

# Toshi Parmar

Theoretical Physics PhD Candidate at the Marchetti Group <sup>[1]</sup>

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I use field theories and agent-based simulations to study emergent and collective phenomena in biology.

## EDUCATION AND WORK EXPERIENCE

- 2021-26 PhD in Theoretical Physics from University of California, Santa Barbara, USA
- 2019-20 Junior Research Fellowship at Simons Centre for the Study of Living Machines, Bangalore, India
- 2015-19 Bachelor of Technology in Engineering Physics from Indian Institute of Technology Bombay, India
- 2018 Research Internship at Laboratory for Bone Biomechanics, ETH Zurich, Switzerland
- 2016 Research Internship at the KEK J-PARC Neutrino Group, Japan

## RESEARCH

- 🔗 **Chemo-mechanical Couplings in Regenerating Hydra** (Jan'25 - present)  
T. Parmar, F. Brauns <sup>[2]</sup>, M. Cristina Marchetti <sup>[3]</sup>

We show that coupling morphogen production to mechanics and active-stress to morphogen can affect the energetic landscape of an active nematic and stabilize higher order topological defects in 2d.

- 🔗 **Mesh-free coarsegraining based on k-Nearest Neighbor method** (Jul'25 - present)  
T. Parmar, F. Brauns <sup>[2]</sup>, M. Cristina Marchetti <sup>[3]</sup>

We describe a new mesh-free method of coarsegraining discrete data into continuum fields inspired by the k-Nearest-Neighbor algorithm. Our method outperforms traditional interpolation and box-averaging strategies for noisy data.

- 🔗 **Proliferating Active Nematic that Collectively Senses an Anisotropic Substrate** (Jan'24 - Jul'24)  
T. Parmar, F. Brauns <sup>[2]</sup>, Y. Luo <sup>[4]</sup>, M. Cristina Marchetti <sup>[3]</sup>

Our theory of a proliferating active nematic with orientational jamming explains starting density dependence of large-scale order in a nematic and suggests a novel mechanism for collective alignment through proliferation-induced flows.

- 🔗 **Rheology of Epithelia under External Perturbations** (Jan'21 - Jan'23)  
T. Parmar, L. Dow, Beth L. Pruitt <sup>[5]</sup>, M. Cristina Marchetti <sup>[3]</sup>

We analytically and numerically studied the response of a tissue confined to a small rectangular patch to external forcing at the boundary. We found that step-strain and fast oscillatory strains are inconsequential for probing the material properties of the epithelia and found a new protocol that helps us establish material properties.

- 🔗 **Ordering and Stochasticity in Phage-Bacterial Interactions** (Sep'19 - Dec'20)  
G. Stephenson, A. Nadig, T. Parmar, V. Krishnamurthy <sup>[6]</sup>, S. Thutupalli <sup>[7]</sup>

We studied the growth and infection dynamics of E. Coli colonies infected with temperate lambda phages. We found that due to the tendency of E. Coli to form aligned domains, the infection of phages can be contained in a sector of the colony for small phage diffusivity and the majority of the colony can grow uninterrupted.

- 🔗 **Coupled Network Models for Bone Remodeling** (May'18 - July'18)  
T. Parmar, R. Muller <sup>[9]</sup>

At every point in a bone matrix during bone remodeling there are at least 16 known elements (hormones, stresses, strains, signaling molecules, etc.) that affect each other and maintain bone density. These can be encoded as high-dimensional networks. We formulated this in the language of movable cellular automaton as an alternative to finite element analysis.

## PUBLICATIONS

- 📄 Engineering alignment for programmable force actuation during in vitro morphogenesis (Jan '26)  
Luo, **Parmar**, Marchetti, Gu, Luo (*Invited review at BPR Reviews, in preparation*)
- 📄 A proliferating nematic that collectively senses an anisotropic substrate <sup>[11]</sup> (Dec '25)  
**Parmar**, Brauns, Marchetti (*Accepted at PRX Life*)

- 📖 Interplay of mechanics, growth and viral infection in a spatially expanding bacterial colony (Sep '25)  
Stephenson, Nadig, **Parmar**, Vijay Kumar, Mitarai, Krishna, Thutupalli (*In preparation*)
- 📖 Spontaneous and sustained oscillations in Epithelia <sup>[12]</sup> (Jan '25)  
**Parmar**, Dow, Pruitt, Marchetti (*PRX Life* 3, 013002)
- 📖 Engineering tools for quantifying and manipulating forces in epithelia <sup>[13]</sup> (May '23)  
Dow, **Parmar**, Marchetti, Pruitt (*Biophysics Rev.* 4, 021303)

#### CONFERENCE PRESENTATIONS

- 📖 American Physical Society - March Meeting <sup>[14]</sup> [Talk] (Mar '25, Mar '24, Mar '23)
- 📖 KITP Active Solids Program [Poster Presentation] (Nov '24)
- 📖 Boulder School for Condensed Matter and Materials Physics <sup>[15]</sup> [Poster Presentation] (Jul '24)
- 📖 Discussion Meeting on Conflict and Cooperation in Cellular Populations <sup>[16]</sup> [Poster presentation] (Feb '20)
- 📖 NCBS Annual Talks - The Circle of Life <sup>[17]</sup> [Poster presentation] (Jan '20)

#### TEACHING EXPERIENCE

- 📖 Interactive Quantitative Biology 210 - Theoretical Biophysics (Fall '25)  
Lectures on analytical and computational methods in biophysics aimed at Quantitative Biology graduate students.  
Included hands-on coding sessions in Python and problem solving sessions centered on derivations and stability analyses.
- 📖 Physics 20CL - Experimental Quantum Physics (Spring '25)  
Lectures on fundamental principles behind quantum mechanics supplementing experimental component.  
Included guiding students in creating and performing a novel measurement as the final exam.
- 📖 Physics 20AL - Experimental Physics (Fall '21, Fall '22, Fall '23)  
Lectures on fundamental principles of mechanics supplementing experimental component for Physics majors.
- 📖 Physics 25L - Modern Physics (Spring '21)
- 📖 Physics 6AL - Introductory Experimental Physics (Winter '21)

#### AWARDS, OUTREACH, AND ACCESSIBILITY

- ★ Finalist for the 2026 APS DSOFTE Emerging Soft Matter Excellence Award (2026)  
Officer for GradLife, the Student Wellbeing Association, Dept. of Physics, UCSB (2023 - present)  
Officer for Women and Gender Minorities in Physics, UCSB (2021 - present)  
Organiser for March for Science, the UCSB chapter of the National March for Science on March 7th (2025)  
Member of the SciCommSci Club <sup>[18]</sup>, a forum for discussing the science of science communication (2019 - 20)
- ★ Recipient of prestigious named scholarships for all four years of undergraduate studies (2015 - 19)  
Editor for Physics Department Newsletter of IIT Bombay (2017 - 19)  
Editor for Insight - Student Media Body of IIT Bombay (2017 - 19)  
Convener for Maths & Physics Club <sup>[19]</sup>, Institute Technical Council, IIT Bombay (2016 - 17)
- ★ Recipient of the KVPY fellowship by the Govt. of India for aptitude in research in basic sciences (2015)  
Among the National Top 1% in Indian National Standard Examination in Physics (NSEP) (2015)