centre and Università della Svizzera italiana (Switzerland).
- ▷ *Tribomechadynamics Research Camp* held at Rice University in Houston, July 2019, organized by Matthew Brake (Rice University, USA).
- ▷ *Advanced Summer School on Continuation Methods for Nonlinear Problems* held at University of Illinois at Urbana-Champaign (UIUC), August 2018, co-organized by Harry Dankowicz (UIUC, USA) and Jan Sieber (University of Exeter, UK).
- ▷ Course in *Substructuring in Engineering Dynamics* held at the International Center for Mechanical Science (CISM) in Udine (Italy), July 2018, organized by Matthew Allen (University of Wisconsin-Madison, USA) and Daniel Rixen (Technische Universität München, Germany).

### Selected courses from M.Sc. & Ph.D. studies

- ▷ Nonlinear Dynamics and Chaos I, II
- ▷ Differential Geometry
- ▷ Introduction to Machine Learning
- ▷ Uncertainty Quantification and Data Analysis in Applied Sciences
- ▷ Numerical Analysis of Stochastic Ordinary Differential Equations
- ▷ Noise and Vibration Engineering
- ▷ Mechatronic Systems and Laboratory

### Computer skills

- ▷ Advanced knowledge of MATLAB®.
- ▷ Expert with *Python* in numerical and machine learning packages, e.g. *NumPy*, *SciPy*, *Pandas*, *Matplotlib*, *FENICS*, *TensorFlow*, *PyTorch*, *Scikit-Learn*.
- ▷ Competent in HTML and  $\text{\LaTeX}$  programming languages, engineering commercial softwares (*Abaqus FEA*®, *Comsol Multiphysics*®, *Inventor*®, *Solidworks*®), *Microsoft Office*® suite.

## RESEARCH INTERESTS

- ▷ Construction of data-driven methods for reduced-order modeling of nonlinear dynamical systems capitalizing on machine learning algorithms.
- ▷ Development analytical techniques for the analysis of multi-degree-of-freedom, forced-damped, nonlinear mechanical systems.
- ▷ Vibration reduction exploiting synergies between periodic structural design and smart elements.

## TEACHING & SUPERVISION ACTIVITIES

- ▷ Teaching Assistant for the course *Dynamics*, undergraduate level, ETH Zürich, 2017.
- ▷ Teaching Assistant for the course *Nonlinear Dynamics and Chaos II*, graduate level, ETH Zürich, 2020.
- ▷ Supervision of master theses:
  - A. Massocco, *Model order reduction of wakes behind bluff bodies*, June - December 2020.
  - R. Uslenghi, *Exploring frequency aware machine learning techniques for discontinuous fluids data*, May - October 2021.
  - Z. Xu, *Experimental identification and control of fluttering instabilities*, February - July 2022.

## PROFESSIONAL SERVICE

- ▷ Reviewer of research articles for the following journals: *Arch. Appl. Mech.*, *Appl. Phys. Lett.*, *Int. J. Non-Linear Mech.*, *J. Appl. Mech.*, *J. Appl. Phys.*, *J. Nonlinear Sci.*, *J. Vib. Acoust.*, *Mech. Syst. Signal Process.*, *Nonlinear Dyn.*, *Phys. Rev. Fluids*
- ▷ Chairman for the session *Data analysis and data-driven modelling* of the conference Dynamics-Days XL, August 23-27, 2021, Nice, France.
- ▷ Chairman for the special session *Global problems in nonlinear dynamics* of the 16th International Conference Dynamical Systems – Theory and Applications (DSTA 2021).
- ▷ Organizer of the minisymposium *Data-driven reduced-order modeling of nonlinear dynamical systems* for the 9th GACM Colloquium on Computational Mechanics 2022, September 21-23, Essen, Germany.

## SOFTWARE DEVELOPMENT

- ▷ SSMLearn: data-driven reduced order modeling package for nonlinear dynamical systems. Available at [github.com/mattiacenedese/SSMLearn](https://github.com/mattiacenedese/SSMLearn)

## AWARDS & RECOGNITIONS

- ▷ Paper featured on *Nature Communications* Editors' Highlights of recent research in *Applied physics and mathematics*: M. Cenedese, J. Axås, B. Bäuerlein, K. Avila & G. Haller, *Data-driven modeling and prediction of non-linearizable dynamics via spectral submanifolds*, *Nature Communications*, 13 (2022) 872. DOI: [10.1038/s41467-022-28518-y](https://doi.org/10.1038/s41467-022-28518-y) [\[link\]](#)
- ▷ Winner of the 2022 SWICCOMAS *Best Thesis Award* among national doctoral thesis for computational methods in applied sciences. [\[link\]](#)
- ▷ 1st prize among presentations by junior scientists at the 8th International Conference on Nonlinear Vibrations, Localization and Energy Transfer, July 6-9, 2021, Ascona, Switzerland.
- ▷ Paper selected for the cover page: M. Cenedese, E. Belloni & F. Braghin, *Interaction of Bragg scattering bandgaps and local resonators in mono-coupled periodic structures*, *Journal of Applied Physics* 129 (2021) 124501. [\[link\]](#)
- ▷ Scholarship *Atlantia per la conoscenza 2015-2016* sponsored by Atlantia S.p.A. (holding company of "Autostrade per l'Italia" and "Aeroporti di Roma") after selection among the best engineering students of Politecnico di Milano.
- ▷ Full tuition waiver obtained for both the master's degrees and half tuition waiver obtained for the bachelor's degree in 2013, 2014.

## IN THE PRESS

- ▷ *Predicting complex dynamics from data*, by O. Morsch, ETH Zürich News. [\[link\]](#)

## TALKS & PRESENTATIONS

### Invited talks

- [1] *Modeling and prediction of non-linearizable phenomena via dynamics-based machine learning*. Applied Machine Learning Days EPFL 2022, March 26-30, Lausanne, Switzerland. [\[video\]](#)

- [2] *Data-driven explicit models and predictions of non-linearizable dynamical systems*. IMES Seminar series, October 8, 2021, ETH Zürich, Switzerland.
- [3] *Reduction of large nonlinear models and data sets to spectral submanifolds* (tutorial). 8th International Conference on Nonlinear Vibrations, Localization and Energy Transfer, July 6-9, 2021, Ascona, Switzerland.
- [4] *Bifurcation and stability of nonlinear oscillations from their conservative limit*. IMES Seminar series, March 27, 2020, ETH Zürich, Switzerland.

### Upcoming conferences & events

ECCOMAS Congress 2022, ESMC 2022, ENOC 2022, GACM Colloquium on Computational Mechanics 2022.

### Conference presentations

- [1] *Data-driven model reduction for nonlinear systems using spectral submanifolds*. International Modal Analysis Conference (IMAC) Ed. 40, February 6-10, 2022, Orlando, FL, USA.
- [2] *Data-driven reduced-order nonlinear models from spectral submanifolds*. 16th International Conference Dynamical Systems – Theory and Applications (DSTA), December 6-9, 2021, Online.
- [3] *Data-driven low-dimensional nonlinear models based on spectral submanifolds*. Dynamics-Days XL, August 23-27, 2021, Nice, France.
- [4] *Learning spectral submanifolds of mechanical systems from vibrations data*. 8th International Conference on Nonlinear Vibrations, Localization and Energy Transfer, July 6-9, 2021, Ascona, Switzerland.
- [5] *Reduced-order modeling for wakes around bluff bodies using spectral submanifolds*. 2nd International Nonlinear Dynamics Conference (NODYCON), February 16-19, 2021, Rome, Italy.
- [6] *Establishing the exact relation between conservative backbone curves and frequency responses via energy balance*. International Modal Analysis Conference (IMAC) Ed. 39 - Virtual, February 8-11, 2021.
- [7] *Experimental spectral submanifold reduced order models from machine learning*. International Modal Analysis Conference (IMAC) Ed. 38, February 10-13, 2020, Houston, TX, USA.
- [8] *Nonlinear system identification of a jointed structure using full field data - part 2: analysis*. Tribomechadynamics Conference 2019, July 29-August 2, 2019, Rice University, Houston, TX, USA.
- [9] *Predicting frequency response as perturbation from the conservative limit* (poster). 7th International Conference on Nonlinear Vibrations, Localization and Energy Transfer, July 1-4, 2019, Marseille, France.
- [10] *A geometric approach for time-periodic resonant perturbations of energy-parametrized families of periodic orbits*. 1st International Nonlinear Dynamics Conference (NODYCON), February 17-20, 2019, Rome, Italy.
- [11] *Constructing backbone curves from free-decay vibrations data in multi-degrees of freedom oscillatory systems*. International Modal Analysis Conference (IMAC) Ed. 37, January 28-31, 2019, Orlando, FL, USA.
- [12] *Design of a smart periodic beam with coupling between local resonances and Bragg band gaps*. 8th ECCOMAS Thematic Conference on Smart Structures and Materials, June 5-8, 2017, Madrid, Spain.

## PUBLICATIONS

### Refereed journal articles

- [1] M. Cenedese, J. Axås, H. Yang, M. Eriten & G. Haller, *Data-driven nonlinear model reduction to spectral submanifolds in mechanical systems*, *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* (2022) in press. Preprint available on [arXiv:2110.01929](https://arxiv.org/abs/2110.01929) [PDF]
- [2] M. Cenedese, J. Axås, B. Bäuerlein, K. Avila & G. Haller, *Data-driven modeling and prediction of non-linearizable dynamics via spectral submanifolds*, *Nature Communications*, 13 (2022) 872. DOI: [10.1038/s41467-022-28518-y](https://doi.org/10.1038/s41467-022-28518-y). Article featured on the Editors' Highlights of recent research in *Applied physics and mathematics* [PDF]
- [3] M. Jin, G. Kosova, M. Cenedese, W. Chen, D. Jana, A. Singh, M. R. W. Brake, C. W. Schwingshackl, S. Nagarajaiah, K. J. Moore & J. Noël, *Measurement and identification of the nonlinear dynamics of a jointed structure using full-field data; Part II - Nonlinear system identification*, *Mechanical Systems and Signal Processing* 166 (2022) 108402. DOI: [10.1016/j.ymssp.2021.108402](https://doi.org/10.1016/j.ymssp.2021.108402) [PDF]
- [4] W. Chen, D. Jana, A. Singh, M. Jin, M. Cenedese, G. Kosova, M. R. W. Brake, C. W. Schwingshackl, S. Nagarajaiah, K. J. Moore & J. Noël, *Measurement and identification of the nonlinear dynamics of a jointed structure using full-field data; Part I – Measurement of nonlinear dynamics*, *Mechanical Systems and Signal Processing* 166 (2022) 108401. DOI: [10.1016/j.ymssp.2021.108401](https://doi.org/10.1016/j.ymssp.2021.108401) [PDF]
- [5] M. Cenedese, E. Belloni & F. Braghin, *Interaction of Bragg scattering bandgaps and local resonators in mono-coupled periodic structures*, *Journal of Applied Physics* 129 (2021) 124501. DOI: [10.1063/5.0038438](https://doi.org/10.1063/5.0038438). Article featured on the [journal cover page](#) [PDF]
- [6] M. Cenedese & G. Haller, *Stability of forced-damped response in mechanical systems from a Melnikov analysis*, *Chaos: an Interdisciplinary Journal of Nonlinear Science* 30 (2020) 083103. DOI: [10.1063/5.0012480](https://doi.org/10.1063/5.0012480) [PDF]
- [7] M. Cenedese & G. Haller, *How do conservative backbone curves perturb into forced responses? A Melnikov function analysis*, *Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences* 476 (2020) 20190494. DOI: [10.1098/rspa.2019.0494](https://doi.org/10.1098/rspa.2019.0494) [PDF]
- [8] E.A. Flores Parra, A. Bergamini, B. Lossouarn, B. Van Damme, M. Cenedese & P. Ermanni, *Bandgap control with local and interconnected LC piezoelectric shunts*, *Applied Physics Letters* 111 (2017) 111902. DOI: [10.1063/1.4994779](https://doi.org/10.1063/1.4994779) [PDF]

### Submitted papers

- [1] J. Axås, M. Cenedese & G. Haller, *Fast data-driven model reduction for nonlinear dynamical systems*, [arXiv:2204.14169](https://arxiv.org/abs/2204.14169) (2022) [PDF]
- [2] B. Kaszás, M. Cenedese & G. Haller, *Dynamics-based machine learning of transitions in Couette flow*, [arXiv:2203.13098](https://arxiv.org/abs/2203.13098) (2022) [PDF]

### Popular science articles

- [1] G. Haller, S. Jain & M. Cenedese, *Dynamics-based machine learning for nonlinearizable phenomena*, *SIAM News*, Volume 55, Number 5, June 2022. [link]

## Conference papers

- [1] M. Cenedese, J. Axås, & G. Haller, *Data-driven reduced-order nonlinear models from spectral submanifolds*, in *abstracts of the 16th Conference on DYNAMICAL SYSTEMS Theory and Applications DSTA 2021*, pp 159-160, edited by J. Awrejcewicz, M. Kaźmierczak, J. Mrozowski & P. Olejnik. Łódź, December 6-9, 2021, Poland. DOI:10.34658/9788366741201
- [2] M. Cenedese & G. Haller, *Establishing the exact relation between conservative backbone curves and frequency responses via energy balance*, in *Nonlinear Structures & Systems*, Vol. 1 (2022), pp 189-192, edited by G. Kerschen, M.R.W. Brake & L. Renson. Conference Proceedings of the Society for Experimental Mechanics Series. IMAC XXXIX. Springer, Cham. DOI:10.1007/978-3-030-77135-5\_21
- [3] M. Cenedese & G. Haller, *Experimental spectral submanifold reduced order models from machine learning*, in *Nonlinear Structures & Systems*, Vol. 1 (2021), pp 249-251, edited by G. Kerschen, M.R.W. Brake & L. Renson. Conference Proceedings of the Society for Experimental Mechanics Series. IMAC XXXVIII. Springer, Cham. DOI:10.1007/978-3-030-47626-7\_36
- [4] G. Kosova, M. Jin, M. Cenedese, W. Chen, A. Singh, D. Jana, M.R.W. Brake, C.W. Schwingshackl, S. Nagarajaiah, K.J. Moore & J.P. Noël, *Nonlinear system identification of a jointed structure using full-field data: part II analysis*, in *Nonlinear Structures & Systems*, Vol. 1 (2021), pp 185-188, edited by G. Kerschen, M.R.W. Brake & L. Renson. Conference Proceedings of the Society for Experimental Mechanics Series. IMAC XXXVIII. Springer, Cham. DOI:10.1007/978-3-030-47626-7\_27
- [5] M. Cenedese & G. Haller, *Constructing backbone curves from free-decay vibrations data in multi-degrees of freedom oscillatory systems*, in *Nonlinear Structures & Systems*, Vol. 1 (2020), pp 221-223, edited by G. Kerschen, M.R. Brake & L. Renson. Conference Proceedings of the Society for Experimental Mechanics Series. IMAC XXXVII. Springer, Cham. DOI:10.1007/978-3-030-12391-8\_30
- [6] M. Cenedese & G. Haller, *Predicting frequency response as perturbation from the conservative limit*, in *7th International Conference on Nonlinear Vibrations, Localization and Energy Transfer: Extended Abstracts* (2019), edited by B. Cochelin, 7th International Conference on Nonlinear Vibrations, Localization and Energy Transfer, Jul 2019, Marseille, France. Publications du LMA, 160. HAL ID:hal-02319600
- [7] E. Belloni, M. Cenedese & F. Braghin, *Dynamics of periodic spring-mass chain coupled with an electric transmission line*, in *Proceedings of SPIE 10164, Active and Passive Smart Structures and Integrated Systems* (2017) 101642Y (11 April 2017). DOI:10.1117/12.2259896
- [8] E. Belloni, G. Cazzulani, M. Cenedese & F. Braghin, *Design of a smart periodic beam with coupling between local resonances and Bragg band-gaps*, in *Proceedings of the 8th Conference on Smart Structures and Materials SMART 2017* (2017), edited by A. Güeme, A. Benjeddou, J. Rodelar & J. Leng. Publication of the International Center for Numerical Methods in Engineering (CIMNE) Barcelona, Spain. [PDF]
- [9] E. Belloni, F. Braghin, G. Cazzulani & M. Cenedese, *Invariant representation of wave propagation properties for a mono-coupled electro-mechanical periodic structure*, in *Proceedings of the ASME 2016 Conference on Smart Materials, Adaptive Structures and Intelligent Systems*, Vol. 1 (2016). Stowe, Vermont, USA. September 28–30. V001T02A004. ASME. DOI:10.1115/SMASIS2016-9117

## REFERENCES

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