# Job Leon Feldbrugge

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## Current position

2019 - present **Postdoc** at the Perimeter Institute (Canada) and Carnegie Mellon University (United States)

## Areas of specialization

Theoretical astronomy • Theoretical cosmology: the early and late time universe • Mathematical physics

## 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
*Defence 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)

## Research Visits

January 2020 Research visit to Beatrice Bonga, Radboud University Nijmegen, 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

## Teaching

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| 2020 - present | Co-advisor PhD student Varun Rustagi, University of Groningen, The Netherlands |
| 2018 - present | Co-supervisor master student Kevin Bixerman, University of Groningen, 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 |

## Publications & talks

### JOURNAL ARTICLES

2020 — 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" (2020). `arXiv:2011.12851 [astro-ph.CO]`

2020 — **J. Feldbrugge**, "Multi-plane lensing in wave optics," (2020). `arXiv:2010.03089 [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**, U.-L. Pen, and N. Turok, "Oscillatory path integrals for radio astronomy," *Physical Review X* (2019, R&R). `arXiv:1909.04632 [astro-ph.HE]`

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.

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| 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. |

### TALKS

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| October 2020 | Pusar group meeting, CITA, Toronto, Canada |
| | Presentation: Multi-plane lensing and gravitational binary lensing in wave optics |
| October 2020 | Quantum & Gravity Seminar, Radboud Universiteit, Nijmegen, The Netherlands |
| | Presentation: Lorentzian quantum cosmology |
| September 2020 | Cosmology from home 2020, virtual conference on all aspects of cosmology. |
| | Presentation: The caustic skeleton of the cosmic web |
| March 2020 | Topological statistics group meeting. Department of statistics at Carnegie Mellon University, Pittsburgh, United States |
| | 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 |
| | Presentation: Path integrals for radioastronomy and gravitational lensing II |
| February 2020 | Cosmology group meeting, Perimeter Institute, Waterloo, Canada |
| | Presentation: The caustic skeleton of the cosmic web |
| January 2019 | The cosmic web in the local universe, Lorentz center, Leiden, The Netherlands |
| | Presentation: The caustics skeleton of the cosmic web |
| November 2019 | Scintillometry 2019, Max Planck Institute for Radio Astronomy, Bonn, Germany |
| | Presentation (invited): Oscillatory path integrals for radio astronomy |
| October 2019 | The Future of Astronomy, Waterloo Centre for Astrophysics, Waterloo, Canada |
| | Poster: Oscillatory path integrals for radio astronomy |
| September 2019 | Theory group meeting, Carnegie Mellon University, Pittsburgh, United States |
| | Presentation: Interference and Picard-Lefschetz theory |
| September 2019 | Simplicity III, Perimeter Institute, Waterloo, Canada |
| | Presentation: Fun with path integrals II |
| August 2019 | Graduate student meeting, Perimeter Institute, Waterloo, Canada |
| | Presentation: Oscillatory integrals in the complex plane |
| June 2019 | Probabilities in cosmology, University of Groningen, The Netherlands |
| | Presentation: Lorentzian beginnings of the universe |
| June 2019 | The cosmic web: from galaxies to cosmology, Edinburgh, United Kingdom |
| | Presentation: Caustic skeleton of the cosmic web |
| May 2019 | Cosmology group meeting Perimeter Institute, Waterloo, Canada |
| | Presentation: lenses and oscillatory integrals |
| June 2018 | 2018 Rotman summer institute in philosophy of cosmology, Godrich, Canada |
| | Presentation (invited): Lorentzian quantum cosmology (two lectures) |
| May 2018 | Albert Einstein Institute group meeting, Potsdam, Germany |
| | Presentation: Classical and weak trajectories |
| November 2017 | Path integral of gravity, Perimeter Institute, Waterloo, Canada |
| | Presentation: Quantum incompleteness of inflation II |
| September 2017 | Cosmology group meeting CITA, Canada |
| | Presentation: The instability of the no-boundary proposal |
| July 2017 | Cosmic web day, University of Toronto, Toronto, Canada |
| | Presentation: The caustic skeleton of the cosmic web |
| May 2017 | PI-day, Perimeter Institute, Waterloo, Canada |
| | Presentation: Lorentzian quantum cosmology |
| May 2017 | Theory Canada 12, York University, Toronto, Canada |
| | Presentation: Lorentzian quantum cosmology |
| May 2017 | Cosmology group meeting Perimeter Institute, Waterloo, Canada |
| | Presentation: Caustics in large-scale structure |
| May 2017 | String cosmology group meeting Van Swinderen Institute, Groningen, Netherlands |
| | Presentation: Lorentzian quantum cosmology |
| April 2017 | New Thoughts 3: About the universe and more, Ely, United Kingdom |
| | Presentation: Lorentzian quantum cosmology |

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| April 2017 | British gravity meeting 2017, University of Oxford, Oxford, United Kingdom |
| | Presentation: Lorentzian quantum cosmology |
| September 2016 | CITA-PI day: Gravitational non-linear instability, CITA, Toronto, Canada |
| | Presentation (invited): Shocks in the early universe and gravitational waves |
| June 2016 | Cosmology group meeting CITA, Canada |
| | Presentation: Statistics of caustics in large-scale structure |
| May 2016 | Cosmology group meeting Perimeter Institute, Canada |
| | Presentation: Statistics of caustics in large-scale structure |
| March 2016 | Statistics of extrema of large-scale structure, Lorentz center, Leiden, The Netherlands |
| | Presentation: Statistics of caustics in large-scale structure |
| June 2014 | IAUS 308: The Zel'dovich universe, Tallinn, Estonia |
| | Presentation: Statistics of caustics in large-scale structure formation |
| October 2012 | Structure of the cosmic web, Leibniz institute astrophysics, Potsdam, Germany |
| | Presentation: Analysis of Betti numbers and persistence diagrams in 2D GRFs |

CONFERENCES AND WORKSHOPS (ATTENDED ONLY)

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| 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 |

# Awards

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| 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

## Service

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 |

## Programming experience

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