# Job Leon Feldbrugge

Univeristy of Edinburgh
Higgs Centre for Theoretical Physics
James Clerk Maxwell Building
Peter Guthrie Tait Road
Edinburgh, EH9 3FD, Scotland

Job.Feldbrugge@ed.ac.uk
jfeldbrugge.github.io

## Referees

**Prof. Neil Turok**, University of Edinburgh, Edinburgh, Scotland and Perimeter Institute for Theoretical Physics, Waterloo, Canada (neil.turok@ed.ac.uk)
**Prof. Ue-Li Pen**, Academia Sinica, Taipei, Taiwan and Canadian Institute for Theoretical Astrophysics, Toronto, Canada (pen@cita.utoronto.ca)
**Prof. Rien van de Weygaert**, University of Groningen, Groningen, The Netherlands (weygaert@astro.rug.nl)

## Academic positions

2021 - present **Higgs Fellow** at the Higgs Centre for Theoretical Physics at the University of Edinburgh (Scotland)
2019 - 2021 **Postdoc** at the Perimeter Institute (Canada) and the Department of Physics, Carnegie Mellon University (United States)

## Education

2015 - 2019 **PhD** Physics, Perimeter Institute, University of Waterloo
*Advisor*: Neil Turok
*Thesis*: Path integrals in the sky: Classical and quantum problems with minimal assumptions
*Defense date*: October 17, 2019

2014 - 2015 **Master** Part III Mathematics (*with distinction*), University of Cambridge
*Committee*: Paul Shellard and Tommaso Giannantonio
*Thesis*: Primordial non-Gaussianity and large-scale structure

2012 - 2014 **Master** Physics (*cum laude*), van Swinderen Institute, University of Groningen
2012 - 2014 **Master** Astronomy (*cum laude*), Kapteyn Institute, University of Groningen
2012 - 2014 **Master** Mathematics (*cum laude*), Bernoulli Institute, University of Groningen
*Committee*: Rien van de Weygaert (cosmology and large-scale structure formation)
Diederik Roest (string cosmology)
Aernout van Enter (statistical mechanics)
*Thesis*: Statistics of caustics in large-scale structure formation

2009 - 2012 **Bachelor** Physics (*cum laude*), van Swinderen Institute, University of Groningen
2009 - 2012 **Bachelor** Astronomy (*cum laude*), Kapteyn Institute, University of Groningen
2009 - 2012 **Bachelor** Mathematics (*cum laude*), Bernoulli Institute, University of Groningen
*Committee*: Rien van de Weygaert (cosmology and large-scale structure formation)
Elisabetta Pallante (quantum field theory)
Gert Vegter (computational geometry)
*Thesis*: Analysis of Betti numbers and persistence diagrams of 2D Gaussian random fields

July 2016 **Summer school** It from qubit summer school, Perimeter Institute, Canada (two weeks)
July 2015 **Summer school** Prospects in theoretical physics: new insights into quantum matter, Institute for Advanced Studies, Princeton (one week)
July 2015 **Summer school** Princeton summer school on condensed matter physics (one week)
August 2011 **Summer school** Dealing with environmental heritage, Bath, United Kingdom (two weeks)
July 2010 **Summer school** University of Cambridge international summer school in science (two weeks)

## Awards

April 2020 — Canadian Association of Physicists' Division of Theoretical Physics (DTP) and Winnipeg Institute for Theoretical Physics (WITP) P.R. Wallace PhD Thesis Prize
Best PhD thesis in Theoretical Physics from a Canadian university (2020).

November 2014 — De Zeeuw-Van Dishoeck award 2014
Best master thesis in Astronomy from a Dutch university (2014).

July 2014 — GUF-100 prize 2014
Best student in the Faculty of Mathematics and Natural Sciences at the University of Groningen (2014).

November 2011 — Silver medal in the university physics competition 2011
A university competition in which groups of three physics students all over the world solve a problem and write an article in 48 hours.

September 2010 — Young Talent encouragement prize 2010 in Physics
Prize awarded by the Koninklijke Hollandse Maatschappij der Wetenschappen (Royal Holland Society of Sciences and Humanities) for the best freshman Physics student at the University of Groningen in 2009-2010.

November 2007 — Third place in the CanSat competition
The CanSat project is an annual competition organized by the Delft University of Technology. Teams of secondary school students design and build a satellite in a Coca-Cola can.

## Scholarships

March 2015 — University of Waterloo scholarship, for PhD at the Perimeter Institute

July 2014 — Hendrik Muller fund 2014: Scholarship for excelling Dutch students

June 2014 — VSB fund 2014: Scholarship for Dutch students studying in abroad

## Research Visits

May 2023 — Research visit to Beatrice Bonga, Radboud University, Nijmegen, The Netherlands

March 2023 — Research visit to Ue-Li Pen, Academia Sinica Institute of Astronomy and Astrophysics, Taipei, Taiwan

March 2023 — Research visit to Beatrice Bonga, Radboud University, Nijmegen, The Netherlands

January 2023 — Research visit to Beatrice Bonga, Radboud University, Nijmegen, The Netherlands

June 2022 — Research visit to Rien van de Weygaert, Kapteyn Institute, Groningen, The Netherlands

January 2020 — Research visit to Beatrice Bonga, Radboud University, Nijmegen, The Netherlands

June 2019 — Research visit to Rien van de Weygaert, Kapteyn Institute, Groningen, The Netherlands

October 2018 — Research visit to Rien van de Weygaert, Kapteyn Institute, Groningen, The Netherlands

May 2018 — Research visit to Jean-Luc Lehners, Albert Einstein Institute, Potsdam, Germany

Feb - Apr 2017 — Research visit to DAMTP, University of Cambridge, United Kingdom

March 2017 — Research visit to Jean-Luc Lehners, Albert Einstein Institute, Potsdam, Germany

## Publications & talks

### Journal articles

2024 — **J. Feldbrugge** and R. van de Weygaert, "What makes a cosmic filament? The dynamical origin and identity of filaments I. fundamentals in 2D", *Monthly Notices of the Royal Astronomical Society* (2024, R&R). arXiv:2405.20475 [astro-ph.CO]

2024 — **J. Feldbrugge**, "Phase-Space Delaunay Tessellation Field Estimator", *Monthly Notices of the Royal Astronomical Society* (2024, R&R). arXiv:2402.16234 [astro-ph.CO]

2023 — **J. Feldbrugge**, D. L. Jow, U.-L. Pen, "Crossing singularities in the saddle point approximation", *Physical Review Letters* (2023, R&R). arXiv:2309.12427 [quant-ph]

2023 — **J. Feldbrugge**, D. L. Jow, U.-L. Pen, "Complex classical paths in quantum reflections and tunneling", *Physical Review D* (2023, R&R). arXiv:2309.12420 [quant-ph]

2023 — **J. Feldbrugge**, N.M.D. Niezink, "Orthogonality relations for conical functions of imaginary order", (2023). arXiv:2309.05616 [math]

2023 **J. Feldbrugge**, "Complex evaluation of angular power spectra: Going beyond the Limber approximation", *Physical Review D* (2023) nr. 108, 103007. arXiv:2304.13064 [astro-ph.CO]

2023 **J. Feldbrugge**, Y. Yan, and R. van de Weygaert, "Statistics of tidal and deformation eigenvalue fields in the primordial Gaussian matter distribution: the two-dimensional case", *Monthly Notices of the Royal Astronomical Society* (2023). arXiv:2301.07200 [astro-ph.CO]

2023 **J. Feldbrugge**, and R. van de Weygaert, "Cosmic web & caustic skeleton: non-linear constrained realizations - 2D case studies", *Journal of Cosmology and Astroparticle Physics* (2013) no.2, 58. arXiv:2212.07840 [astro-ph.CO]

2023 **J. Feldbrugge**, U.-L. Pen, and N. Turok, "Oscillatory path integrals for radio astronomy," *Annals of Physics* (2023) no.451, 169255. arXiv:1909.04632 [astro-ph.HE]

2023 **J. Feldbrugge**, "Multi-plane lensing in wave optics," *Monthly Notices of the Royal Astronomical Society* (2023) nr.250, 2995-3006. arXiv:2010.03089 [astro-ph.CO]

2022 **J. Feldbrugge**, and N. Turok, "Existence of real time quantum path integrals", *Annals of Physics* (2023) arXiv:2207.12798 [hep-th]

2022 D. Jow, U.-L. Pen, and **J. Feldbrugge**, "Regimes in astrophysical lensing: refractive optics, diffractive optics, and the Fresnel scale", *Monthly Notices of the Royal Astronomical Society* (2022). arXiv:2204.12004 [astro-ph.CO]

2021 G. Wilding, K. Nevenzeel, R. van de Weygaert, G. Vegter, P. Pranav, B.J.T. Jones, K. Efstathiou, and **J. Feldbrugge**, "Persistent homology of the cosmic web. I: Hierarchical topology in ΛCDM cosmologies" *Monthly Notices of the Royal Astronomical Society* (2020) nr.507, 2968-2990. arXiv:2011.12851 [astro-ph.CO]

2020 **J. Feldbrugge**, and N. Turok, "Gravitational lensing of binary systems in wave optics," *Physical Review Letters* (2020, R&R). arXiv:2008.01154 [gr-qc]

2019 **J. Feldbrugge**, M. van Engelen, R. van de Weygaert, P. Pranav, and G. Vegter, "Stochastic homology of Gaussian vs. non-Gaussian random fields: Graphs towards Betti numbers and persistence diagrams, *Journal of Cosmology and Astroparticle Physics* (2019) no.9, 52–100. arXiv:1908.01619 [astro-ph.CO]

2019 A. Di Tucci, **J. Feldbrugge**, J.-L. Lehners, N. Turok, "Quantum incompleteness of inflation," *Physical Review D, 100* (2019) no.6, 63517. arXiv:1906.09007 [hep-th]

2019 P. Pranav, R. van de Weygaert, G. Vegter, B.J.T. Jones, R.J. Adler, **J. Feldbrugge**, C. Park, T. Buchert, and M. Kerber, "Topology and geometry of Gaussian random fields I: on Betti numbers, Euler characteristic, and Minkowski functionals" *Monthly Notices of the Royal Astronomical Society, 485* (2019) no.3, 4167–4208. arXiv:1812.07310 [astro-ph.CO]

2018 **J. Feldbrugge**, J.-L. Lehners, and N. Turok, "Inconsistencies of the new no-boundary proposal," *Universe, 4* (2018), no.10, 100–115. arXiv:1805.01609 [hep-th]

2018 **J. Feldbrugge**, R. van de Weygaert, J. Hidding, and J. Feldbrugge, "Caustic skeleton & cosmic web," *Journal of Cosmology and Astroparticle Physics* (2018) no.05, 27–81. arXiv:1703.09598 [astro-ph.CO]

2018 **J. Feldbrugge**, J. Lehners, and N. Turok, "No rescue for the no boundary proposal: Pointers to the future of quantum cosmology," *Physical Review D, 97* (2018), no.2, 23509 arXiv:1708.05104 [hep-th]

2017 **J. Feldbrugge**, J.-L. Lehners, and N. Turok, "No smooth beginning for spacetime," *Physical Review Letters, 119* (2017), no.17, 171301. arXiv:1705.00192 [hep-th]

2017 **J. Feldbrugge**, J.L. Lehners, and N. Turok, "Lorentzian quantum cosmology," *Physical Review D, 95* (2017), no.10, 103508. arXiv:1703.02076 [hep-th]

2016 **J. Feldbrugge**, J. Hidding, and R. van de Weygaert "Statistics of caustics in large-scale structure formation," *The Zeldovich Universe: Genesis and Growth of the Cosmic Web, Proceedings of the International Astronomical Union, IAU Symposium, 308* (2016), 107–114. arXiv:1412.5121 [astro-ph.CO]

2013 R. van de Weygaert, G. Vegter, H. Edelsbrunner, B.J.T. Jones, P. Pranav, C. Park, W. Hellwing, B. Eldering, N. Kruithof, E.G.P. Bos, J. Hidding, **J. Feldbrugge**, E. ten Have, M. van Engelen, M. Caroli, and M. Teillaud, "Alpha, Betti and the megaparsec universe: On the topology of the cosmic web," *Transactions on Computational Science XIV: Special Issue on Voronoi Diagrams and Delaunay Triangulation. Lecture Notes in Computer Science, Vol. 6970. Springer Berlin Heidelberg* (2013). arXiv:1306.3640 [astro-ph.CO]

### Theses

2019 **J. Feldbrugge**, "Path integrals in the sky: classical and quantum problems with minimal assumptions," PhD thesis, Perimeter Institute, University of Waterloo, supervised by N. Turok. Available online.

2015 **J. Feldbrugge**, "Primordial non-Gaussianity and large-scale structure," Part III Essay, University of Cambridge, supervised by P. Shellard and T. Giannantonio. Available online.

2014 **J. Feldbrugge**, "Statistics of caustics in large-scale structure formation," Master thesis, University of Groningen, supervised by R. van de Weygaert, D. Roest, A.E. van Enter. Available online.

2012 **J. Feldbrugge** and M. van Engelen, "Analysis of Betti numbers and persistence diagrams of two-dimensional Gaussian random fields," Bachelor thesis, University of Groningen, supervised by R. van de Weygaert, E. Pallante, G. Vegter. Available online.

### Invited talks

June 2024 Singular and Oscillatory Integrals, University College London
Presentation: Integration in the complex plane with Picard-Lefschetz theory

May 2024 Tuorla-Tartu meeting 2024: Borderless Universe
Presentation: What makes a cusp/filament?

December 2023 Gauge-Gravity by the ghats' seminar, Center for High Energy Physics (CHEP), Indian Institute of Science, India.
Presentation: Complex classical paths in quantum reflections and tunnelling

December 2023 Large-scale parity violation, Academia Sinica, Institute of Astronomy and Astrophysics, Taipei, Taiwan,
Presentation: Dissecting the cosmic web with caustics

October 2023 International Loop Quantum Gravity Seminar
Presentation: Complex saddle points in gravitational path integrals

September 2023 Theoretical Physics seminar Newcastle, University of Newcastle
Presentation: On the existence of real-time path integrals

September 2023 Complexity and Cosmos, Gran Sasso Science Institute, L'Aquila, Italy
Presentation: On the existence of real-time path integrals

July 2023 Quantum Gravity 2023, Radboud University, Nijmegen, The Netherlands
Presentation: On the existence of real-time path integrals

July 2023 Theoretical physics group, University of New Brunswick, New Brunswick, Canada
Presentation: On the existence of real-time path integrals

March 2023 Optimal Transport Theory and Applications to Physics, Ecole Physique, Les Houches, France
Presentation: Dissecting the cosmic web with caustics

September 2022 2nd Roman Juskiewicz Symposium, Nicolaus Copernicus Astronomical Center, Warsaw, Poland
Presentation: Dissecting the cosmic web with caustics

June 2022 Information Universe 4, University of Groningen, Groningen, The Netherlands
Presentation: Dissecting the cosmic web with caustics

May 2022 Cosmology seminar, Oxford University, Oxford, England
Presentation: Dissecting the cosmic web with caustics

May 2022 UK Cosmo Meeting 2022, Newcastle University, Newcastle, England
Presentation (keynote): Dissecting the cosmic web with caustics

October 2021 Higgs hour, University of Edinburgh, Edinburgh, Scotland
Presentation: Interference, caustics and oscillatory integrals

May 2021 Seminar Universidad Nacional Autonoma de Mexico, Mexico city
Presentation: Interference phenomena in lensing and quantum physics

May 2021 Sirius A symposium 2021: To infinity and beyond
Presentation: The caustic skeleton of the cosmic web

October 2020 Quantum & Gravity Seminar, Radboud Universiteit, Nijmegen, The Netherlands
Presentation: Lorentzian quantum cosmology

October 2020 Pusar group meeting, CITA, Toronto, Canada
Presentation: Multi-plane lensing and gravitational binary lensing in wave optics

November 2019 Scintillometry 2019, Max Planck Institute for Radio Astronomy, Bonn, Germany
Presentation: Oscillatory path integrals for radio astronomy

June 2018 2018 Rotman summer institute in philosophy of cosmology, Godrich, Canada
Presentation: Lorentzian quantum cosmology (two lectures)

September 2016 CITA-PI day: Gravitational non-linear instability, CITA, Toronto, Canada
Presentation: Shocks in the early universe and gravitational waves

### Contributed talks

July 2024 Relativistic effects and novel observables, University of Geneva
Presentation: What makes a filament/wall?

July 2024 Cosmology from home
Presentation: What makes a filament/wall?

June 2024 Theoretical Modeling of the Large Scale Structure of the Universe, University of Edinburgh
Presentation: What makes a filament/wall?

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| March 2024 | Large Scale Structure group meeting Cambridge, University of Cambridge<br>Presentation: Caustic skeleton: what makes a filament in the cosmic web? |
| February 2023 | The Co-evolution of the Cosmic Web and Galaxies across Cosmic Time, Kavli Institute for Theoretical Physics, UC Santa Barbara, California, United States<br>Presentation: Dissecting the cosmic web with caustics |
| July 2022 | Cosmology from Home<br>Presentation: Dissecting the cosmic web with caustics |
| March 2022 | Cosmic Cartography 2022: Exploring the Cosmic Web and Large-Scale Structure, Kavli IPMU, Kashiwa, Japan<br>Presentation: The caustic web and non-linear constrained Gaussian random fields |
| October 2021 | Tuorla-Tartu meeting 2021, University of Turku, Turku, Finland<br>Presentation: Caustic skeleton of the cosmic web |
| September 2020 | Cosmology from home 2020, virtual conference on all aspects of cosmology.<br>Presentation: The caustic skeleton of the cosmic web |
| March 2020 | Topological statistics group meeting. Department of statistics at Carnegie Mellon University, Pittsburgh, United States<br>Two presentations: Cosmology and topology I, and Cosmology and topology II |
| February 2020 | The centre for the universe Waterloo Centre for Astrophysics day, Waterloo, Canada<br>Presentation: Path integrals for radioastronomy and gravitational lensing II |
| February 2020 | Cosmology group meeting, Perimeter Institute, Waterloo, Canada<br>Presentation: The caustic skeleton of the cosmic web |
| January 2019 | The cosmic web in the local universe, Lorentz center, Leiden, The Netherlands<br>Presentation: The caustics skeleton of the cosmic web |
| October 2019 | The Future of Astronomy, Waterloo Centre for Astrophysics, Waterloo, Canada<br>Poster: Oscillatory path integrals for radio astronomy |
| September 2019 | Theory group meeting, Carnegie Mellon University, Pittsburgh, United States<br>Presentation: Interference and Picard-Lefschetz theory |
| September 2019 | Simplicity III, Perimeter Institute, Waterloo, Canada<br>Presentation: Fun with path integrals II |
| August 2019 | Graduate student meeting, Perimeter Institute, Waterloo, Canada<br>Presentation: Oscillatory integrals in the complex plane |
| June 2019 | Probabilities in cosmology, University of Groningen, The Netherlands<br>Presentation: Lorentzian beginnings of the universe |
| June 2019 | The cosmic web: from galaxies to cosmology, Edinburgh, United Kingdom<br>Presentation: Caustic skeleton of the cosmic web |
| May 2019 | Cosmology group meeting Perimeter Institute, Waterloo, Canada<br>Presentation: lenses and oscillatory integrals |
| May 2018 | Albert Einstein Institute group meeting, Potsdam, Germany<br>Presentation: Classical and weak trajectories |
| November 2017 | Path integral of gravity, Perimeter Institute, Waterloo, Canada<br>Presentation: Quantum incompleteness of inflation II |
| September 2017 | Cosmology group meeting CITA, Canada<br>Presentation: The instability of the no-boundary proposal |
| July 2017 | Cosmic web day, University of Toronto, Toronto, Canada<br>Presentation: The caustic skeleton of the cosmic web |
| May 2017 | PI-day, Perimeter Institute, Waterloo, Canada<br>Presentation: Lorentzian quantum cosmology |
| May 2017 | Theory Canada 12, York University, Toronto, Canada<br>Presentation: Lorentzian quantum cosmology |
| May 2017 | Cosmology group meeting Perimeter Institute, Waterloo, Canada<br>Presentation: Caustics in large-scale structure |
| May 2017 | String cosmology group meeting Van Swinderen Institute, Groningen, Netherlands<br>Presentation: Lorentzian quantum cosmology |
| April 2017 | New Thoughts 3: About the universe and more, Ely, United Kingdom<br>Presentation: Lorentzian quantum cosmology |
| April 2017 | British gravity meeting 2017, University of Oxford, Oxford, United Kingdom<br>Presentation: Lorentzian quantum cosmology |
| June 2016 | Cosmology group meeting CITA, Canada<br>Presentation: Statistics of caustics in large-scale structure |

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| May 2016 | Cosmology group meeting Perimeter Institute, Canada<br>Presentation: Statistics of caustics in large-scale structure |
| March 2016 | Statistics of extrema of large-scale structure, Lorentz center, Leiden, The Netherlands<br>Presentation: Statistics of caustics in large-scale structure |
| June 2014 | IAUS 308: The Zel'dovich universe, Tallinn, Estonia<br>Presentation: Statistics of caustics in large-scale structure formation |
| October 2012 | Structure of the cosmic web, Leibniz institute astrophysics, Potsdam, Germany<br>Presentation: Analysis of Betti numbers and persistence diagrams in 2D GRFs |

CONFERENCES AND WORKSHOPS (ATTENDED ONLY)

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| January 2023 | New Directions in Theoretical Physics 4, University of Edinburgh, Edinburgh, Scotland |
| June 2022 | Analogue Models of Gravity and Fluctuation-Induced phenomena, University of Edinburgh, Edinburgh, Scotland |
| June 2022 | Online Workshop "Physics of the Early Universe" |
| January 2021 | Cosmology 2021: the rise of field theory, University of Cambridge, Cambridge, The United Kingdom |
| October 2020 | The information universe: What is the role of information in our Universe? University of Groningen, Groningen, The Netherlands |
| January 2020 | First Dutch Mathematical Relativity Day, Radboud University Nijmegen, Nijmegen, The Netherlands |
| September 2019 | Cosmological frontiers in fundamental physics 2019, Perimeter Institute, Waterloo, Canada |
| November 2018 | Quantum universe, in celebration of Neil Turok's 60th birthday, Centro de Estudio Cientificos (CECs), Valdivia, Chile |
| August 2018 | Cosmology and gravitational physics with lambda, Nordita, Stockholm, Sweden |
| June 2018 | Scanning new horizons: Emergent space-time, black holes and quantum information, Van Swinderen Institute, Groningen, The Netherlands |
| January 2018 | Gravity in the early universe, Princeton University, Princeton, United States |
| June 2017 | Bounce scenarios in cosmology, Perimeter Institute, Waterloo, Canada |
| January 2017 | Fundamentals of the universe, Van Swinderen Institute, Groningen, The Netherlands |
| January 2017 | New directions in theoretical physics II, Higgs center for theoretical physics, Edinburgh, United Kingdom |
| October 2016 | Midwest relativity meeting, Perimeter Institute, Waterloo, Canada |
| June 2016 | Time in cosmology, Perimeter Institute, Canada |
| June 2016 | Concepts and paradoxes in a quantum universe, Perimeter Institute, Canada |
| June 2016 | Cosmological frontiers in fundamental physics 2016, Perimeter Institute, Canada |
| June 2015 | Convergence, Perimeter Institute, Canada |
| April 2014 | Quantum universe 4, University of Groningen, The Netherlands |
| March 2013 | Quantum universe 3, University of Groningen, The Netherlands |

# Advising

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| 2023 - present | Advisor PhD project, Benjamin Hertzsch, University of Edinburgh, Edinburgh, United Kingdom: **Probing cosmological redshift surveys with the caustic skeleton** |
| 2023 - present | Co-advisor PhD project, Anne Weber, University College London, London, United Kingdom: **Complex trajectories in laser ionization and recombination experiments** |
| 2023 - present | Co-advisor PhD project, Johanna Borissova, Perimeter Institute, Waterloo, Canada: **Lorentzian worm holes** |
| 2023 - present | Co-advisor PhD project, Ariadna Metidieri, Radboud University, Nijmegen, The Netherlands: **Lensing of rotating stars and photons in wave optics** |
| 2022 - present | Co-advisor PhD project, Joshua Jones, Dublin Institute for Advanced Studies, Dublin, Ireland: **Monte Carlo integration of oscillatory integrals** |
| 2024 - present | Advisor master project, Maé Rodriguez, University of Edinburgh, Edinburgh, United Kingdom: **Hamiltonian Monte Carlo sampling of primordial caustic constraints** |
| 2023 | Advisor master project, Vera Li, University of Edinburgh, Edinburgh, United Kingdom: **The caustic skeleton and redshift space distortions** |
| 2022 - 2023 | Co-advisor bachelor project, Yonatan Sklansky, University of Pennsylvania, United States: **Topology of multi-stream regions in $N$-body simulations** |
| 2022 - 2023 | Advisor master project, Yihan Yan, University of Waterloo, Canada: **Statistics of critical points in eigenvalue fields** |
| 2020 - 2022 | Co-advisor PhD project, Georg Wilding, University of Groningen, The Netherlands: **Topology of the two-dimensional cosmic web** |

2021 - 2022 Advisor bachelor project, Yihan Yan, Waterloo University, Canada: **Homology of two- and three-dimensional Gaussian random fields**

2020 - 2021 Co-advisor PhD project, Varun Rustagi, University of Groningen, The Netherlands: **The caustic skeleton of the local universe**

2018 - 2022 Co-supervisor master project Kevin Bixerman, University of Groningen, The Netherlands: **The caustic skeleton of the local universe**

## Teaching

June 2023 School on Fundamentals of the Universe, Lorentz Center, Leiden, The Netherlands

June 2018 2018 Rotman summer institute in philosophy of cosmology, Godrich, Canada
Two lectures on Lorentzian quantum cosmology

January 2018 PSI winter school, co-supervisor project 'Pair creation in de Sitter spacetime', Huntsville, Canada

2010 - 2015 Physics lecturer, exam training for secondary school students, UOCG Market BV

2013 - 2014 Developer of teaching material for exam training in physics, UOCG Market BV

2008 - 2014 Tutoring in mathematics and physics for secondary school students

## Service

2022 Co-organizer of the conference New Directions in Theoretical Physics 4 at the University of Edinburgh

2018 - present Reviewer for Physical Review Letters (PRL), Physical Review D (PRD), the Journal of Cosmology and Astroparticle Physics (JCAP), the Journal of High Energy Physics (JHEP), and Universe.

2013 - 2014 Chairman of the professor Hendrik de Waard foundation

2012 - 2013 Treasurer of the professor Hendrik de Waard foundation

2011 - 2012 Member of the education committee mathematics, chairman of the student council

2010 - 2014 Guide at the Gratama telescope of the Blaauw observatory, Groningen, at stargazing events

## Languages

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| Dutch | Mother tongue | English | Fluent |
| German | Elementary | French | Elementary |
| Latin | Elementary | | |

## Programming experience

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| Mathematica | Fluent | C++ | Fluent |
| Python | Moderate | Matlab | Moderate |
| Swift | Moderate | Julia | Elementary |
| Fortran | Elementary | R | Elementary |