

# SURAJ SHANKAR

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LSA Physics  
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🔗 <https://surajshankar.com>

## RESEARCH INTERESTS

Statistical physics, elasticity, hydrodynamics, soft and active matter, physical biology

## ACADEMIC POSITIONS

Assistant Professor of Physics Jan 2024  
University of Michigan

LSA Collegiate Fellow July 2023 - present  
University of Michigan

Postdoctoral Fellow (Physics & SEAS) July 2022 - June 2023  
Harvard University

Junior Fellow, Harvard Society of Fellows July 2019 - June 2023  
Harvard University

Visiting Affiliate, Kavli Institute for Theoretical Physics March 2017 - May 2019  
University of California, Santa Barbara

Graduate Fellow, Kavli Institute for Theoretical Physics July 2017 - Dec 2017  
University of California, Santa Barbara

## EDUCATION

PhD. in **Physics** Aug 2014 - May 2019  
Syracuse University, Syracuse  
Grade Point Average (GPA): **3.97/4**  
*Advisors:* Prof. Mark J. Bowick & Prof. M. Cristina Marchetti  
Dissertation: **Geometric and Topological Aspects of Soft & Active Matter**

B. Tech (Hons.) **Chemical Engineering** Aug 2010 - July 2014  
Indian Institute of Technology Madras, Chennai  
Minor: **Physics**  
Cumulative Grade Point Average (CGPA): **9.52/10**  
*Advisor:* Prof. P. B. Sunil Kumar  
B. Tech Project: **Modeling of Membranes with In-Plane Order**

## AWARDS

- International Union of Pure and Applied Physics (IUPAP) Early Career Scientist Prize in Statistical Physics (2022), citation: *“For his outstanding theoretical contributions to soft matter and nonequilibrium statistical physics, particularly active matter and extreme mechanics, distinguished by a singular eye for connecting ideas from different fields.”*
- Rising Stars in Soft and Biological Matter, University of Chicago (2021)
- American Physical Society (APS) Dissertation Award in Statistical and Nonlinear Physics (2020), citation: *“For an outstanding doctoral thesis that blends geometry and statistical mechanics to uncover new topological phenomena in both equilibrium and active soft matter physics.”*
- Syracuse University Doctoral Dissertation Prize (2019)
- Harvard Junior Fellowship (2019)
- Kavli Institute for Theoretical Physics (KITP) Graduate Fellow (Fall 2017)
- Syracuse University IGERT Associate (2017)

- Levinstein Fellowship for Outstanding Junior Graduate Student (2015)
- Syracuse University Graduate Fellowship (2014)
- Prof. M Ramanujam Memorial Award in Chemical Engineering at IIT Madras (2012)

**PREPRINTS &  
PUBLICATIONS**

22. **S. Shankar\***, L. V. D. Scharrer\*, M. J. Bowick, M. C. Marchetti; “Spatiotemporal control of active topological defects”, 2022 [[arXiv:2212.00666](#)]
21. **S. Shankar**, L. Mahadevan; “Active muscular hydraulics”, 2022 [[bioRxiv:2022.02.20.481216](#)]
20. **S. Shankar\***, V. Raju\*, L. Mahadevan; “Optimal transport and control of active drops”, PNAS **119**(35) e2121985119 (2022) [[arXiv:2112.05676](#)]
19. R. Benzi, D. R. Nelson, **S. Shankar**, F. Toschi, X. Zhu; “Spatial population genetics with fluid flow”, Rep. Prog. Phys. **85** 096601 (2022) [[arXiv:2112.09079](#)]  
Invited review.
18. **S. Shankar**; “Quantifying and mimicking life”, Physics Today **75**, 8, 54 (2022)  
Invited book review.
17. P. Gulati, **S. Shankar**, M. C. Marchetti; “Boundaries control active channel flows”, Front. Phys. **10**:948415 (2022) [[arXiv:2205.08636](#)]
16. N. P. Mitchell\*, D. J. Cislo\*, **S. Shankar**, Y. Lin, B. I. Shraiman, S. J. Streichan; “Visceral organ morphogenesis via calcium-patterned muscle contractions”, eLife **11**:e77355 (2022) [[bioRxiv:2021.11.07.467658](#)]  
Featured in [eLife-Insight](#).
15. **S. Shankar**, A. Souslov, M. J. Bowick, M. C. Marchetti, V. Vitelli; “Topological active matter”, Nat. Rev. Phys. **4**, 380-398 (2022) [[arXiv:2010.00364](#)]  
Invited review. Featured on the [cover](#).
14. **S. Shankar\***, P. Bryde\*, L. Mahadevan; “Geometric control of topological dynamics in a singing saw”, PNAS **119**(17) e2117241119 (2022) [[arXiv:2108.10875](#)]  
Featured in media outlets including [NY Times](#), [Physics Today](#), [Harvard SEAS News & Events](#), [Phys.org](#), [EurekaAlert!](#).
13. **S. Shankar**, D. R. Nelson; “Thermalized buckling of isotropically compressed thin sheets”, Phys. Rev. E **104**, 054141 (2021) [[arXiv:2103.07455](#)]
12. A. Chardac\*, **S. Shankar\***, M. C. Marchetti, D. Bartolo; “Emergence of dynamic vortex glasses in disordered polar active fluids”, PNAS **118**(10) e20182181182020 (2021) [[arXiv:2002.12893](#)]  
Featured on the [cover](#).
11. S. Liu\*, **S. Shankar\***, M. C. Marchetti, Y. Wu; “Viscoelastic control of spatiotemporal order in bacterial active matter”, Nature **590**, 80-84 (2021) [[arXiv:2007.16206](#)]  
Featured in media outlets including [CUHK News](#), [Phys.org](#), [Bioengineer.org](#) and [Asia Research News](#).
10. **S. Shankar**; “Excavating Topology to Find Structure”, Physics **14**, 12 (2021)  
Invited viewpoint.
9. B. Loewe\*, F. Serafin\*, **S. Shankar\***, M. J. Bowick, M. C. Marchetti; “Shape and size changes of adherent elastic epithelia”, Soft Matter **16**, 5282 (2020) [[arXiv:2002.03961](#)]
8. **S. Shankar**, M. C. Marchetti; “Hydrodynamics of Active Defects: from order to chaos to defect ordering”, Phys. Rev. X **9** 041047 (2019) [[arXiv:1907.02468](#)]
7. M. Moshe\*, E. Esposito\*, **S. Shankar\***, B. Bircan, I. Cohen, D. R. Nelson, M. J. Bowick; “Kirigami mechanics as stress relief by elastic charges”, Phys. Rev. Lett. **122**, 048001 (2019) [[arXiv:1808.00925](#)]
6. M. Moshe\*, E. Esposito\*, **S. Shankar\***, B. Bircan, I. Cohen, D. R. Nelson, M. J. Bowick; “Non-linear mechanics of thin frames”, Phys. Rev. E **99**, 013002 (2019) [[arXiv:1801.08263](#)]

5. **S. Shankar**, S. Ramaswamy, M. C. Marchetti, M. J. Bowick; "Defect unbinding in active nematics", *Phys. Rev. Lett.* **121**, 108002 (2018) [[arXiv:1804.06350](https://arxiv.org/abs/1804.06350)]
4. **S. Shankar**, M. C. Marchetti; "Hidden entropy production and work fluctuations in an ideal active gas", *Phys. Rev. E* **98**, 020604(R) (2018) [[arXiv:1804.03099](https://arxiv.org/abs/1804.03099)]
3. **S. Shankar**, S. Ramaswamy, M. C. Marchetti; "Low-noise phase of a two-dimensional active nematic system", *Phys. Rev. E* **97**, 012707 (2018) [[arXiv:1710.05400](https://arxiv.org/abs/1710.05400)]  
Selected as Editor's suggestion.
2. **S. Shankar**, M. J. Bowick, M. C. Marchetti; "Topological sound and flocking on curved surfaces", *Phys. Rev. X* **7**, 031039 (2017) [[arXiv:1704.05424](https://arxiv.org/abs/1704.05424)]  
Featured in Physics *Synopsis*, Research News: **Editor's Choice** and various media outlets including [The Current \(UCSB\)](#), [The Wire](#), [Phys.org](#), [EurekaAlert!](#) and [Physics World](#).
1. P. Guillamat, J. Ignés-Mullol, **S. Shankar**, M. C. Marchetti, F. Sagués; "Probing the shear viscosity of an active nematic film", *Phys. Rev. E*, **94**, 060602(R) (2016) [[arXiv:1606.05764](https://arxiv.org/abs/1606.05764)]

\*equal contribution

#### TEACHING EXPERIENCE

Co-Lecturer (with L. Mahadevan), AM230/PHY230 (Harvard): Active matter, Spring 2023

Teaching Assistant, 8<sup>th</sup> School on Mathematical Physics: **Random Geometries**, at Universidad de los Andes, Bogota, Colombia, May 2016

#### MENTORSHIP

*Graduate students*

Grace Zhang (Harvard University), 2021-2023

Lauren Niu (Harvard University) - co-mentored with L. Mahadevan, 2021-2023

Paarth Gulati (UC Santa Barbara) - co-mentored with M. C. Marchetti, 2020-2022

Petur Bryde (Harvard University) - co-mentored with L. Mahadevan, 2019-2022

*Undergraduate students*

Luca Scharrer (UC Santa Barbara) - co-mentored with M. J. Bowick, M. C. Marchetti, 2021-2022

#### CONFERENCES, TALKS & SCHOOLS

*Invited*

"Controlling active matter - from drops to defects", PMS seminar: MIT, Cambridge, USA, Nov 2023

"Wet, active solids: Physics and Physiology", **Active Matter and Beyond**: ICTS, Bangalore, India, Nov 2023

"Controlling active matter - from drops to defects", Seminar: University of Tokyo, Tokyo, Japan, Aug 2023

"Active hydraulics and odd mechanics of muscle", Seminar: RIKEN, Kobe, Japan, Aug 2023

"Controlling active matter - from drops to defects", Seminar: University of Tokyo, Tokyo, Japan, Aug 2023

"Active hydraulics and odd mechanics of muscle", Seminar: RIKEN, Kobe, Japan, Aug 2023

“Active hydraulics and nonreciprocal mechanics of muscle”, STATPHYS28: University of Tokyo, Tokyo, Japan, Aug 2023

“Additive control of active topological defects”, **Frontiers in nonequilibrium physics: Active matter, topology and beyond**: YITP, Kyoto University, Kyoto, Japan, Aug 2023

“Controlling active matter - from drops to defects”, Physics seminar, IITM, Chennai, India, July 2023

“Active hydraulics and odd mechanics of muscle”, Simons seminar, NCBS, Bangalore, India, July 2023

“Optimally transporting active fluids”, AIMS 2023 minisymposium: **Optimal Transport and Mean Field Games with Applications and Computations**, UNC Wilmington, North Carolina, USA, June 2023

“The Physics of Active Matter”, Physics Today webinar (*virtual*), May 2023

“Active hydraulics: Physics and Physiology”, Physics seminar (*virtual*): University of Cambridge, Cambridge, UK, March 2023

“Geometry, Topology and Emergent Simplicity”, Living Histories of Ideas: APS March Meeting, Las Vegas, March 2023

“Inverse problems and controlling active matter”, Mathematical Biology seminar: Brandeis University, Waltham, USA, March 2023

“Active matter: Physics and Function”, Theoretical Physics seminar (*virtual*): University of Oxford, Oxford, UK, Feb 2023

“Active hydraulics: Physics and Physiology”, Biophysics Symposium: Yale University, New Haven, USA, Feb 2023

“Thin sheets as condensed matter”, Physics Colloquium: University of Michigan, Ann Arbor, USA, Jan 2023

“Controlling active matter - from drops to defects”, ChBE Colloquium: Georgia Tech, Atlanta, USA, Jan 2023

“Active muscular hydraulics”, Physics Colloquium: Syracuse University, Syracuse, USA, Jan 2023

“Active hydraulics: Physics and Physiology”, **Active Matter in Complex Environments**: Aspen Center for Physics, Aspen, USA, Jan 2023

**Living Histories** talk (*virtual*), Dec 2022

“Active muscular hydraulics”, Mathematics Colloquium: UIUC, Urbana-Champaign, USA, Dec 2022

“Optimally transporting active drops”, MRS Fall 2022, Boston, USA, Nov 2022

“Controlling active matter - from drops to defects”, Applied Math seminar (*virtual*): UCL, London, UK, Nov 2022

“Designing active matter in space-time”, Seminar: SFI, Santa Fe, USA, Oct 2022

“Physical determinants of muscle’s speed limit”, MCB retreat: Harvard University, Cambridge, USA, Sept 2022

“Thin sheets as condensed matter”, Physics seminar (*virtual*): SUSTech, Shenzhen, China, Sept 2022

“Active matter lessons for muscle physiology?”, **Active Matter: The Next 25 Years** (*virtual*): Lorentz Center, Leiden, Netherlands, Aug 2022

“Active muscular hydraulics”, BLaST mini-seminar (*virtual*): Georgia Tech, Atlanta,

USA, Aug 2022

“The fast and furious of muscle movement”, Computations in Science seminars: University of Chicago, Chicago, USA, May 2022

“Thin sheets as condensed matter”, Condensed Matter seminar: UMass Amherst, Amherst, USA, April 2022

“Muscular need for speed”, PLS Short Talk: MIT, Cambridge, USA, April 2022

“Active matter - from patterns to control”, Physics Colloquium: UC Berkeley, Berkeley, USA, March 2022

“Viscoelastic manipulation of collective bacterial swimming”, Cell Migration seminar (*virtual*), USA, Feb 2022

“Swimming through the weeds, bacterially”, BPPB seminar (*virtual*), USA, Feb 2022

“Active muscular hydraulics”, PMS seminar: MIT, Cambridge, USA, Feb 2022

“Active matter - from patterns to control”, WAM seminar: Harvard University, Cambridge, USA, Feb 2022

“Active matter - from patterns to control”, CSMR seminar: NYU, New York, USA, Feb 2022

“Active muscle hydraulics”, **Aditi Simha Memorial Symposium**: IISc, Bangalore, India, Jan 2022

“Need for speed: Active hydraulic limits of muscle”, MCB Friday Talk: Harvard University, Cambridge, USA, Nov 2021

“Optimal transport and control of active matter”, **Rising Stars in Soft and Biological Matter** Symposium (*virtual*): University of Chicago, Chicago, USA, Sept 2021

“Optimal transport and control of active drops”, DAMTP Statistical Physics and Soft Matter seminar (*virtual*): University of Cambridge, Cambridge, UK, June 2021

“Flocking through complex environments”, SLAAM seminar (*virtual*): UC Merced, Merced, USA, June 2021

“Active topology”, Theoretical Physics Colloquium (*virtual*): TIFR, Mumbai, India, June 2021

“Fluctuating plates and singing saws”, SIAM-MS2021 minisymposium: **At the intersection of geometry, elasticity and metamaterials** (*virtual*), Bilbao, Spain, May 2021

“Flocking through complex environments”, Kavli seminar (*virtual*): Harvard University, Cambridge, USA, April 2021

“Defect-driven melting of active fluids”, KITP program on **Symmetry, Thermodynamics and Topology in Active Matter** (*virtual*), Santa Barbara, USA, April 2020

“Geometry and Topology in Motion”, GSNP Dissertation Award Talk (*virtual*), APS March Meeting, March 2020

“Topology in motion”, Workshop on **Fluid phases of matter: From electron liquids to active matter**, CUNY, New York, USA, Dec 2019

“Hydrodynamics of active defects: from chaos to defect ordering and patterning”, MRSEC seminar: Brandeis University, Waltham, USA, Nov 2019

“Topology in motion”, Squishy Physics seminar: Harvard University, Cambridge, USA, Oct 2019

“Flocking through disorder”, PLS Short Talk: MIT, Cambridge, USA, Oct 2019

“Hydrodynamics of active defects: from chaos to defect ordering and patterning”,

Seminar: ICTS, Bangalore, India, Oct 2019

"Flocking with topology", CCMT seminar: IISc, Bangalore, India, Oct 2019

"Defect unbinding in and out of equilibrium", Aspen Summer Workshop on **Active and Driven Matter: Connecting Quantum and Classical Systems** at Aspen Center for Physics, Aspen, USA, June 2019

"Topological aspects of active & living matter", Condensed Matter Physics seminar: Harvard University, Cambridge, USA, Nov 2018

"Flocks on a sphere sound topological", Seminar: Center for Physics of Biological Function, Princeton University, Princeton, USA, Oct 2018

"Statistics and Mechanics of Kirigami", Workshop on **Geometry of Soft Matter** at IIP, Natal, Brazil, May 2018

"Flocks on a sphere sound topological", Workshop on **Topological protection in messy matter: disorder, quasicrystals, fluids and emergent states**, Georgia Institute of Technology, Atlanta, USA, May 2018

"Topological Sound & Flocking on Curved Surfaces", Berkeley Fluids seminar: UC Berkeley, Berkeley, USA, Sept 2017

"Probing Defect Dynamics in a 2D Active Nematic", Soft/Bio seminar: MRL, UC Santa Barbara, Santa Barbara, USA, April 2017

"Controlling Defect Dynamics in a 2D Active Nematic", Seminar: TIFR-TCIS Hyderabad, India, Aug 2016

#### *Contributed*

**Motility induced patterning in range expansions**, APS March Meeting, Las Vegas, USA, March, 2023

**Physics of Morphing Matter**, PCTS, Princeton, USA, Dec 2022 (*Poster Presentation: Morphable topological acoustics in a singing saw*)

"How the singing saw gets its voice", APS March Meeting, Chicago, USA, March 2022

"How the singing saw gets its voice", **Greater Boston Area Statistical Mechanics Meeting** at Northeastern University, Boston, USA, Oct 2021

**Gordon Research Seminar & Conference** on Stochastic Physics in Biology, Ventura, USA, Oct 2021 (*Poster Presentation: Need for speed: Active hydraulic limits of muscle*)

"Optimal transport of an active drop", APS March meeting (*virtual*), March 2021

"Thermalized buckling of clamped plates", APS March meeting (*virtual*), March 2021

"Optimal transport of a drop - internally actuated case", APS DFD meeting (*virtual*), Nov 2020

80<sup>st</sup> **New England Complex Fluids Workshop** at Harvard University, Cambridge, USA, Dec 2019

7<sup>th</sup> Annual Harvard Physics Department Postdoc Retreat 2019, Harvard University, Cambridge, USA, Sept 2019 (*Best Poster Award: When topology gets active!*)

**Gordon Research Seminar & Conference** on Soft Condensed Matter Physics at Colby-Sawyer College, New London, USA, Aug 2019 (*Poster Presentation: When topology gets active!*)

"Defect unbinding and a motile Kosterlitz-Thouless transition in active nematics", APS March meeting, Boston, USA, March 2019

**Materials Research Outreach Program Symposium** 2019, UC Santa Barbara, Santa Barbara, USA, Jan 2019 (*Poster Presentation*: When topology gets active!)

“Flocking on Curved Surfaces and Topological Sound”, APS March Meeting, Los Angeles, USA, March 2018

Aspen Winter Conference on **Fundamental Problems in Active Matter** at Aspen Center for Physics, Aspen, USA, Jan 2018 (*Best Poster Award*: Irreversibility in an active gas)

**Gordon Research Seminar & Conference** on Soft Condensed Matter Physics at Colby-Sawyer College, New London, USA, Aug 2017 (*Poster Presentation*: Topological Sound and Flocking on Curved Surfaces)

7<sup>th</sup> **Northeast Complex Fluids & Soft Matter Workshop** at Princeton University, Princeton, USA, May 2017 (*Best Poster Award*: Topological Sound and Flocking on Curved Surfaces)

“Geometry and Mechanics of Kirigami”, APS March Meeting, New Orleans, USA, March 2017

**ICAM Active and Smart Matter Conference** at Syracuse University, Syracuse, USA, June 2016

“Controlling Defects and Flow in Active Nematic Suspensions”, APS March Meeting, Baltimore, USA, March 2016

Boulder School for Condensed Matter and Materials Physics: **Soft Matter In and Out of Equilibrium**, at UC Boulder, Boulder, Colorado, USA, July 2015 (*Poster Presentation*: Confined Nematic Defects as Active Particles)

Workshop on **Small Clusters, Polymer Vesicles and Unusual Minima** at ICERM, Providence, USA, March 2015 (*Poster Presentation*: Confined Nematic Defects as Active Particles)

14<sup>th</sup> **New York Complex Matter Workshop** at Cornell University, Ithaca, USA, Dec 2014

“Numerical Methods in Fluid Flow Computations”, 11<sup>th</sup> **Indo-German Winter Academy** (Modeling & Algorithms For Fluid Dynamics & Heat Transfer) at CSIR-CMERI, Durgapur, India, Dec 2012

## PROFESSIONAL SERVICES

### Seminars and scientific meetings

Co-organizer: Soft, Living, Active, and Adaptive Matter (SLAAM) seminar series (Jan 2022 - present)

### Professional societies

Nominated for APS-DBIO Early Career Member (2022)

Member of Biophysical Society (BPS)

Member of Materials Research Society (MRS)

Member of American Physical Society (APS)

### Journal and book review

Referee for Nature, Nature Physics and Nature Communications; Science Advances; eLife; Reviews of Modern Physics; Physical Review Letters, Research, E and X; Proceedings of the National Academy of Sciences; Journal of Fluid Mechanics; Journal of Statistical Mechanics; New Journal of Physics; Journal of Physics A and D; and Soft Matter.

Referee for condensed matter books for Physics Today.