

# Pratyush Pranav

ENS de Lyon France

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Born: Feb 18, 1985—Darbhanga, India

Nationality: Indian

## Areas of specialization

Cosmology, applied geometry and topology, statistics

## Current position

ERC postdoctoral fellow, ENS de Lyon, Univ. Lyon 1, France.

## Research experience

- (Nov. 2017 - Present) ERC advanced grant postdoctoral fellow, ENS de Lyon, Univ. Lyon 1, Lyon, France.  
*(Focus: Development and interpretation of geometric and topological tools in the context of cosmological data sets. Topology and geometry analyses of CMB (Planck) and galaxy survey (SDSS) datasets.)*

Supervisor: Thomas Buchert

- (Nov. 2015 - Nov. 2017) ERC advanced grant postdoctoral fellow, Faculty of electrical Engineering, Technion, Israel.  
*(Focus: Topology and geometry of stochastic processes in general, and Gaussian and Gaussian-related random fields in particular. Investigating the topology of the temperature fluctuations in the CMB to test the hypothesis of isotropy, homogeneity and Gaussianity.)*

Supervisor: Robert Adler

## Education

- 2010 – 2015 • PhD in Applied topology and Cosmology, University of Groningen, Groningen, The Netherlands.  
*(Focus: Geometry and Topology, Astrophysics (cosmology), and their interface. Development and application of tools arising from computational geometry and topology to cosmological datasets.)*
- Supervisors: Rien van de Weygaert (Kapteyn Astronomical Institute), Gert Vegter (J. B. Institute for Comp. Sci. & Maths), and Bernard Jones (Kapteyn Astronomical Institute)
- 2006 – 2009 • MS in Physics, Dept. of Physics, Indian Institute of Science, Bangalore, India.
- 2003 – 2006 • B.Sc. in Physics (Honours) and Mathematics, St. Stephens college, University of Delhi, India

## Grants, honors and awards

- 2019 – FIL Interlab grant for hiring two master students for internship (in collaboration with INSA Lyon)
- 2017 – ERC advanced grant fellowship, ENS de Lyon, Lyon, France
- 2016 – 2017 Andrew and Erna Viterbi Fellowship, Technion, Israel
- 2015 – 2017 ERC advanced grant fellowship, Technion, Haifa, Israel
- 2010 – 2014 Ubbo Emmius Fellowship (PHD), University of Groningen, Groningen, The Netherlands
- 2007 – 2008 Selected for undergraduate research school, University of Lancashire, UK
- 2006 – 2007 Selected for undergraduate research school, National University of Singapore, Singapore
- 2003 – 2006 Council of Scientific and Industrial Research (CSIR) student associate under Central Program for Youth Leadership in Science (CPYLS) for being in the top 0.1 % scorers in higher secondary examination at national level, India
- 2002 School topper's gold medal for scoring highest mark in the school in higher secondary examination, India
- 2002 National Cyber Olympiad, All India Rank 5
- 2001 National Cyber Olympiad, All India Rank 1

## Conferences and colloquia

“Topology and geometry: Application to cosmological datasets”, Korean Institute of Advanced Studies 9th Cosmology workshop – online, Seoul, South Korea, 2020 (Invited Speaker)

“Topology of fractal models: an approach to characterizing cracks in reservoirs”, 48<sup>th</sup> International -Summer School-Conference – online, Advanced Problems in Mechanics, Moscow, Russia, 2020 (Invited speaker)

“Unexpected topology of the temperature fluctuations in the Cosmic Microwave Background”, CAFFE LATTES: cosmological analysis featuring galactic foreground emission, Lattes, France, 2020 (Invited speaker)

“Topology of the matter distribution in the Universe”, Colloquium, Chebyshev Lab. of Applied Mathematics, St. Petersburg State University Russia, 2019 (Invited speaker)

“Simplicial Topology”, Colloquium, Discrete and Computational Geometry Lab., Jaroslavl State University Russia, 2019 (Invited speaker)

“Testing isotropy and homogeneity in the CMB”, Inhomogeneous cosmologies IV, Torun, Poland, 2019 (Invited speaker)

“Persistent holes in the Universe”, Colloquium, Indian Institute of Astrophysics, Bangalore, India, 2019 (Invited speaker)

“Hierarchical topology of the cosmic mass distribution”, Colloquium, Indian Institute of Science, Bangalore, India, 2019 (Invited speaker)

“Hierarchical topology of the cosmic mass distribution”, Colloquium, Indian University Center for Astronomy and Astrophysics, Pune, India, 2019 (Invited speaker)

”Hypothesis testing with persistent homology”, Colloquium, Institut national des sciences appliques de Lyon (INSA LYON), 2019 (Invited speaker)

“Identification of cosmic structures”, Colloquium, Ludwig-Maxmillian University (LMU), Munich, Germany, 2018 (Invited speaker)

“Tukey depth and CMB data”, Session at CME Statistics conference, Pisa Italy, 2018 (Invited speaker)

“Relative homology for masked datasets: Application to CMB”, Seminar at Institute of Science and Technology (IST), Vienna, Austria, 2017 (Speaker – Edelsbrunner group)

“Inhomogeneity in the CMB: analysis of Planck maps”, Inhomogeneous cosmologies IV, Torun, Poland, 2019 (Invited speaker)

“MS complex segmentation and identification of cosmic structures”, Applied Topology: Methods, Computation and Science (ATMCS), Turin, Italy, 2016 (Speaker)

“Intensity maps as empirical probabilistic description of persistence diagrams”, Applied

Probability seminar, Department of Mathematics, Technion, Israel, 2014 (Invited speaker)

“Topological data analysis”, Institute of Mathematics and its Applications, University of Minnesota, Minneapolis, 2013 (Speaker)

“Alpha, Betti and the megaparsec Universe”, Tea talk, Kavli Institute of Particle Astrophysics and Cosmology, Stanford University, 2013 (Invited Speaker)

“Alpha shape topology of the cosmic mass distribution”, Lunch talk at Johns Hopkins University, Baltimore, USA, 2013 (Invited Speaker)

“Topology of level sets of cosmological simulations”, Lunch talk at Caltech, Pasadena, USA, 2013 (Invited Speaker)

“Probing dark energy with alpha shapes and Betti numbers”, Geometry and topology of cosmic web, Warsaw, Poland, 2012 (Speaker)

“Probing for primordial non-Gaussianity using topological methods”, Primordial Features and Non-Gaussianities, HRI, Allahabad, India, 2010 (Speaker)

“Persistent topology of the LCDM universe”, Topological data analysis, Monastir, Tunisia, 2010 (Speaker)

“Algebraic topology and cosmic structure formation”, Workshop on topology and cosmology, Leiden, Netherlands, 2009 (Speaker)

## Research Visits

2017 –

- Department of Electrical Engineering, Technion, Israel. Host: Prof. Robert Adler. Period: 6 weeks.
- Chebyshev Lab. for applied maths, St. Petersburg, Russia. Host: Prof. Iskander Taimanov. Period: 1 week.
- Department of Computer Science, Jaroslavl State University, . Host: Prof. Iskander Taimanov. Period: 1 week.
- LMU, Munich, UK. Host: Prof. Jochen Weller. Period: 1 week.
- Institute of Science and Technology, Austria. Host: Prof. Herbert Edelsbrunner. Period: 4 weeks.
- Indian Institute of Astrophysics, India. Host: Prof. Pravabati Chingangbam. Period: 2 weeks.

- Institute of Mathematical Sciences, Chennai, India. Host: Prof. Areejit Samal. Period 1 week.

2015 – 2017

- Kapteyn Astronomical Institute, the Netherlands. Host: Prof. Rien van de Weygaert. Period: 4 weeks.
- Institute of Science and Technology, Austria. Host: Prof. Herbert Edelsbrunner. Period: 4 weeks.
- Indian Institute of Astrophysics, India. Host: Prof. Pravabati Chingambam. Period: 2 weeks.

2011 – 2015

- Every year a month or two to Edelsbrunner group, IST Austria
- INRIA Saclay, Host: Frederic Chazal. Period: 1 month
- INRIA Sophia-Antipolis, Antibes, France, Host Monique Teillaud. Period: 1 month.
- Inter University Center for Astronomy and Astrophysics, India, Host: Varun Sahni. Period: 1 month.

## Teaching

- 2012-2014 Teaching Assistant, University of Groningen. Taught tutorial sessions and performed assessment in undergraduate courses in astrophysics and applied topology.
- 2007-2009 Laboratory and course assistance, Indian Institute of Science. Assisted in introductory level course in physics.
- 2003-2006 Taught physics at high school level during bachelor course.

## Student Supervision

- 2020 Siddharth Kumar, Department of Physics, IISc, Bangalore *Co-supervisor with Malcolm Egan, INSA Lyon, MS project*, under FIL Interlab grant (Euro 3500).
- 2017– Quentin Vigneron, ENS de Lyon, *Co-supervisor with Prof. Thomas Buchert, PhD Candidate.*
- 2017– Etienne Jaupart, ENS de Lyon, *Co-supervisor with Prof. Thomas Buchert, PhD Candidate.*
- 2017– Master 1 and License 3 students, ENS de Lyon, *Co-supervisor with Prof. Thomas Buchert.*
- 2012–2014 Keimpe Nevenzeel, Kapteyn Astronomical Institute, *Co-supervisor with Prof. Rien van de Weygaert, MS Candidate.*
- 2012–2014 Matti van Engelen, Kapteyn Astronomical Institute, *Co-supervisor with Prof. Rien van de Weygaert, BSc Candidate.*

## Service

### Review:

- Invited book review, *Computational topology for Biomedical Images and Data: Theory and Applications*, to appear in IEEE signal processing magazine.
- Review services for the *Journal of Cosmology and Astroparticle Physics*.

### Workshop and Seminar Organization:

- *Two round table conferences at ENS de Lyon, funded from ERC grant, 2017, 2019 with Thomas Buchert.*

### Outreach:

- 2020* • *Producing a movie for school students in Russia about interaction of applied mathematics and cosmology.*
- 2011-2013* • *Assisted in public outreach events conducted by Kapteyn Astronomical institute during PhD. Gave lectures and telescope demonstration to a general audience of non-scientists including school students.*
- 2015-2017* • *Organized telescope viewing events in association with amateur astronomers and Technion for general public.*

## Referee contact information

- Prof. Robert Adler,  
Louis and Samuel Seiden Academic Chair,  
Department of Electrical Engineering,  
Technion – Israel Institute of Technology, Haifa,  
Israel.  
*Email: radler@technion.ac.il*
- Prof. Thomas Buchert,  
Centre de Recherche Astrophysique de Lyon (CRAL),  
Universite Lyon1, École Normale Supérieure de Lyon,  
Lyon, France.  
*Email : buchert@ens-lyon.fr*
- Prof. Herbert Edelsbrunner,  
Institute of Science and Technology (IST),  
Am campus 1, Maria Gugging,  
Klosterneuburg,  
Austria.  
*Email : edels@ist.ac.at*
- Prof. Bernard J. T. Jones,  
Kapteyn Astronomical Institute,  
University of Groningen,  
Landleven 12, Groningen,  
The Netherlands.  
*Email :bernard@bernardjones.net*
- Prof. Rien van de Weygaert,  
Kapteyn Astronomical Institute,  
University of Groningen,  
Landleven 12, Groningen,  
The Netherlands.  
*Email : weygaert@astro.rug.nl*

## Publications

### JOURNAL PUBLICATIONS:

**P. Pranav**, R. J. Adler, T. Buchert, H. Edelsbrunner, B. J. T. Jones, A. Schwartzman, H. Wagner, and R. Van de Weygaert, *Unexpected topology of the temperature fluctuations in the cosmic microwave background*, *Astronomy & Astrophysics*, 627, A163, 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(3), 4167-4208, 2019.

J. Feldbrugge, M. van Engelen, R. van de Weygaert, **P. Pranav**, 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 (9), 052, 2019.

R. J. Adler, S. Agami, and **P. Pranav**, *Modelling and replicating statistical topology, and evidence for CMB non-homogeneity*, *Proceedings of the National Academy of Sciences*, 114 (45), 11878-11883, 2017.

**P. Pranav**, H. Edelsbrunner, R. Van de Weygaert, G. Vegter, M. Kerber, B. J. T. Jones, M. Wintraecken, *The topology of the cosmic web in terms of persistent Betti numbers*, *Monthly Notices of the Royal Astronomical Society*, 465(4), 4281-4310, 2016.

N. Shivshankar, **P. Pranav**, V. Natarajan, R. van de Weygaert, E. G. P. Bos, S. Reider, *Felix: A topology based framework for visual exploration of cosmic filaments*, *IEEE Transactions on Visualizations and Computer Graphics*, 22 (6), 1745-1759, 2015.

**P. Pranav**, *Persistent Holes in the Universe: A (hierarchical) Topology of the Cosmic Mass Distribution*, PhD Thesis, University of Groningen, 2015.

C. Park, **P. Pranav**, P. Chingangbam, R. van de Weygaert, B. J. T. Jones, G. Vegter, I. Kim, J. Hidding, W. Hellwing, *Betti numbers of Gaussian random fields*, *Journal of the Korean Astronomical Society*, 46, 125-131, 2013.

R. van de Weygaert, G. Vegter, H. Edelsbrunner, B. J. T. Jones, **P. Pranav**, C. Park, W. Hellwing et. al., *Alpha, Betti and the megaparsec universe: on the topology of the cosmic web*, *Transactions on Computational Science*, 14, 60 – 101, Springer Verlag, 2011.

**P. Pranav**, C. J. Jog, *Response of a galactic disk to vertical perturbations: strong dependence on density distribution*, *Monthly Notices of the Royal Astronomical Society*, 406 (1), 576-585, 2010.



**INVITED REVIEW:**

**P. Pranav**, *Book Review: Computational topology for Biomedical Images and Data*, to appear in IEEE Signal Processing Magazine

**UNDER REVIEW, IN PREPARATION:**

**P. Pranav**, *Loops abound in the cosmic microwave background: A  $4\sigma$  anomaly on super-horizon scales*, in submission.

**P. Pranav**, R. van de Weygaert, G. Vegter, B. J. T. Jones, T. Buchert, J. Feldbrugge and A. Schwartzman, *Topology and geometry of Gaussian random fields II: on Morse theory and persistent homology*, in preparation.

**P. Pranav**, *Topology and geometry of the SDSS galaxy catalogue*, in preparation.

G. Wilding, K. Nevenzeel, R. van de Weygaert, G. Vegter, **P. Pranav**, B. J. T. Jones, K. Efsthathiou, J. Feldbrugge, *Persistent homology of the cosmic web. I: Hierarchical topology in  $\Lambda$ CDM cosmologies*, submitted to MNRAS.

F. Telschow, D. Cheng, **P. Pranav**, and A. Schwartzman, *Estimation of expected Euler characteristic curves of non-stationary smooth Gaussian random fields*, under final review round at Journal of American Statistical Association.