Casey O. Barkan

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Education

PhD Candidate in Physics, University of California, Los Angeles (2019-Present)

- GPA: 3.98/4.00
- Thesis advisor: Robijn F. Bruinsma
- Expected graduation: May 2025

MS in Physics, University of Pennsylvania (2018-2019)

- GPA: 3.93/4.00

BSE in Chemical and Biomolecular Engineering, University of Pennsylvania (2014-2018)

- GPA 3.83/4.00
- Second major: Physics
- Minors: Economics, Mathematics
- *Summa Cum Laude*

Research Focus and Interests

My PhD research is in theoretical non-equilibrium statistical mechanics, with applications to biology and medicine. Two topics of particular interest (and in which I have written papers) are the foundations of statistical mechanics and thermalization, and the mechanics of protein-protein interactions.

I have broad interests in the natural and social sciences (particularly in physics, economics, and artificial intelligence). I believe AI will profoundly impact our world, and I view research into AI safety and into the economic impacts of AI as critical for ensuring this impact is positive.

Publications and Preprints

C.O. Barkan and R.F. Bruinsma. (2023). Catch-slip bonding, pathway switching, and singularities in the flow of molecular deformation. *Physical Review Research*. https://doi.org/10.1103/PhysRevResearch.5.023161

C.O. Barkan and S. Wang. (2023). Multiple phase transitions shape biodiversity of a migrating population. *Physical Review E*. https://doi.org/10.1103/PhysRevE.107.034405

C.O. Barkan and R.F. Bruinsma. (2024). Topology of molecular deformation induces triphasic catch bonding in selectin-ligand bonds. *Proceedings of the National Academy of Sciences*. https://doi.org/10.1073/pnas.2315866121

C.O. Barkan. (2024). On the convergence of phase space distributions to microcanonical equilibrium: dynamical isometry and generalized coarse-graining. *Journal of Physics A: Mathematical and Theoretical.* https://iopscience.iop.org/article/10.1088/1751-8121/ad7c9e

C.O. Barkan and S. Wang. (2024). Migration feedback yields novel critical transitions and emergent ecotypes in connected populations. *In revision at Physical Review E*. https://arxiv.org/abs/2309.10884

Conference Presentations

(Note: I was the presenter for all listed presentations)

Oral presentations:

C.O. Barkan. (March 2024). Modeling the structural mechanism of TCR-pMHC catch bonding. *APS March Meeting, Minneapolis, MN.*

C.O. Barkan and S. Wang. (Sept 2023). Migration feedback yields novel critical transitions and emergent ecotypes in connected populations. *UCLA QCBio Retreat, Los Angeles, CA.*

C.O. Barkan and R.F. Bruinsma. (March 2023). Geometric Signatures of Switching Behavior in Mechanobiology. *APS March Meeting, Las Vegas, NV.*

C.O. Barkan. (March 2023). Theory of force-sensitive bonds: complex behavior from simple mechanisms. *APS March Meeting, Las Vegas, NV.*

Poster presentations:

C.O. Barkan. (Nov 2023). Mechanical Allostery Induces Tunable Catch Bonding. *5th course on multi-scale integration in biological systems, Curie Institute, Paris.*

C.O. Barkan and R.F. Bruinsma. (Feb 2023). Geometric Signatures of Switching Behavior in Mechanobiology. *Biophysical Society Meeting, San Diego, CA.*

C.O. Barkan and R.F. Bruinsma. (Sept 2022). Geometric Signatures of Switching Behavior in Mechanobiology. *EMBO Physics of Cells, Ein Gedi, Israel.*

C.O. Barkan and S. Wang. (March 2022) Phase Transitions Shape Biodiversity of a Migrating Population. *APS March Meeting, Chicago, IL.*

C.O. Barkan and S. Wang. (Sept 2021). Emergent Ecological Phenomena in an Evolving and Migrating Population. *UCLA QCBio Retreat, Los Angeles, CA.*

Computational Skills

- **Languages:** Python (PyTorch, Numpy, Scipy, Matplotlib, QuTip), Mathematica, Matlab.
- **Machine learning and AI:** Physics-informed neural networks for high-dimensional PDEs, Steering LLMs with sparse autoencoders.
- **Numerical methods:** ODEs, PDEs, Stochastic processes and SDEs, Optimal control theory, Decision making under uncertainty, Simulation of complex systems, Quantum algorithms and dynamics, Topological data analysis.

Honors and Awards

- UCLA Dissertation Year Award (2024)
- Outstanding Teaching Assistant Award, UCLA Physics (2021)
- NSF Graduate Research Fellowship (2019)

- American Chemical Society Scholastic Achievement Award (2018)
- Melvin C. Molstad Prize for best Chemical Engineering design project, Penn CBE (2018)
- Norman Hixson Laboratory Report Prize in Chemical Engineering, Penn CBE (2018)
- Tau Beta Pi Engineering Honors Society (2017)

International Research Experiences

- 5th Course in Multi-scale Integration in Biological Systems (Nov. 8-14, 2023).
  Curie Institute, Paris, France.
- International School on Biological Physics of Cells (Sept 11-23, 2022).
  Weizmann Institute, Rehovot, Israel.
- Research intern in Neurobiology (Sept 2013 - April 2014).
  Bacigalupo Laboratory, University of Chile, Santiago, Chile.

Teaching Assistant Experience

At UCLA:

- Phys 245: Quantum Computation, *graduate level course* (Fall 2022)
- Phys 117: Electronics for Physical Measurement, *upper division course* (Spring 2021)
- Phys 5B: Thermodynamics for Life Sciences (Winter 2021)
- Phys 110A: Electrodynamics, *upper division course* (Fall 2020)
- Phys 5BL: Thermodynamics for Life Sciences, Laboratory (Summer 2020)
- Phys 1A: Introductory Mechanics (Fall 2019)

At The University of Pennsylvania:

- Chem 115: Honors Introductory Chemistry (Fall 2017)
- Math 103: Introductory Calculus (Fall 2016)

Volunteering and Outreach

YEE STEM Tutoring and Mentorship program (UCLA student group)

- Lead organizer (2022): Wrote a grant to provide funding for background checks for 27 tutors/mentors. Worked with a community partner (Innovate Public Schools) to organize summer tutoring and mentoring.
- Volunteer tutor/mentor (2020-2023).

West Philadelphia Tutoring Project (Penn student group)

- Volunteer tutor for underprivileged youth in Philadelphia (2018-2019).