

Mechanical Metamaterials, M. van Hecke (2017-2022)

Biography



Martin van Hecke was born on June 18, 1967 in Amsterdam, The Netherlands. He did his PhD in theoretical physics from 1992-1996 at the University of Leiden under the supervision of Prof W. van Saarloos. From 1996-2000 he worked as a postdoc at the Niels Bohr Institute (Copenhagen) and Max Planck Institute for Complex Matter (Dresden). In 2000 he started a hybrid experimental-theoretical group in granular media in Leiden, and was appointed full professor in 2007. Since 2014 he divides his time 50/50 between AMOLF and Leiden, and from 2015-2020 he was Department Head 'Designer Matter' at AMOLF. He won the 2020 Fysica prize and was elected fellow of the APS in 2020.

His research works in the broad area of emergence of complex behavior in flexible and frustrated matter, and combines experiments, simulations and theory. In the past decade he developed programmable, shape-shifting and self-folding metamaterials which straddle the boundary between material and machine. Partly funded by an ERC/adv grant, he is currently exploring how complex materials – from multistable metamaterials to crumpled sheets – can be understood from the perspective of information processing, and how these insights can lead to novel strategies for computing *in materia*.

Group output

Peer reviewed Publications 2017-2022

2017

1. K. Bertoldi, V. Vitelli, J. Christensen & M. van Hecke, *Flexible mechanical metamaterials*, Nat. Rev. Mater. **2**: 17066 (2017).
2. S. Dagois-Bohy, E. Somfai, B.P. Tighe & M. van Hecke, *Softening and Yielding of Soft Glassy Materials*, Soft Matter **13**, 9036-9045 (2017).
3. S. Waitukaitis, A. Zuiderwijk, A. Souslov, C. Coulais, and M. van Hecke, *Coupling the Leidenfrost effect and elastic deformations to power sustained bouncing*, Nat. Phys. **13**, 1095-1099 (2017)
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4. Luuk A. Lubbers, M. van Hecke and Corentin Coulais, *A nonlinear beam model to describe the postbuckling of wide neo-Hookean beams*, J. Mech. Phys. Solids **106**, 191–206 (2017)
5. A. Pandey, S. Karpitschka, L.A. Lubbers, J.H. Weijs, L. Botto, S. Das, B. Andreotti and J.H. Snoeijer, *Dynamical theory of the inverted cheerios effect*, Soft Matt. **13**, 6000-6010 (2017)
6. M. Hubert, M. Labousse, S. Perrard, *Self-propulsion and crossing statistics under random initial conditions*, Phys. Rev. E, **95**, 062607 (2017)

2018

1. C. Coulais, A. Sabbadini, F. Vink and M. van Hecke, *Multi-step self-guided pathways for shape-changing metamaterials*, Nature **561**, 512-527 (2018). **Green OA**
2. S. Waitukaitis, K. Harth and M. van Hecke, *From Bouncing to Floating: The Leidenfrost Effect with Hydrogel Spheres*, Phys. Rev. Lett. **121**, 048001: 1-5 (2018). **Green OA**
3. S. Waitukaitis, *Clicks for doughnuts*, Nat. Phys. **14**, 777-778 (2018). **Gold OA**

4. V. Lee, N.M. James, S. Waitukaitis and H. M. Jaeger, *Collisional charging of individual submillimeter particles: Using ultrasonic levitation to initiate and track charge transfer*, Phys. Rev. Mater. **2**: 035602: 1-11 (2018). **Green OA**
5. C. Coulais, C. Kettenis and M. van Hecke, *A characteristic length scale causes anomalous size effects and boundary programmability in mechanical metamaterials*, Nat. Phys. **14**, 40-45 (2018). **Green OA**

2019

1. S.C. Zhao, M. Maas, K. Jansen and M. van Hecke, *3D Printed Actuators: Reversibility, Relaxation, and Ratcheting*, Adv. Funct. Mater., 1905545: 1-8 (2019). **Hybrid OA**
2. L.A. Lubbers and M. van Hecke, *Excess floppy modes and multibranched mechanisms in metamaterials with symmetries*, Phys. Rev. E **100**, 021001: 1-5, (2019). **Green OA**
3. M. Kadic, G.W. Milton, M. van Hecke and M. Wegener, *3D Metamaterials*, Nature Rev. Phys. **1**, 198-210, (2019). **Green OA**

2020

1. H.C. Hendrikse, A. van der Weijden, M. Ronda-Lloret, T. Yang, R. Bliem, R. Shiju, M. van Hecke, L. Li and W.L. Noorduin, *Shape-Preserving Chemical Conversion of Architected Nanocomposites*, Adv. Mater. **32**, (52), 2003999: 1-7, (2020). **Green OA**
2. S. Waitukaitis, P. Dieleman and M. van Hecke, *Non-Euclidean origami*, Phys. Rev. E **102**, 031001 (R): 1-5, (2020). **Green OA**
3. P.K. Morse, S. Wijnmans, M. van Deen, M. van Hecke and M.L. Manning, *Differences in plasticity between hard and soft spheres*, Phys. Rev. Research **2**, (2), 023179: 1-6 (2020). **Gold OA**
4. A.S. Meeussen, E.C. Oguz, M. van Hecke and Y. Shokef, *Response evolution of mechanical metamaterials under architectural transformations*, New J. Phys. **22**, 023030: 1-24 (2020). **Gold OA**
5. A.S. Meeussen, E.C. Oguz, Y. Shokef and M. van Hecke, *Topological defects produce exotic mechanics in complex metamaterials*, Nat. Phys. **16**, 307-311 (2020). **Green OA**
6. P. Dieleman, N. Vasmel, S. Waitukaitis and M. van Hecke, *Jigsaw puzzle design of pluripotent origami*, Nat. Phys. **16**, 63-68 (2020). **Green OA**
7. H. Bense, M. Tani, M. Saint-Jean, E. Reyssat, B. Roman and J. Bico, *Elastocapillary adhesion of a soft cap on a rigid sphere*, Soft Matt. **16**, 1961-1966, (2020).
8. H. Bense, J. Snoeijer, B. Andreotti, *Mechanics and energetics of electromembranes*, Soft Robotics **7**, 675-687 (2020). **Hybrid OA**

2021

1. H. Bense and M. van Hecke, *Complex pathways and memory in compressed corrugated sheets*, PNAS **118**, e2111436118: 1-7 (2021). **Hybrid OA**
2. M. van Hecke, *Profusion of transition pathways for interacting hysterons*, Phys. Rev. E **104**, 054608: 1-11 (2021). **Green OA**
3. N. Singh and M. van Hecke, *Design of pseudo-mechanisms and multistable units for mechanical metamaterials*, Phys.Rev.Lett. **126**, 248002: 1-5 (2021). **Hybrid OA**
4. H.C. Hendrikse, A. Aguirre, A. van der Weijden, A.S. Meeussen, F. Neira D'Angelo and W.L. Noorduin, *Rational Design of Bioinspired Nanocomposites with Tunable Catalytic Activity*, Cryst.Growth Des. **21**, (8), 4299-4304 (2021). **Hybrid OA**

2022

1. R.V. Van Mastrigt, M. Dijkstra, M. van Hecke and C. Coulais, *Machine Learning of Implicit Combinatorial Rules in Mechanical Metamaterials*, Phys.Rev.Lett. **129**, 198003 (2022) **Green OA**
2. C.T. van Campenhout, D.N. ten Napel, M. van Hecke and W.L. Noorduin, *Rapid formation of uniformly layered materials by coupling reaction–diffusion processes with mechanical responsiveness*, PNAS **119**, (39), e2123156119: 1-6 (2022). **Green OA**

3. J. Ding and M. van Hecke, *Sequential snapping and pathways in a mechanical metamaterial*, J. Chem. Phys. **156**, (20), 204902: 1-8 (2022). **Green OA**
4. A. van der Weijden, M. van Hecke and W.L. Noorduyn, *Contraction and expansion of nanocomposites during ion exchange reactions*, Cryst.Growth Des. **22**, 2289-2293 (2022). **Hybrid OA**
5. M. Czajkowski, C. Coulais, M. van Hecke and D.Z. Rocklin, *Conformal elasticity of mechanism-based metamaterials*, Nat. Commun. **13**, 211: 1-9 (2022) **Gold OA**

Contributions to scientific books (chapters or entire book) 2017-2022

2017

1. C. Coulais and M. van Hecke, *Combinatorial Design of Flexelated Metamaterials*, In: Active Matter / ed. S. Tibbits. - Cambridge: MIT Press, 2017. - pp. 143-146

PhD theses 2017-2022

2018

1. P. Dieleman, *Origami Metamaterials: Design, Symmetries, and Combinatorics*, Leiden University, 2018-10-16
2. L. A. Lubbers, *Mechanical Metamaterials: Nonlinear Beams and Excess Zero Modes*, Leiden University, 2018-09-13

2019

1. N. Singh, *Strategies for mechanical metamaterial design*. Leiden University, October 4, 2019.

2020

N/A

2021

1. A.S. Meeussen, *Imperfections: using defects to program designer matter*, Leiden University, 25/05/2021.

Masters and Bachelors theses 2017-2022

2021

1. George Korovin, *"Transition graphs for linearly coupled hysterons"* master's thesis, University of Leiden, 02/2021.
2. Colin Meulblok, *"Toggling mechanical bits"*, master's thesis, University of Leiden, 10/2021.
3. Margot Teunissen, *"Inhomogeneous actuation in a non-commuting material"* master's thesis, University of Leiden, 07/2021.

Invited lectures at international conferences and meetings

2017

1. M. van Hecke, *Mechanical Metamaterials*, , ICMS winterschool 2017, Eindhoven, The Netherlands, February 16 2017.
2. M. van Hecke, *Transformers*, Heinrichfest, Chicago, USA June 3 2017.
3. M. van Hecke, *Shape Morphing Metamaterials*, Programmable Matter ESPCI, Paris, France, June 7 2017.
4. M. van Hecke, *Digital Manufacturing of Designer Matter*, 3D print conferentie Vondelpark, Amsterdam, The Netherlands, June 15 2017.

5. M. van Hecke, *Multimodal Mechanical Metamaterials*, Marseille Metamaterials 2017, Marseille, France, August 29 2017.
6. M. van Hecke, *Mechanical Metamaterials*, MSC Diderot, Paris, France, September 25 2017.

2018

1. M. van Hecke, *Mechanical Metamaterials*, LC Workshop Soft Matter & Machine Learning, 10-14 Dec 2018, Leiden
 2. M. van Hecke, *Sequential Mechanical Metamaterials*, MRS Fall Meeting, Boston, USA, 25 – 30 november 2018.
 3. M. van Hecke, *Complex Mechanical Metamaterials*, SES, Madrid, 10-12 october
 4. M. van Hecke, *Combinatorial Design of Origami*, 7OSME Autumn Convention, Oxford, United Kingdom, 4 – 9 september 2018.
 5. M. van Hecke, *Complex Mechanical Metamaterials*, META'18, Espoo, Finland, 27 aug – 1 september 2018.
 6. M. van Hecke, *Sequential Mechanical Metamaterials*, European Workshop in Acoustic & Mechanical Metamaterials, London, United Kingdom, 9-11 July 2018
 7. M. van Hecke, *Complex Mechanical Metamaterials*, LC workshop 'Topology in Complex Fluids', May 22-25, 2018.
 8. M. van Hecke, *Sequential Mechanical Metamaterials*, Symposium on Soft Matter Frontiers, Georgia Tech, Atlanta, USA, April 18 – 20, 2018
- M. van Hecke, *Bouncing, active granular matter with the elastic Leidenfrost effect*, Southern Workshop on Granular Materials, Puerto Varas (CL), Dec 5, 2018

2019

1. M. van Hecke, *Mechanical Metamaterials*, Estec, Noordwijk, the Netherlands, February 22, 2019.
2. M. van Hecke, *Topological Defects in Mechanical Metamaterials*, CECAM, Tel Aviv, Israël, April 1, 2019.
3. M. van Hecke, *Topological Defects in Mechanical Metamaterials*, DIEP, Utrecht, the Netherlands, July 2, 2019.
4. M. van Hecke, *Defects in Metamaterials*, MRS, Boston (MA), USA, December 1, 2019.
5. M. van Hecke, *Mechanical Metamaterials*, M2i, Noordwijk, the Netherlands, December 9, 2019 (keynote lecture).
6. M. van Hecke, *Sequential Metamaterials*, APS, Boston (MA), USA, December 7, 2019.

2020

1. M. van Hecke, International Conference on Programmable Materials Berlin, 27 – 29. april 2020 plenary (postponed)
2. M. van Hecke, Sequential Mechanical Metamaterials, International Congress of Theoretical and Applied Mechanics, Milano 22-27 Aug. 2020, Plenary (postponed)

2021

1. M. van Hecke, *Mechanical Memory and Information Processing*, Meeting Soft Robots, Lorentz Center, Leiden, 10/03/2021.

2022

1. M. van Hecke, *Infomatter: Can Crumples Think?* ICMS Annual Symposium (TuE), Eindhoven, The Netherlands, 24 March 2022
2. M. van Hecke, *Two lectures on mechanical metamaterials*, Saclay summerschool, France, June 17, 2022
3. M. van Hecke, *Pathways and Computing in Metamaterials*, Programmable Matter Conference Berlin Germany, 14 July 2022

4. M. van Hecke, *Pathways and Information Processing*, Harvard Applied Mechanics seminar, Material Bits, Cambridge MA, USA, 9 December 2022
5. M. van Hecke, *Multishape and Multistep Shapemorphing*, Princeton Physics of Morphing Matter workshop, Princeton NJ, USA, 13 December 2022

Academic teaching 2017-2022

2021

1. Teaching first year bachelor course (experimental physics) and master's course (mechanical metamaterials) at Leiden University.

2022

1. *Education: Master course 'Mechanical Metamaterials'; 1st year course Experimental Physics EN2*
2. Lennard Kwakernaak, Nikhef Student talk, Amsterdam, The Netherlands, 25 March 2022
Title invited oral presentation: *Beam Counters and the Four Horsemen of the Mechanical Metamaterial Apocalypse*

Selected awards & recognitions 2017-2022

2017

1. S. Waitukaitis, Leiden Institute of Physics nominee for C.J. Kok Publieksprijs, i.e. "Discoverer of the year" award

2018

1. S. Waitukaitis, Winner of Fysica Young Speakers Contest, *NNV Fysica Congress*, Utrecht (NL) 2018
2. S. Waitukaitis, Block Prize for Outstanding Young Researcher, *Aspen Center for Physics* 2018

2020

1. M. van Hecke, 2020 Physica Prize of the Dutch Physical Society
2. M. van Hecke, 2020 ESPCI (Paris) Guest Professorship (postponed due to covid)

2021

1. A. Meeussen: Ehrenfest-Afanassjewa thesis prize, awarded by the Dutch Physics Council, Leiden, 12/11/2021.
2. M. van Hecke, ERC Advanced Grant.

Valorization 2017-2022

1. Joint patent application of AMOLF, Leiden University, and ESPCI, titled "Device implementing a configurable finite state machine" based on the Invention Disclosure "Mechanical cryptography by using non-commuting metamaterials". IDF approved by AMOLF, 20/10/20.
2. Visit to Puma headquarters in Herzogenaurach, Germany, to discuss metamaterials in footwear (Jul 3-4 2017).
3. Collaborations with ASML/ARCNL in joint PhD project with Bas Overvelde and ARCNL.
4. Collaborations with a large consortium of chemical industries including BASF through joint ARCSAM PhD project 'Nacre' with Wim Noorduin.
5. Joint application with large consortium of mechanical engineering companies for Perspective Grant (2020, not granted)