Job Leon Feldbrugge

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Higgs Centre for Theoretical Physics
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Current position

2021 - present **Higgs Fellow** at the Higgs Centre for Theoretical Physics at the University of Edinburgh (Scotland)

Areas of specialization

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

Past position

2019 - 2021 **Postdoc** at the Perimeter Institute (Canada) and 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
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

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

2022 - present	Advisor master student Joshua Jones, United Kingdom
2022 - present	Co-advisor bachelor project Yonatan Sklansky, University of Pennsylvania, United States
2022 - present	Advisor research project Yihan Yan, University of Waterloo, Canada
2020 - 2022	Co-advisor PhD student Georg Wilding, University of Groningen, The Netherlands
2021 - 2022	Advisor bachelor project Yihan Yan, Waterloo University, Canada
2020 - 2021	Co-advisor PhD student Varun Rustagi, University of Groningen, The Netherlands
2018 - 2022	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

2022 **J. Feldbrugge**, and N. Turok, "Existence of real time quantum path integrals", 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", 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" (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.

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

July 2022 Cosmology from Home
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

March 2022 Cosmic Cartography 2022: Exploring the Cosmic Web and Large-Scale Structure, Kavli IPMU, Kashiwa, Japan
Presentation: The caustic web and non-linear constrained Gaussian random fields

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

October 2021 Tuorla-Tartu meeting 2021, University of Turku, Turku, Finland
Presentation: Caustic skeleton of the cosmic web

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

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

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
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)

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

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

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

Dutch	Mother tongue	English	Fluent
German	Elementary	French	Elementary
Latin	Elementary		

Programming experience

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