Shabeeb Ameen

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RESEARCH INTERESTS

- Theoretical and computational soft matter physics of disordered systems (living and synthetic), including reconfigurable particle packings and multicellular networks (e.g., 3D vertex models).
- Mechanisms of physical learning, adaptation, and reconfiguration, where interactions and local rules enable systems to store information and acquire function.
- Emergent behavior at the interface of rigidity, geometry, and biology, with applications to processes such as tumor invasion and extracellular matrix remodeling.

SELECTED PUBLICATIONS AND PREPRINTS

(Candidate name in bold; * denotes equal contribution.)

Preprints

1. **S. Ameen**, T. Zhang, J. M. Schwarz, Training cell stress patterns in 3D cellular packings, *arXiv:2604.25439.*
2. **S. Ameen**, K. Kim, L. Theeyancheri, M. Thanh, M. Wu, A. E. Patteson, J. M. Schwarz, T. Zhang, Cell strain-stiffening drives cell breakout from embedded spheroids, *arXiv:2602.08737 (under review at eLife).*
3. W. Guo, V. R. Anisetti, K. Zhang, **S. Ameen**, A. Kandala, M. Stern, N. Pashine, J. D. Paulsen, J. M. Schwarz, T. Zhang, Learning associations in reconfigurable particle packings via local cyclic driving, *arXiv:2603.14534.*

Publications

4. T. Zhang, **S. Ameen**, S. Ghosh, et al., Enhanced extracellular matrix remodeling due to embedded spheroid fluidization, *New Journal of Physics 27, 073301 (2025).*
5. M. T. Ho Thanh, A. Poudel, **S. Ameen**, et al., Vimentin promotes collective cell migration through collagen networks via increased matrix remodeling and spheroid fluidity, *bioRxiv 2024.06.17.599259 (accepted at Communications Biology).*
6. N. R. Smith*, **S. Ameen***, et al., The neuroanatomical organization of the hypothalamus is driven by spatial and topological efficiency, *Frontiers in Systems Neuroscience 18, 1417346 (2024).*

EDUCATION

Ph.D. in Physics, Syracuse University *Expected Aug 2026*
Advisor: Prof. Jennifer M. Schwarz. Dissertation: “Learning in Reconfigurable Physical Systems: From Sand to Cells”.

B.Sc. in Physics, University of Dhaka *2014 – 2019*

RESEARCH EXPERIENCE

Graduate Research Assistant, Schwarz Theory Group *2021 – present*
Department of Physics, Syracuse University. Advisor: Prof. Jennifer M. Schwarz.

- Developed large-scale computational models of learning, rigidity, and mechanical stress organization in reconfigurable disordered systems, including 3D cellular vertex models and mechanically adaptive particle packings.
- Built and maintained simulation frameworks in C++ and Python for high-throughput numerical studies of collective mechanics, physical learning, and emergent behavior in living and synthetic matter.
- First-author work spans brain connectome analysis, tumor invasion mechanics, and learning in cellular networks.

Visiting Researcher, Wu Lab *2022 – 2023*

Biological & Environmental Engineering, Cornell University. Advisor: Prof. Mingming Wu.

- Developed computational and theoretical models of tumor spheroid mechanics and extracellular matrix remodeling.

INVITED TALKS

"Training Stress Patterns in 3D Reconfigurable Cellular Networks" *2026*
APS Global Summit 2026, Focus Session: Networks and Graphs in Biology: Topology, Geometry and Functions. Sponsored by the Division of Biological Physics and the Division of Statistical and Nonlinear Physics.

"Modeling Collective Interactions Between Embedded Spheroids and Collagen Fibers" *(delivered on behalf of T. Zhang).* *2023*
APS March Meeting 2023, Invited Session Z13: Tumor-like Spheroids Embedded in Fibrous Environments and Interacting with Immune Cells.

TECHNICAL SKILLS

Methods: Large-scale simulations of disordered many-body systems, 3D vertex models for multicellular mechanics, design and implementation of physical learning algorithms, image segmentation, quantitative microscopy analysis.

Programming: C++, Python (NumPy, SciPy, pandas, matplotlib), Bash, Mathematica.

Tools & Infrastructure: GNU/Linux, Git, CMake, LaTeX, HTCondor, U-Net segmentation, ImageJ/Fiji, ParaView.

SCHOOLS AND WORKSHOPS

- Max Planck Institute for the Physics of Complex Systems, "Unifying the Principles of Learning with and without Brains", Dresden, Germany. *2025*
- National Institute for Theory and Mathematics in Biology (NITMB), "Biological Systems that Learn". *2025*
- Aspen Center for Physics Winter Program, "Computing with Physical Systems". *2024*
- Summer School on Soft Solids and Complex Fluids, University of Massachusetts Amherst. *2023*

- ICTP-SAIFR School on Disordered Elastic Systems. *2022*

TEACHING EXPERIENCE

Lecturer, Department of Mathematics and Natural Sciences *Jan 2020 – Oct 2020*
BRAC University, Dhaka, Bangladesh.

Teaching Assistant, Department of Physics, Syracuse University

- AST 104, Stars, Galaxies & the Universe *Spring 2021, Spring 2024*
- PHY 211, General Physics I *Fall 2021*
- PHY 101, Major Concepts of Physics I *Summer 2021*

REFERENCES

Prof. Jennifer M. Schwarz
Ph.D. advisor. Professor of Physics, Syracuse University. jmschw02@syr.edu

Dr. Tao Zhang
Collaborator. Associate Professor, School of Chemistry and Chemical Engineering, Shanghai Jiao Tong University. zhangtao.scholar@gmail.com

Prof. Mingming Wu
Research internship host and collaborator. Professor, Department of Biological and Environmental Engineering, Cornell University. mw272@cornell.edu