NADA ELMELIGY

Ph.D. Candidate, Department of Physics
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Research Interests: Biological physics, soft matter, and the statistical physics of learning.

Education

Syracuse University, Syracuse, NY Aug 2021 – Present
Ph.D. in Physics (expected May 2027)

- **Thesis:** *Learning Without a Brain: Embodiment and Sleep in Physical Networks*
- **Advisor:** Prof. Jennifer M. Schwarz (Sept 2024 – present)
- **Previous Advisor:** Prof. Ivan Pechenezhskiy (May 2022 – Aug 2024)

Zewail City of Science and Technology, Giza, Egypt Sept 2017 – Jun 2021
B.Sc. in Theoretical High Energy Physics

- **Thesis:** *Quantum Weak Measurement Review and Application* (Advisor: Prof. Salem Hegazy)

Publications

Preprints

[1] **N. Elmeligy**, N. Chen, and J. M. Schwarz, "Embodied physical learning: a trained bacterial cell wall can guide organism behavior," arXiv:2611.07112 (2026).

In Final Revision

[2] **N. Elmeligy**, N. Pashine, and J. M. Schwarz, "Why continual physical learners need sleep". *(arXiv preprint forthcoming)*

Research Experience

Graduate Researcher, Schwarz Group, Syracuse University Sept 2024 – Present
Computational Biophysics and Physical Learning

- **Embodied physical learning in the bacterial cell wall** [1]
  Trained a model of the *E. coli* cell wall with a local learning rule so that wall contact on one side reaches the motors on the other, turning the cell away from surfaces. On the first tumble after the cell is trapped at a wall, it recovers 89% of the escape advantage of an ideal controller that senses which side was hit.
- **Why continual physical learners need sleep** [2]
  Showed that learning uses up a network's capacity to learn, and derived a conservation law that tracks this cost. Local repair restores that capacity at a cost to memory, and it works better offline because ongoing task activity distorts the signal repair relies on.
- **Emergence of sleep-wake rhythms**
  Developing a model in which a learner switches between online task learning and offline consolidation on its own, through local damage-sensing and repair, without an externally imposed schedule.
- **Crypt formation in intestinal organoids**
  With M. Blatchley, building on S. Ameen's model of an organoid in an elastic fiber-network matrix (based on T. Zhang's 3D vertex model code) to study how crypts form; extending the model with tissue growth now, and with a lumen and chemical gradients next.

Graduate Researcher, Pechenezhskiy Lab, Syracuse University May 2022 – Aug 2024
Superconducting Quantum Computing

- Performed low-temperature microwave spectroscopy of superconducting qubit devices; built Python software for instrument control, data acquisition, analysis, and hardware calibration.

Fellowships and Awards

- **Syracuse University Fellowship, College of Arts and Sciences** 2024–2025
- **Merit Scholarship (95% tuition), Zewail City of Science and Technology** 2017–2021

Summer Schools and Workshops

- **Boulder Summer School in Condensed Matter and Materials Physics** July 2026
  Geometry and Topology in Soft Matter, University of Colorado Boulder.
- **Unifying the Principles of Learning with and without Brains** July 2025
  International workshop, Max Planck Institute for the Physics of Complex Systems (MPI-PKS), Dresden, Germany.

Conference Presentations

Contributed Talks

- **APS Global Physics Summit**, March 2026, Denver, CO
  N. Elmeligy and J. M. Schwarz, "Can a Trained Elastic Network Make *E. coli* Smarter?"
- **APS Global Physics Summit**, March 2025, Anaheim, CA
  N. Elmeligy and J. M. Schwarz, "Lenia in Physical Learning: a Biologically Relevant Artificial Life Model for Principles of Learning and Adaptation"

Posters

- **Bioinspired Institute and EmIRGE-Bio NRT Symposium**, November 2026, Syracuse, NY
  N. Elmeligy, N. Pashine, and J. M. Schwarz, "Why continual physical learners need sleep"
- **Boulder Summer School in Condensed Matter and Materials Physics**, July 2026, Boulder, CO
  N. Elmeligy, N. Chen, and J. M. Schwarz, "Physical Learning in Living Matter: Training the Bacterial Cell Wall to Escape from Surfaces"
- **Mechanobiology Hub Summer Symposium**, May 2026, Cornell University, Ithaca, NY
  N. Elmeligy, N. Chen, and J. M. Schwarz, "Mechanochemical Model for Adaptive Motility in *E. coli* via Peptidoglycan Network Training"
- **Gordon Research Conference on Soft Condensed Matter Physics**, August 2025, New London, NH
  N. Elmeligy and J. M. Schwarz, "Learning Maze Geometry: A Physical Learning Network Model for *E. coli* Locomotion"
- **Unifying the Principles of Learning with and without Brains**, July 2025, MPI-PKS, Dresden, Germany
  N. Elmeligy, "Learning and Adaptation in Particle Lenia"

Technical Skills

- **Programming & Software:** Python, Git, LaTeX, Mathematica, MATLAB
- **Computational Methods:** Disordered elastic-network simulation, sparse linear-response solvers, agent-based motility simulation
- **Experimental:** Low-temperature spectroscopy on superconducting qubit devices, microwave engineering, instrument control, data acquisition, equipment calibration
- **Languages:** Arabic (native), English (fluent)

Teaching Experience

- **TA, Syracuse University** (course to be assigned) Spring 2027
- **TA, AST 101 – Our Corner of the Universe, Syracuse University** Fall 2022
- **TA, PHY 101 – Major Concepts of Physics I, Syracuse University** Fall 2021, Spring 2022
- **Junior TA, Philosophy, Zewail City of Science and Technology** Fall 2018

Service and Outreach

- **Vice President, Head of Fundraising, Zewail City Science Festival (∼2,000 attendees)** 2019
- **STEM Tutor, Banati Foundation (Abnaa Alghad), Cairo** 2019
- **Editor and Translator (Physics), Egyptian Researchers** 2014–2017

References

Available upon request.