Tejas Kalelkar

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Research Interests:
My broad area of research is Low-dimensional Topology and Combinatorial Topology. In particular I am interested in triangulations, spatial graphs, knots, hyperbolic structures, foliations and Heegaard splittings of 3-dimensional manifolds.

Academic Experience:

May 2022 onwards	Associate Professor, Indian Institute of Science Education and Research Pune
December 2013 - May 2022	Assistant Professor, Indian Institute of Science Education and Research Pune
September 2010 - May 2013	William Chauvenet Postdoctoral Fellow, Washington University in St Louis, USA
November 2008 - June 2010	Postdoctoral Fellow, Institute of Mathematical Sciences, India

Education:

2010	PhD (Mathematics)	Indian Statistical Institute
2002	MSc (Mathematics)	Indian Institute of Technology Bombay
2000	BSc (Mathematics (principal), Physics - Statistics (subsidiary))	Maharaja Sayajirao University of Baroda

Publications:

1. *Essential surfaces in Seifert fiber spaces with singular surfaces,* Tejas Kalelkar and Ramya Nair, Topology and its Applications, Volume 337, 2023, Paper No. 108627.
2. *Prism complexes*, Tejas Kalelkar and Ramya Nair, Topology Proceedings, Volume 62, 2023, 45–63
3. *Bounds on Pachner moves and systoles of cusped 3-manifolds*, Tejas Kalelkar and Sriram Raghunath, Algebraic & Geometric Topology, Volume 22, Number 6, 2022, 2951–2996

4. *An upper bound on Pachner moves relating geometric triangulations*, Tejas Kalelkar and Advait Phanse, Discrete and Computational Geometry, Volume 66, Number 3, 2021, 809–830.
5. *Geometric bistellar moves relate geometric triangulations,* Tejas Kalelkar and Advait Phanse, Topology and its Applications, Volume 285, 2020, 107390–107397
6. *Strongly irreducible Heegaard splittings of hyperbolic 3-manifolds*, Tejas Kalelkar, Proceedings of American Mathematical Society, Volume 148, Number 10, 2020, 4527–4529
7. *Taut foliations in surface bundles with multiple boundary components*; Tejas Kalelkar and Rachel Roberts, Pacific Journal of Mathematics Volume 273, Number 2, 2015, 257–275.
8. *A Chain complex and Quadrilaterals for normal surfaces;* Siddhartha Gadgil and Tejas Kalelkar, Rocky Mountain Journal of Mathematics, Volume 43, Number 2, 2013, 479-487
9. *Incompressibility and normal minimal surfaces*; Tejas Kalelkar, Geometriae Dedicata, Volume 142, 2009, 61-70
10. *Euler characteristic and quadrilaterals of normal surfaces*; Tejas Kalelkar, Proceedings Mathematical Sciences, Indian Academy of Science, Volume 118, Number 2, 2008, 227-233

Accepted articles:

1. *Writhe invariants of 3-regular spatial graphs*; Stefan Friedl, Tejas Kalelkar and José Pedro Quintanilha, arXiv:2404.09649 (Accepted in Osaka Journal of Mathematics)

Submitted articles:

1. *Connecting essential triangulations I: via 2-3 and 0-2 moves*; Tejas Kalelkar, Saul Schleimer and Henry Segerman, arXiv:2405.03539
2. *Connecting essential triangulations II: via 2-3 moves only*; Tejas Kalelkar, Saul Schleimer and Henry Segerman, arXiv:2407.16509

Teaching Experience:

• ***Courses taught at Indian Institute of Science Education and Research Pune, India:***

Graduate courses

1. Topology II (Spring 2014, Fall 2022)
2. Topology I (Fall 2014, Spring 2022)
3. Riemannian Geometry (Spring 2016)
4. Low-dimensional Topology (Spring 2017)

Upper-division Undergraduate courses

1. Differential Geometry (Spring 2015, Spring 2018, Spring 2020, Spring 2021)
2. Ordinary Differential Equations (Fall 2016)
3. Algebraic Topology (Fall 2018, Fall 2020, Fall 2021)

4. Calculus on Manifolds (Spring 2019)

Lower-division Undergraduate courses
1. Singe-variable Calculus (Fall 2015)
2. Calculus II (Spring 2023)
3. Calculus I (Fall 2023, Fall 2025)

• ***Courses taught at Washington University in St Louis, USA:***
Graduate courses
1. Geometry (Fall 2012)
2. Algebraic Topology (Spring 2013)

Upper-division Undergraduate courses
1. An Introduction to Topology and Modern Analysis I (Fall 2011)
2. An Introduction to Topology and Modern Analysis II (Spring 2012)

Lower-division Undergraduate courses
1. Elementary Probability and Statistics (Fall 2010)
2. Calculus of Several Variables (Spring 2011)
3. Calculus II for the Life, Social and Managerial sciences (Fall 2011)
4. Introduction to Combinatorics (Fall 2012)

PhD dissertations supervised:
1. Ramya Nair, *Seifert fiber spaces with singular surfaces,* Defended in Jan 2024
2. Advait Phanse, *Pachner moves on Geometric triangulations*, Defended in May 2020

Masters Thesis supervised:
1. Megha Bhatt, *Geometric triangulations and hyperbolic knot theory*, 2021-2022
2. Sriram Raghunath, *Hyperbolic knot theory*, 2019-2020
3. Chris John, *Topology and geometry of 2 and 3 dimensional manifolds*, 2016-2018
4. Safeer K.M, *A study of Riemannian Geometry*, 2015-2016
5. Anay Jain, *Hyperbolic knot theory, 2025-2026 (ongoing)*

Reading Projects with students:
1. Spring 2014: Minor Thesis of PhD student Makarand Sarnobat, titled “Grushko’s Theorem on free products: A topological proof”
2. Fall 2014: Reading project for BS-MS student Safeer K.M, titled “Differential Topology”
3. Spring 2015: Minor Thesis for PhD student Girish Kulkarni, titled “Constructing 3-manifolds from S^3”
4. Fall 2015: Reading project for BS-MS student Chris John, titled “Introduction to knot theory”

5. Spring 2016: Reading project for BS-MS student Chris John, titled “Introduction to 3-manifolds”
6. Fall 2016: Reading project for BS-MS student Tanushree Shah, titled “Introduction to Homology and Cohomology”
7. Spring 2017: Graduate Theory project for PhD student Ramya Nair, titled “Low-dimensional Topology”
8. Spring 2017: Reading project for BS-MS student Tanushree Shah, titled “Low dimensional topology and geometry”
9. Summer 2017: Summer project for Irene Mallordy from ENS Lyon, France, titled “Hyperbolic Geometry and complex dynamics”
10. Summer 2017: Sumer project for Shreya Sharma from Delhi University and Kaushal Pillay from IISER Tirupathi, titled “Geometry of Surfaces”
11. Fall 2017: Reading project for BS-MS student Vishwajeet Bhoite, titled “Differential Geometry of curves and surfaces”
12. Spring 2018, Minor Thesis of PhD student Debaprasanna Kar, titled “On square peg problem and some relatives”
13. Spring 2019, Reading project for BS-MS student Sriram Raghunathan, titled ‘Introduction to Hyperbolic Knot Theory’
14. Fall 2019, Reading project for BS-MS student Kaustubh Mishra, titled ‘Convex Geometry’
15. Spring 2020, Reading project for BS-MS student Kaustubh Mishra, titled ‘Introduction to polytopes’
16. Spring 2021, Reading project for BS-MS student Megha Bhat, titled ‘Hyperbolic geometry and knot theory’
17. Fall 2021, Reading project for BS-MS student Ipsa Bezbarua, titled ‘Introduction to surfaces’
18. Spring 2022, Reading project for BS-MS student Ipsa Bezbarua, titled ‘Introduction to 3-manifolds’
19. Spring 2023, Reading project for BS-MS student Aniketh Sivakumar, titled ‘Geometry of surfaces’
20. Fall 2023, Reading project for BS-MS student Pranjal Jain, titled ‘Introduction to Knot Theory’
21. Spring 2024, Reading project for BS-MS student Pranjal Jain, titled ‘Homology and Cohomology’
22. Spring 2024, Reading project for BS-MS student Sutirtha Datta, titled ‘Introduction to surfaces and 3-manifolds’
23. Spring 2025, Reading project for PhD student Aakash Gupta, titled ‘Introduction to 3-manifolds’
24. Fall 2025, Reading project for BS-MS student Shravan Rekhi, titled ‘Algorithmic Methods for 3-Manifolds’

Awards/Fellowships:

1. Council of Scientific and Industrial Research Shyama Prasad Mukherjee Fellowship

This prestigious national fellowship is granted to the top few students clearing the all-India University Grants Commission National Entrance Test.

2. National Board of Higher Mathematics Research Fellowship.
3. Teaching Appreciation Award in Mathematics 2025 by IISER Pune.

Grants

1. SERB's Mathematical Research Impact Centric Support (MATRICS) a 3-year grant for a project titled 'Low dimensional Topology', 2018-2021, INR 6,60,000

Refereeing/Reviewing work:

1. Referee for Algebraic & Geometric Topology
2. Referee for the American Mathematical Monthly
3. Referee for the Journal of Ramanujan Mathematical Society
4. Referee for Proceedings - Mathematical Sciences, Indian Academy of Sciences
5. Reviewer for Zentralblatt MATH
6. Reviewer for MathSciNet

Institute-level Committee work

1. Associate Dean (Academics), 2025-2028 (ongoing)
2. Chair, Medical Committee, 2021 - 2023
3. Committee for Student and Campus Activities, 2021 - 2023
4. Medical Committee, 2018-2021
5. Committee for Monitoring Academic Progress, 2018 - 2021
6. Controller of Exams (CEC) committee, 2013-2016.

Department-level Committee work

1. Infrastructure Committee, 2025-onwards
2. Project Committee, 2025-onwards
3. IT Committee, 2016-2017 and 2023-2025
4. Curriculum Review Committee, 2023-2025
5. Department Safety Committee, 2021-2025
6. Research Advisory Committee for PhD students Hitesh Raundal, 2013-2018, Tumpa Mahato, 2019-2024 and Debjit Pal, 2019-2024
7. Chair, IT Committee, 2018-2023
8. Chair, Capital Expenses Budget Committee, 2022-2023
9. Seminars and Colloquia Committee, 2014-2015 and 2021-2023
10. 5th year projects committee, 2017-2018
11. BS-MS Undergraduate Committee, 2017-2018
12. In charge of the student festival Mathematics Day 2016
13. In charge of the student festival Mathematics Day 2015

Conferences organized

1. Conference on “Geometry and Topology of Surfaces”, a Symposium of the 29th Annual Conference of the RMS, held at IISER Pune (July 2014).
2. National Center for Mathematics Workshop on “Differential Geometry”, held at IISER Pune (July 2017).
3. Inter-IISER Math Meet at IISER Pune (May 2017).
4. Workshop on the Volume Conjecture and related topics in Knot Theory, held at IISER Pune (Dec 2018)
5. Conference on Geometric Topology, held at Bhaskaracharya Pratishthana (Dec 2019)
6. IISc-IISER Pune Twenty-20 Symposium, held online (Sep 2021)
7. International conference on Low-Dimensional Topology, which was organised in collaboration with TIFR Mumbai and Max Planck Society, held at IISER Pune (Sep 2023)

Outreach Activities

1. Taught at the Annual Foundation School at IISER Thiruvananthapuram (May 2015)
2. Research seminar and interacion with Maharashtra state board school teachers from Satara, as part of a program by the NGO ‘Lend a Hand India’ (December 2016)
3. Seminar on math research to students of Khalsa college visiting IISER Pune (July 2017)
4. Demonstration-talk to school children as part of a series by the NGO ‘Exciting Science Group’ (August 2017)
5. Short talk as part of a panel discussion with school children organized by the Times of India NIE meeting on ‘Scope for Scientific Research in India’ (March 2018)
6. Judge and mentor for the math panel on the inter-college student quiz Mimamsa in 2015, 2017, 2018 and 2020.
7. Seminar and tutorial session at “A glimpse into higher mathematics”, a DST funded workshop at University of Mumbai, (February 2019)
8. Workshop on ‘Euler, Plato and Balloons’ at Muktangana Science Education Center, Pune (April 2019)
9. Recorded a live online session at IISER's Science Activity Center as part of the the Next-Gen Science camps (August 2020)
10. Online lecture for the Math Training and Talent Search Trust, ‘Shapes of Space’ (Dec 2020)
11. Online lecture for the Math Club of IISER Bhopal, ‘Shapes of Space’ (Dec 2020)
12. Online lecture for the Mathematics Training and Talent Search, ‘An introduction to knot theory’ (Nov 2021)
13. Lecture to college teachers from Maharashtra as part of the MS-DEED program at IISER Pune, ‘Pedagogy that promotes research in mathematics’ (Aug 2022 and Dec 2022)
14. Lecture to school children as part of the Pi Day celebrations at IISER Pune, ‘Euler, Plato and Balloons’ (Mar 2023)

15. Lecture to college teachers from Maharashtra as part of the MS-DEED program at IISER Pune, 'Teaching mathematics as an unfinished story' (Nov 2023)
16. Taught at the Annual Foundation School at Indian Institute of Space Science and Technology (July 2024)
17. Outreach webinar for IISER in Gujarati (April 2025)

Funded Research Visits:

1. Funding by the University of Sydney Mathematical Research Institute, Australia, as part of their International Visitor Program from mid May- mid July 2025 (as part of my sabbatical).
2. Funding by the Max Planck Institute for Mathematics in Bonn, Germany, for a research visit in February - April 2025 (as part of my sabbatical).
3. Funding by Washington University in St Louis, USA, for a research visit in August-December 2024 (as part of my sabbatical).
4. Funding by Washington University in St Louis to cover travel and by GeorgiaTech to cover accommodation, to attend the Tech Topology Summer School at GeorgiaTech, USA, July 2023
5. Funding by University of Regensburg, Germany, that covered hotel stay and EUR 207 for local travel for a research seminar, January 2023
6. Mathematisches Forschungsinsitut Oberwolfach, Germany, covering food and accommodation to attend workshop, January 2023
7. International Congress of Mathematicians' Chebyshev Travel Grant, Russia, covering registration fees, food, accommodation and travel (cancelled due to the ICM moving online).
8. NSF's GEAR Travel award to visit University of California Davis for collaboration with Dr. Maria Trnkova, USA, May 2020, USD 3500 (cancelled due to the pandemic)
9. NSF support to give a talk at the Georgia Topology Conference, USA, May 2019, covering hotel accommodation and USD 400 for local travel
10. Okinawa Institute of Science and Technology's support to attend Geometry and Topology of 3-manifolds workshop, Japan, May 2018, covering accommodation and JPY 60,000 for travel
11. NSF's GEAR Travel award to visit University of California Davis for collaboration with Dr. Maria Trnkova, USA, June 2017, USD 2270
12. National Board for Higher Mathematics' Travel award to attend the International Congress of Mathematicians, South Korea, August 2014, INR 2,00,000

Invited lectures at conferences/workshops:

1. University of Missouri at St Louis, "Incompressibility and normal minimal surfaces" (Feb 2011)
2. Boston College, "Normal and incompressible surfaces in 3-manifolds" (March 2011)
3. Park City, 28th Annual Workshop in Geometric Topology, "Always-normal surfaces are incompressible" (May 2011)

4. Oklahoma State University, Stillwater ,“Taut foliations in punctured surface-bundles” (October 2012)
5. Indian Institute of Science Education and Research, Trivandrum, “Taut foliations of 3-manifolds” (August 2013)
6. Indian Statistical Institute, Kolkata, “Taut foliations in punctured surface-bundles” (November 2013)
7. Center for Theoretical Studies, Indian Institute of Technology, Kharagpur, “What does negatively curved space look like?” (November 2013)
8. Indian Statistical Institute, Delhi, “Taut foliations in surface bundles with multiple boundary components” (March 2014)
9. Knots and Low-dimensional Manifolds: A satellite conference to the International Congress of Mathematicians, Busan, Korea, “Taut foliations in surface bundles” (August 2014)
10. IISER Bhopal, Topology and Dynamics Conference, “Taut foliations of 3-manifolds” (December 2015)
11. Institut Fourier Grenoble, France, Summer workshop on Geometric Analysis, Metric Geometry and Topology “Taut foliations of 3-manifolds” (June 2016)
12. BHU Varanasi, International conference of The Indian Mathematics Consortium and American Mathematical Society, “Taut foliations of compact 3-manifolds” (December 2016)
13. Delhi University, “Shapes of space” (February 2017)
14. University of California at Davis, USA, “Taut foliations in compact manifolds with constrained boundary slopes” (June 2017)
15. Tokyo University of Science, Japan, “Taut foliations in compact 3-dimensional manifolds with constrained boundary slopes” (June 2018)
16. IISER Bhopal, Inter IISER Math Meet, “Taut foliations of 3-manifolds” (July 2018)
17. IIT Bombay, Diamond Jubilee Symposium , “Taut foliations in compact 3-manifolds” (January 2019)
18. 2019 Georgia Topology Conference, University of Georgia, USA, “Taut foliations on compact 3-manifolds with constrained boundary slopes” (May 2019)
19. Bhaskaracharya Pratishthana, Conference on Geometric Topology, “Geometric triangulations of constant curvature manifolds” (Dec 2019)
20. University of Wurzburg (Online), 36th European Workshop on Computational Geometry - EuroCG 2020, “Geometric bistellar moves relate triangulations of Euclidean, hyperbolic and spherical manifolds” (Mar 2020)
21. IISER Mohali (Online), Inter IISER-NISER Math Meet, “Bounds on Pachner moves in cusped 3-manifolds” (July 2020)
22. Spring 2021 Redbud Conference (Online), Oklahoma State University, “An upper bound on Pachner moves relating geometric triangulations” (Mar 2021)
23. IISc-IISER Pune Twenty-20 Symposium (Online), IISc-IISER Pune, “An algorithm to recognised hyperbolic manifolds” (Sep 2021)

24. The 39th Annual workshop in Geometric Topology (Online), Texas Christian University, “An Algorithm to Identify Hyperbolic Manifolds from Their Geometric Triangulations” (June 2022)
25. Tomsk State University, Russia, International conference on knot theory and applications - a satellite conference to the ICM (Online), “Bounds on Pachner moves in cusped hyperbolic 3-manifolds” (July 2022)
26. Knots and Representation Theory, Moscow-Beijing Topology Seminar series (Online), “Bounds on Pachner moves in cusped hyperbolic 3-manifolds” (Aug 2022)
27. Research seminar at IIT Kharagpur, “Techniques to recognise knots” (Oct 2022)
28. Topology’22 conference by Prof B L Sharma Higher Mathematics Trust at Benaras Hindu University (Online), “An algorithm for hyperbolic knot recognition” (Dec 2022)
29. 37th Annual Conference of the Ramanujan Mathematical Society at SSN College of Engineering, “An algorithm to identify hyperbolic manifolds using their geometric triangulations” (Dec 2022)
30. Research seminar at University of Regensburg, Germany, “An algorithm to recognise cusped hyperbolic 3-manifolds” (Jan 2023)
31. Research seminar at IISER Mohali, “An algorithm to recognise hyperbolic knots” (12th May, 2023)
32. Research seminar at University of Virginia, USA, “Algorithms to recognise knots” (3rd Aug, 2023)
33. Research seminar at International conference on Low-Dimensional Topology at IISER Pune, “ Algorithms to recognise knots” (29th Sep, 2023)
34. Research seminar at Inter IISER-NISER Mathematics meet at IISER Thiruvananthapuram, “Connecting Essential Triangulations” (26th June, 2024)
35. Geometry and Topology Seminar series, City University of New York Graduate Center, USA, “Connecting essential triangulations” (10th December, 2024)
36. Topology Seminar, University of Regensburg, Germany, “Connecting Essential Triangulations” (4th March, 2025)
37. Low-dimensional Topology Seminar, Max Planck Institute for Mathematics, Germany, “Connecting Essential Triangulations (8th April, 2025)
38. Topology Seminar, Max Planck Institute for Mathematics, Germany, “Triangulations of 3-manifolds” (14th April, 2025)
39. Yuktibhasa Seminar Series, IIT Palakkad, “Introduction to Knot Theory”, (18th August, 2025)

Workshops/Conferences Attended as a Participant (not as a speaker):

1. Mathematics Training and Talent Search, at the Indian Institute of Technology, Chennai, India (1999)
2. Mathematics Training and Talent Search, at the Indian Institute of Technology, Bombay, India (2001)
3. Visiting Students Research Program, Tata Institute of Fundamental Research, Bombay, India (2002)

4. Joint India-AMS Mathematics Meeting, Indian Institute of Science, Bangalore, India (2003)
5. Conference on Low-dimensional manifolds and Groups, Indian Statistical Institute, Bangalore, India (2004)
6. Summer School and Conference on Geometry and Topology of 3-Manifolds, International Center for Theoretical Physics (ICTP), Trieste, Italy (2005)
7. Conference cum workshop on Geometric methods in Topology, Indian Institute of Science, Bangalore, India (2006)
8. Teaching Assistant at the Advanced Training in Mathematics School, Indian Statistical Institute, Bangalore, India (2007)
9. International Workshop and Conference on Surface Mapping Class Groups and Related Topics, North-Eastern Hill University, Shillong, India (2008).
10. Workshop on Topology and Geometry of Foliations, Indian Statistical Institute, Kolkata, India (2008)
11. RMS/SMF/IMSc Indo-French Conference in Mathematics, Institute of Mathematical Sciences, Chennai, India (2008)
12. Advanced Instructional School on Atiyah-Singer Index Theorem, Indian Institute of Technology, Bombay, India (2009)
13. Instructional Workshop on Topology of Manifolds, Institute of Mathematical Sciences, Chennai, India (2010)
14. Geometry, Dynamics and Topology Day, Eastern Illinois University, Charleston, USA (2011)
15. Faces of Geometry: 3-Manifolds, Groups and Singularities - A Conference in Honor of Walter Neumann, Columbia, New York, USA (2011)
16. Geometry & Topology Down Under - A Conference in Honour of Hyam Rubinstein, Melbourne University, Melbourne, Australia (2011)
17. American Mathematical Society Fall 2011 Central Sectional Meeting, University of Nebraska - Lincoln, Lincoln, USA (2011)
18. Conference on Triangulations, Mathematisches Forschungsinstitut Oberwolfach, Oberwolfach, Germany (2012)
19. Rigidity and flexibility in dimensions 2,3 and 4, Centre International de Rencontres Mathematiques, Marseille, France (2012)
20. 3-Manifolds: Heegaard Splittings, the Curve Complex, and Hyperbolic Geometry, Rice University, Houston, USA (2013)
21. International Congress of Mathematicians, Seoul, South Korea (2014)
22. Advanced School and Discussion meeting on Symplectic Geometry and Contact Topology, TIFR, Mumbai, India (2014)
23. Summer workshop on Geometric Analysis Metric Geometry and Topology, Institut Fourier Grenoble, France (2016)
24. International conference of The Indian Math Consortium and American Math Society, BHU Varanasi, India (2016)
25. Georgia International Topology Conference, University of Georgia, USA (2017)

26. Geometry and Topology Workshop, Okinawa Institute of Science and technology, Okinawa, Japan (May 2018)
27. Mathematisches Forschungsinsitut Oberwolfach, Germany (Jan 2023)
28. Tech Topology Summer School, Georgia Tech University, Atlanta, USA (Jul 2023)

Research Summary

My broad area of research is Low-dimensional Topology and Combinatorial Topology. In particular I am interested in triangulations, spatial graphs, knots, hyperbolic structures, foliations and Heegaard splittings of 3-dimensional manifolds. Below are some of the areas that I have been working on:

Manifold recognition (with my students Advait Phanse and Sriram Raghunath): Triangulations of a manifold allow us to use combinatorial algorithms to resolve problems in geometric topology. Any two PL-triangulations of a PL-manifold are related by a finite sequence of triangulations each obtained from the previous one by one of a finite number of local combinatorial changes called bistellar moves. An explicit bound on the number of such moves needed in this bistellar sequence leads to a recognition algorithm for PL-manifolds. The geometrisation theorem of Thurston-Perelman says that all 3-dimensional manifolds can be split into pieces which are either hyperbolic or have the structure of a circle bundle over an orbifold, called Seifert fibered spaces. For geometric triangulations of hyperbolic, spherical and Euclidean n-dimensional manifolds, we have obtained an explicit bound on the length of this bistellar sequence. We have also obtained such a bound for a bistellar sequence between ideal geometric triangulations of cusped hyperbolic manifolds, which leads to an effective algorithm for hyperbolic knot equivalence. The bound is in terms of the number of tetrahedra along with an upper bound on the length of edges in the compact case and a lower bound on the dihedral angles in the cusped case. Additionally, we have shown that it is possible to construct this bistellar sequence entirely through triangulations that remain geometric. We also obtain a lower bound on systole lengths of cusped hyperbolic manifolds in terms of the number of tetrahedra and lower dihedral angle bound.

Normal surfaces: A surface embedded in a triangulated 3-manifold is called normal if it intersects each tetrahedron of the triangulation in triangular or quadrilateral disks. Normal surfaces allow us to algorithmically resolve questions about interesting surfaces in 3-manifolds. We have given a lower bound on the Euler characteristic of a normal surface, a topological invariant, in terms of the number of normal quadrilaterals in its embedding. Incompressible surfaces are an interesting class of embedded surfaces along which a 3-manifold can be cut and simplified. Haken had proved that when an incompressible surface is isotoped to have least PL-area with respect to a given triangulation, then the surface is in normal form. We have proved a converse of this result, i.e., we have shown that if with respect to every triangulation, a least PL-area representative of the given

surface is normal, then the surface must be incompressible. In joint work with my advisor Siddhartha Gadgil, we associate the homology of a chain complex to the normal surfaces in a 3-manifold. And using this we show that quadrilaterals determine a normal surface up to vertex linking spheres.

Seifert Fibered spaces (with my student Ramya Nair): We have introduced the notion of prism complexes in place of simplicial complexes and shown that while every 3-manifold has a prism complex structure, it has a special prism complex structure if and only if it is a Seifert fibered space. Incompressible surfaces are well-studied in orientable Seifert fiber spaces. But not much work has been done in the non-orientable case, where the model neighbourhood around a fiber can be either a fibered solid torus or a fibered solid Klein bottle, and hence the singular fibers may not be isolated. Extending the work of Frohman and Rannard to Seifert fiber spaces with such singular surfaces, we have shown that incompressible surfaces in such manifolds are of one of two types: pseudo-horizontal or pseudo-vertical.

Taut Foliations (with Rachel Roberts): A foliation of a 3-manifold is a decomposition into 2-dimensional injectively immersed submanifolds that are locally parallel. Taut foliations are a special kind of foliation with close links to contact structures and open book decompositions. Roberts had shown that given a surface bundle over a circle with connected boundary, the surface fibers can be perturbed to taut foliations that realise all rational boundary slopes in some neighbourhood of the slope of the fiber. We have extended her result to the multiple boundary case using the idea of laminar branched surfaces developed by Tao Li.

Heegaard Splittings: A Heegaard splitting is a way to cut a 3-manifold along an embedded surface into simpler pieces called handlebodies. Gabai and Colding gave an effective version of Li's theorem that there are only finitely many irreducible splittings of a non-Haken hyperbolic manifold. They end with an open question for the structure of irreducible splittings of Haken manifolds. We have extended their result and resolved their question for strongly-irreducible Heegaard splittings of all closed hyperbolic 3-manifolds. Our result says that there exist finitely many strongly-irreducible splittings S_i and finitely many incompressible surfaces K_j such that every splitting surface is obtained as a Haken sum of some S_i with a linear combination of K_j (up to one-sided associates).

Spatial Graphs (with Stephan Friedl and Jose Pedro Quintanilha): A basic question in spatial graph theory is to obtain an algorithm that determines when two given spatial graphs are equivalent. The writhe of a knot is a number calculated from the diagram of a knot and is not a knot invariant. However, we have obtained a linear algebraic test to check if two 3-regular spatial graphs are isomorphic by using the writhes of the circuits in the graph.

Connecting essential 3-dimensional manifold triangulations via flips (with Henry Segerman and Saul Schleimer): Edges of a triangulated 3-manifold are called inessential if they are trivial loops. Triangulations of a 3-manifold with all edges essential are called essential triangulations. We have shown that any two essential triangulations of a 3-manifold are related by a sequence of bistellar moves through essential triangulations, without introducing or removing any vertices. In particular, ideal essential triangulations of a cusped manifold are related by a sequence of bistellar moves through ideal essential triangulations. These results are proved in the more general setting of L-essential triangulations, i.e., triangulations that are essential with respect to a labelling on the lift of the cusps of the manifold to the universal cover. Given a representation, we also construct an ideal triangulation for which a solution to the Thurston's gluing equations recovers the representation. This also leads to the invariance of the quantum 1-loop invariant.

Connecting higher-dimensional manifold triangulations via flips (ongoing work with Henry Segerman): Benedetti-Petronio fine-tuned Pachner's result using the dual view-point of spines to show that any two triangulations of a closed 3-manifold with the same number of vertices are related by bistellar moves through triangulations with the same number of vertices. Matveev and Amendola generalised this to cusped 3-manifolds. This is beneficial both for defining 3-manifold invariants using triangulations and also for improving efficiency in making censuses of 3-manifolds. We are currently working on extending this result to triangulations of higher dimensional manifolds.