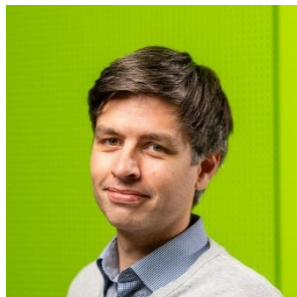


Photonic Forces, E. Verhagen (2017-2022)

Biography



Ewold Verhagen was born on October 28, 1980 in Leiderdorp, The Netherlands. He obtained his PhD in 2009 from Utrecht University for research performed at AMOLF supervised by Prof. dr. Albert Polman and Prof. dr. Kobus Kuipers. His cum laude PhD research in the fields of nanophotonics and metamaterials was awarded the national Physics Thesis Award. After a postdoctoral fellowship in the group of Prof. dr. Tobias Kippenberg at the Swiss Federal Institute of Technology Lausanne (EPFL), he started his research group *Photonic Forces* at AMOLF in 2013. He is scientific head of the *AMOLF NanoLab Amsterdam* and of the *Nanophotonics* expertise center at AMOLF. Since 2017, he is also part-time professor at Eindhoven University of Technology (TU/e). He was awarded an NWO Vidi grant, an ERC Starting Grant, and an ERC Consolidator Grant.

Ewold Verhagen studies nanophotonics and nanomechanics. His research exploits light-matter interactions that are enhanced by confining photons to very small length scales. He seeks to understand, use, and evade fundamental limits to measurement and control of light and mechanical motion. He focuses in particular on the coupling between light and nanomechanical resonators in optomechanical systems, and novel wave phenomena that are induced through controlled breaking of spatiotemporal symmetries. Current lines of research in his group are quantum measurement and control of mechanical motion, topological states of light and sound at the nanoscale, nonreciprocal photonic devices, and nanophotonic sensors and transducers.

Group output

Peer reviewed Publications 2017-2022

2017

1. Z. Zobenica, R. W. van der Heijden, M. Petruzzella, F. Pagliano, R. Leijssen, T. Xia, L. Midolo, M. Cotrufo, Y.-J. Cho, F. W. M. Van Otten, E. Verhagen, and A. Fiore, *Integrated nano-opto-electro-mechanical sensor for spectrometry and nanometrology*, Nat. Commun. **8**, 2216 (2017). **Gold OA**
2. E. Verhagen and A. Alù, *Optomechanical nonreciprocity*, Nat. Phys. **13**, 922-924 (2017). **Green OA**
3. R. Leijssen, G. La Gala, L. Freisem, J. Muhonen, and E. Verhagen, *Nonlinear cavity optomechanics with nanomechanical thermal fluctuations*, Nat. Commun. **8**, 16024 (2017). **Gold OA**
4. F. Alpeggiani, N. Parappurath, E. Verhagen, and L. Kuipers, *Quasinormal-mode expansion of the scattering matrix*, Phys. Rev. X **7**, 0214035 (2017). **Gold OA**
5. M.-A. Miri, F. Ruesink, E. Verhagen, and A. Alù, *Optical nonreciprocity based on optomechanical coupling*, Phys. Rev. Applied **7**, 064014 (2017). **Green OA**
6. M.-A. Miri, E. Verhagen, and A. Alù, *Optomechanically-induced spontaneous symmetry breaking*, Phys. Rev. A **95**, 053822 (2017). **Green OA**
7. N. Parappurath, F. Alpeggiani, L. Kuipers, and E. Verhagen, *The origin and limit of asymmetric transmission in chiral resonators*, ACS Photonics **4**, 884 (2017). **Hybrid OA**
8. M. Cotrufo, A. Fiore, and E. Verhagen, *Coherent atom-phonon interaction through mode field coupling in hybrid optomechanical systems*, Phys. Rev. Lett. **118**, 133603 (2017). **Green OA**

2018

1. F. Ruesink, H. M. Doeleman, E. Verhagen and A.F. Koenderink, *Controlling nanoantenna polarizability through backaction via a single cavity mode*, Phys. Rev. Lett. **120**, 206101: 1-6 (2018). **Green OA**
2. F. Ruesink, J. P. Mathew, M. A. Miri, A. Alù and E. Verhagen, *Optical circulation in a multimode optomechanical resonator*, Nat. Commun. **9**, 1798: 1-6 (2018). **Gold OA**

2019

1. J.T. Muhonen, G.R. La Gala, R. Leijssen and E. Verhagen, *State preparation and tomography of a nanomechanical resonator with fast light pulses*, Phys.Rev.Lett. **123**, 113601, (2019). **Green OA**
2. R. Duggan, J. Pino, E. Verhagen and A. Alù, *Optomechanically Induced Birefringence and Optomechanically Induced Faraday Effect*, Phys.Rev.Lett. **123**, 023602, (2019). **Green OA**

2020

1. J.P. Mathew, J. del Pino and E. Verhagen, *Synthetic gauge fields for phonon transport in a nano-optomechanical system*, Nat. Nanotechnol. **15**, 198-202, (2020). **Green OA**
2. N. Parappurath, F. Alpeggiani, L. Kuipers, and E. Verhagen, *“Direct observation of topological edge states in silicon photonic crystals”*, Spin, dispersion, and chiral routing, Sci. Adv. **6**, eaaw4137, (2020). **Gold OA**
3. R. Burgwal, J. del Pino, and E. Verhagen, *“Comparing nonlinear optomechanical coupling in membrane-in-the-middle and single-cavity systems”*, New. J. Phys. **22**, 113006, (2020). **Gold OA**
4. R.D. Buijs, N.J. Schilder, T.A.W. Wolterink, G. Gerini, E. Verhagen and A.F. Koenderink, *Super-Resolution without Imaging: Library-Based Approaches Using Near-to-Far-Field Transduction by a Nanophotonic Structure*, ACS Photonics **7**, (11), 3246-3256, (2020). **Hybrid OA**
5. D. Zeuch, F. Hassler, J.J. Slim and D.P. DiVincenzo, *Exact rotating wave approximation*, Ann. Phys. **423**, 168327: 1-29, (2020). **Green OA**
6. R.E.F. Silva, J. del Pino, F.J. Garcia-Vidal and J. Feist, *Polaritonic molecular clock for all-optical ultrafast imaging of wavepacket dynamics without probe pulses*, Nat. Commun. **11**, (1), 1423: 1-8, (2020) **Gold OA**

2021

1. R.D. Buijs, T.A.W. Wolterink, G. Gerini, A.F. Koenderink and E. Verhagen, *Information advantage from polarization-multiplexed readout of nanophotonic scattering overlay sensors*, Opt. Express **29**, 42900-42910 (2021) **Gold OA**
2. W. Chen, P. Roelli, H. Hu, S. Verlekar, S.P. Amirtharaj, A.I. Barreda, T.J. Kippenberg, M. Kovylyna, E. Verhagen, A. Martínez and C. Galland, *Continuous-wave frequency upconversion with a molecular optomechanical nanocavity*, Science **374**, 1264-1267 (2021) **Green OA**
3. I. Shlesinger, K.G. Cognée, E. Verhagen and A.F. Koenderink, *Integrated Molecular Optomechanics with Hybrid Dielectric-Metallic Resonators*, ACS Photonics **8**, (12), 3506-3516 (2021) **Hybrid OA**
4. T.A.W. Wolterink, R.D. Buijs, G. Gerini, E. Verhagen and A.F. Koenderink, *Calibration-based overlay sensing with minimal-footprint targets*, Appl. Phys. Lett. **119**, 111104: 1-6 (2021) **Green OA**
5. L. Mercadé, K. Pelka, R. Burgwal, A. Xuereb, A. Martínez and E. Verhagen, *Floquet Phonon Lasing in Multimode Optomechanical Systems*, Phys. Rev. Lett. **127**, 073601: 1-7 (2021) **Green OA**
6. R.D. Buijs, T.A.W. Wolterink, G. Gerini, E. Verhagen and A.F. Koenderink, *Programming Metasurface Near-Fields for Nano-Optical Sensing*, Adv. Opt. Mater. **9**, 2100435: 1-10 (2021) **Green OA**
7. T.A.W. Wolterink, R.D. Buijs, G. Gerini, A.F. Koenderink and E. Verhagen, *Localizing nanoscale objects using nanophotonic near-field transducers*, Nanophotonics **10**, 1723-1732 (2021) **Gold OA**

8. A. Laucht, F. Hohls, N. Ubbelohde, F.M. Gonzalez-Zalba, D.J. Reilly, S. Stobbe, T. Schröder, P. Scarlino, J.V. Koski, A. Dzurak, C.-H. Yang, J. Yoneda, F. Kuemmeth, H. Bluhm, J. Pla, C. Hill, J. Salfi, A. Oiwa, J.T. Muhonen, E. Verhagen, M.D. LaHaye, H.H. Kim, A.W. Tsen, D. Culcer, A. Geresdi, J.A. Mol, V. Mohan, P.K. Jain and J. Baugh, *Roadmap on quantum nanotechnologies*, *Nanotechnol.* **32**, 162003: 1- 49, (2021) **Hybrid OA**
9. P. Neveu, J. Clarke, M. Vanner and E. Verhagen, *Preparation and verification of two-mode mechanical entanglement through pulsed optomechanical measurements*, *New J. Phys.* **23**, 023026: 1-11 (2021) **Gold OA**
10. S. Arora, T. Bauer, R. Barczyk, E. Verhagen and L. Kuipers, *Direct quantification of topological protection in symmetry-protected photonic edge states at telecom wavelengths*, *Light: Sci. Appl.* **10**, 9:1-7 (2021) **Gold OA**

2022

1. R. Barczyk, N. Parappurath, S. Arora, T.A. Bauer, L.K. Kuipers and E. Verhagen, *Interplay of Leakage Radiation and Protection in Topological Photonic Crystal Cavities*, *Laser & Photonics Rev.* **16**, 2200071: 1-9 (2022) **Hybrid OA**
2. G.R. La Gala, J.P. Mathew, P. Neveu and E. Verhagen, *Nanomechanical design strategy for single-mode optomechanical measurement*, *J. Phys. D: Appl. Phys.* **55**, 22501 (2022) **Green OA**
3. J. del Pino, J.J. Slim and E. Verhagen, *Non-Hermitian chiral phononics through optomechanically induced squeezing*, *Nature* **606**, 82-87 (2022) **Green OA**
4. S. Arora, T.A. Bauer, N. Parappurath, R. Barczyk, E. Verhagen and L.K. Kuipers, *Breakdown of Spin-to-Helicity Locking at the Nanoscale in Topological Photonic Crystal Edge States*, *Phys.Rev.Lett.* **128**, 203903: 1-6 (2022) **Green OA**

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

2020

1. E. Verhagen, *Nano-optomechanics*, in *Proceedings of the International School of Physics "Enrico Fermi" Course 204 "Nanoscale Quantum Optics"*, edited by M. Agio, I. D'Amico, R. Zia, and C. Toninelli (IOS, Amsterdam; SIF, Bologna), (2020).

PhD theses 2017-2022

2017

1. Rick Leijssen, *Measuring mechanical motion using light confined at the nanoscale* (promotor, Eindhoven University of Technology, defense date: 19/10/2017)
2. Freek Ruesink, *Manipulating light with ring resonators coupled to antennas and mechanical motion* (promotor, Eindhoven University of Technology, defense date: 23/11/2017)
3. Michele Cotrufo, *Light-matter interaction in nanophotonic structures* (co-promotor, Eindhoven University of Technology, defense date: 24/01/2017)

2019

1. H.M. Doleman, *Hybrid resonators for light trapping and emission control*, University of Amsterdam, January 18, 2019 (2nd promotor). **OA**
2. N. Parappurath, *Chiral flow of light in photonic crystals with broken symmetries*, Eindhoven University of Technology, July 3, 2019 (promotor). **under embargo**

2020

1. G. R. La Gala, "*Glancing at tiny vibrations: Backaction evading measurements of mechanical motion close to the quantum regime*", Eindhoven University of Technology, July 2, 2020 (promotor). **OA**

2021

1. R.D. Buijs, *Nano-optical sensing and metrology through near- to far-field transduction*, Eindhoven University of Technology, 06/07/2021, **OA**

Masters and Bachelors theses 2017-2022

2018

1. BSc thesis; Omar Abdel Aal (2018) *Optimizing the reactive ion etching process for high-quality silicon nano-optomechanical resonators*. Applied Physics, The Hague University of Applied Sciences, Delft.
2. MSc thesis; Hessel Jagers (2018) *Characterization & tuning of double cavity optomechanical nanobeams*. Physics, Utrecht University.
3. MSc thesis; Amy van der Hel (2018) *Sliced photonic crystal nanobeam as a spin-to-photon transducer*. Advanced Matter and Energy Physics, University of Amsterdam.

2022

1. MSc thesis; K. Zijp (2022) *Evaluating known operator learning using a coupled dipole model for calculating the diffraction of optical metasurfaces*. Theoretical Physics, University of Amsterdam.
2. MSc thesis; G. Katsikas (2022) *Towards Designing Photonic Crystals with Deep Learning*. Theoretical Physics, University of Amsterdam.

Invited lectures at international conferences and meetings

2017

1. E. Verhagen, *Measurement and control of nanomechanical motion with photons confined at the nanoscale*, SPIE Optics+Photonics, San Diego, CA, United States, 8/8/2017

2018

1. E. Verhagen, *Breaking optical reciprocity through optomechanical interactions*, Frontiers of Circuit QED and Optomechanics, Vienna, Austria, February 12th – 14th, 2018.
2. E. Verhagen, *Breaking optical reciprocity through photon-phonon interactions*, UK-Netherlands Bilateral International Meeting, Milton Keynes, United Kingdom, February 21st – 22nd, 2018.
3. E. Verhagen, *Nonreciprocity in light-matter interactions*, Mechanical Systems in the Quantum Regime – Gordon Research Conference, February 25th – March 2nd, 2018.
4. E. Verhagen, *Nonlinear and pulsed optomechanical measurement in sliced photonic crystal nanobeams*, ImagineNano 2018, Bilbao, Spain, March 13th – 15th, 2018.
5. E. Verhagen, *Nano-optomechanics*, "E. Fermi" International School of Physics on Nanoscale Quantum Optics, Varenna, Italy, July 23rd – 28th, 2018.
6. E. Verhagen, *Nanophotonic optomechanics: from quantum measurement to topological phononics*, EMRS Fall Meeting, Warsaw, Poland, September 17th – 20th, 2018.

2019

1. E. Verhagen, *Effective magnetic fields for photons and phonons*, NanoMeta 2019, Seefeld, Austria, January 4, 2019.
2. E. Verhagen, *Effective magnetic fields for photons and phonons*, OMT-HOT Meeting 2019, Saanen, Switzerland, January 22, 2019.
3. E. Verhagen, *Effective magnetic field for photons and phonons through optomechanical interactions*, 3rd Workshop on Optomechanics and Brillouin Scattering (WOMBAT), Tel Aviv, Israel, March 26-28, 2019.
4. E. Verhagen, *Nonreciprocal light and sound through radiation pressure interactions*, International Nanophotonics School, Amsterdam, the Netherlands, June 17-21, 2019.
5. E. Verhagen, *Topological photons and phonons with silicon nanophotonics*, DIEP Workshop Topology and Broken Symmetries, Utrecht, the Netherlands, July 2, 2019.
6. E. Verhagen, *Controlling nanomechanical transport with radiation pressure*, Hybrid Optomechanical Technologies Network Conference (HOT2019), Ascona, Switzerland, July 7-11, 2019.
7. E. Verhagen, *Direct observation of topological states in silicon photonic crystals*, META 2019, Lisbon, Portugal, July 23, 2019.
8. J. del Pino, *Synthetic magnetic fields for phonons and photons through optomechanical interactions*, OSA Advanced Photonics Congress 2019, San Francisco, CA, USA, July 29th, August 1, 2019.
9. E. Verhagen, *Direct observation of topological states in silicon photonic crystals*, SPIE Optics & Photonics 2019, San Diego, CA, USA, August 14, 2019.
10. E. Verhagen, *Mechanical state preparation and tomography through nanophotonic measurements*, SPIE Optics & Photonics 2019, San Diego, CA, USA, August 15, 2019.
11. E. Verhagen, *Photons and phonons moving like electrons*, US/Middle East Conference on Photonics, New York, NY, USA, November 5, 2019.

2020

1. E. Verhagen, *"Light-induced breaking of time-reversal symmetry in optomechanical networks"*, CLEO 2020, online, May 11, 2020.
2. E. Verhagen, *"Topological protection in photonic crystals"*, SPIE Optics and Photonics, online, August 23-27, 2020.
3. E. Verhagen, *"Nano-optomechanical metamaterials with broken spatiotemporal symmetries"*, Metamaterials 2020, online, October 1, 2020.
4. E. Verhagen, *"Topological protection of light propagation in photonic crystals"*, ECOC 2020, online, December 10, 2020.

2021

1. E. Verhagen, *"Non-Hermitian chiral phononics in nanomechanical networks with broken symmetries"*, Physics@Veldhoven 2021 (online), Veldhoven, The Netherlands, 18/01/2021.
2. E. Verhagen, *"Nano-optomechanical sensors for measurement beyond the quantum limit"*, Physics@Veldhoven 2021 (online), Veldhoven, The Netherlands, 20/01/2021.
3. E. Verhagen, *"Non-Hermitian chiral phononics in nano-optomechanical networks"*, Topology Meets Quantum Optics (online), Benasque, Spain, 04/06/2021.
4. E. Verhagen, *"Optomechanical frequency conversion: Fundamentals and applications in photonics and phononics"*, SPPM2021 (online), Spain, Keynote talk, 10/06/2021.
5. E. Verhagen, *"Non-Hermitian chiral phononics through optomechanical interactions"*, SPIE Optics & Photonics (online), San Diego, United States, 01-05/08/2021.
6. E. Verhagen, *"Topological phononics and optomechanics"*, Topological Bosonics and Electronics, (online), 30/08/2021.

2022

1. E. Verhagen, *Probing topological states and their robustness in photonic crystals*, Nanolight, Benasque, Spain, 07/03/2022.
2. E. Verhagen, *Non-Hermitian chiral phononics in optomechanical networks*, Topological Photonics 2022, San Sebastian, Spain, 01/06/2022
3. E. Verhagen, *Topological photons in nanophotonic architectures*, CIMTEC, Perugia, Italy, 27/06/2022.
4. E. Verhagen, *Non-Hermitian chiral phononics through laser-induced synthetic magnetic fields in nano-optomechanical networks*, META, Torremolinos, Spain, 20/07/2022.
5. E. Verhagen, *Probing topological states and their robustness in two-dimensional photonic crystals*, SPIE Optics & Photonics, San Diego, CA, USA, 21/08/2022.
6. E. Verhagen, *Non-Hermitian chiral phononics in nano-optomechanical networks*, Metamaterials, Siena, Italy, 13/09/2022.
7. E. Verhagen, *Quantum measurement and sensing with mechanical resonators*, MoSaiQC Autumn School, Innsbruck, Austria, 07/10/2022.
8. E. Verhagen, *Nonreciprocal phenomena in non-Hermitian optomechanical networks*, Workshop on Extreme Wave Phenomena, New York, NY, USA, 19/10/2022.
9. E. Verhagen, *Multimode and continuum phononic systems*, Quantum Optics Meets Acoustics Workshop, Leiden, The Netherlands, 14/11/2022

Academic Teaching 2017-2022

2017

1. Guest Lecturer in *Nanophotonics* MSc course (2017), University of Amsterdam (NL).

2018

2. Guest Lecturer in *Nanophotonics* MSc course (2018), University of Amsterdam (NL).
3. Guest Lecturer in *Nanophotonics* MSc course (2018), Eindhoven University of Technology (NL).

2019

1. E. Verhagen, Guest Lecturer in *Nanophotonics* MSc course (2018), University of Amsterdam, the Netherlands.
2. E. Verhagen, Guest Lecturer in *Nanophotonics* MSc course (2018), Eindhoven University of Technology, the Netherlands.
3. E. Verhagen, *Nano-optomechanics*, International Nanophotonics School, Amsterdam, the Netherlands, June 17-21, 2019.

2020

1. E. Verhagen, Guest Lecturer in *Nanophotonics* MSc course (2020), University of Amsterdam, the Netherlands.
2. E. Verhagen, Guest Lecturer in *Nanophotonics* MSc course (2020), Eindhoven University of Technology, the Netherlands.

2021

1. E. Verhagen, Guest Lecturer in *Nanophotonics* MSc course (2021), University of Amsterdam, the Netherlands.
2. E. Verhagen, Guest Lecturer in *Nanophotonics* MSc course (2021), Eindhoven University of Technology, the Netherlands.

2022

1. E. Verhagen, Guest Lecturer in *Nanophotonics* MSc course (2022), University of Amsterdam, the Netherlands.
2. E. Verhagen, Guest Lecturer in *Nanophotonics* MSc course (2022), Eindhoven University of Technology, the Netherlands.

Selected awards & recognitions 2017-2022

2017

1. E. Verhagen, ERC Starting Grant, 2017.
2. E. Verhagen, Appointed professor of Nano-optomechanics, Eindhoven University of Technology, 1/7/2017.

2019

1. R. Buijs, second poster prize at the 7th International Topical Meeting on Nanophotonics and Metamaterials (NanoMeta) 2019, Seefeld, Austria.

2022

1. E. Verhagen, ERC Consolidator Grant, 2022
2. J. J. Slim, Oral Presentation Award, WOMBAT 2022, Erlangen, Germany, 15/06/2022.

Valorization 2017-2022

1. Collaboration with G. Gerini (TNO Delft) and contacts with R. Verberk (TNO Delft), J. Osborne (Bruker Nano), W. Coene (ASML), and R. Koops (VSL) on *reconfigurable meta-instruments for sensing and inspection* (TTW HTSM project). (2017-2021)
2. Contacts with S. Combri , L. Morvan, A. Martin, D. Dolfi (Thales), P. Seidler (IBM), M. Del Sarto (ST Micro), J. Haig (Hitachi) on *Hybrid optomechanical technologies* (FET Proactive project HOT). (2017-2021)
3. Contacts with P. Gellie (Lytid) on *THz detector technology and molecular optomechanics* (FET Open project THOR). (2018-2022)
4. Contact with Thales and TNO on compressive sensing. (2019)
5. Contact with PhotonDelta on academic and industrial research agendas. (2019)
6. Contact with Quantum.Amsterdam on academic and industrial research agendas. (2020)
7. Presentation at AMOLF industry event: "Nanophotonic sensing and metrology", AMOLF (online), 02/06/2021.
8. Discussions with FET-Open THOR Industry Advisory Committee. (2021)
9. Collaboration within Quantum Delta NL on development of *Testbed for mechanical quantum sensing* (2021-2022).
10. Contact with G. Gruca and A. Erkelens (Optics11) to explore opportunities for optical sensing development (2021).