Sam Dillavou, Ph.D. 3231 Walnut St, Philadelphia, PA 19104 dillavou@sas.upenn.edu

EDUCATION

2020 **Ph.D. in Physics**, Department of Physics, Harvard University, Cambridge, MA
Thesis: Hidden Dynamics of Static Friction Faculty Advisor: Shmuel M Rubinstein

2016 **M.A. in Physics**, Department of Physics, Harvard University, Cambridge, MA

2012 **B.A. in Physics**, Cornell University, Ithaca, NY

RESEARCH EXPERIENCE

2020- **Postdoctoral Fellow**, University of Pennsylvania, Dept of Physics and Astronomy
with Douglas J Durian & Andrea J Liu
Emergent Learning in Physical Systems; Clogging in Granular Flows; Machine Learning Tools in Experimental Science

2018 **Visiting Researcher**, EPFL, Lausanne, Switzerland, Dept of Mechanical Engineering
with John M Kolinski Developed ultrafast (≥ MHz) imaging technique for any camera

FELLOWSHIPS and AWARDS

Fellowships

Data Science Postdoctoral Fellow UPenn, $5,000/year, (2022-Present)
Smith Family Fellowship Harvard U, ~$90,000, 1 year (2015-16)
Purcell Fellowship Harvard U, ~$90,000, 1 year (2014-15)

Research & Teaching Recognition

1st prize GSNP Postdoc. Presentation Awards, American Physical Society March Meeting (2024)
1st prize (out of 84) American Physical Society March Meeting Postdoc. Poster Competition (2023)
Herbert B. Callen Memorial Prize, U of Pennsylvania (2023)
2nd place, MRSEC National Science Slam: Learning Networks on the Radio (2022)
Editor's Suggestion (Dillavou et. al. PR Applied, 2022)
Rising Stars in Soft and Biological Matter Honorarium, U Chicago (2021)
Editor's Suggestion (Dillavou & Rubinstein, PRL, 2018)
Bok Center Certificate of Teaching Excellence, Harvard U (Spring 2018)

TEACHING and MENTORING EXPERIENCE

Research Mentorship

At U Penn: 1 local graduate student (2020-2024), 3 local undergraduates (2021-present), and visiting students from Yale (2024), Williams (2024), Penn. State (2024), U Maryland (2022), Moravian U (2022), Swarthmore (2021), U Texas Rio Grande Valley (2021)

At Harvard: 3 local undergraduates (2017-2020), visiting students from ESPCI Paris (2019), Tsinghua U (graduate student, 2017-2018), Hebrew U Jerusalem (2016)

Teaching Assistant

Introduction to Fluid Mechanics‡ (Spring 2018) Harvard U, 60 Undergraduate Students
Develop new materials, in-class demos, supervising labs, grading, overseeing projects, Received *Bok Center Certificate of Teaching Excellence*

Introduction to Soft Matter (Fall 2015) Harvard U, 20 Graduate Students
Write problem sets, develop new materials, teaching section, grading

Substitute Lecturer
PHYS 3351 - Analytical Mechanics (Prof Douglas Durian)

Workshops
Taught two winter-term mini-courses at Harvard: Intro to Long-Form Improvisation (2016), Improving Presentation and Discussion Through Improvisation (2019).

Designed and taught over thirty improvisational theater workshops at Harvard, Tufts, Yale, Cornell, Deloitte Consulting, and more, for middle and high school students, undergraduates, graduate students, business professionals, and academic faculty.

Pedagogical Training
Teaching and Communicating Physics (Spring 2015) Harvard U

Tutoring
Hundreds of hours with dozens of students in high-school/college mathematics and physics, SAT.

PROFESSIONAL SERVICE

Journal Referee
Physical Review [B, E, Applied, and Letters], US Geological Survey Internal, Journal of Geophysical Research - Solid Earth, Science, Nature Communications

Outreach
Philly Materials Day (K-12), design, construct and demo trainable elastic material (2024)
Design and teach U Penn REU Machine Learning Workshop (2022, 2023, 2024)
Design and teach Data Driven Discovery Initiative Machine Learning Workshop (2023, 2024)
DEEPenn STEM (see below), volunteer, mentor, presenter (2023)
Science Café speaker, "*Friction: The surprising unsolved science behind earthquakes and tire treads*", (Wilmington, Delaware 2023)
Planning committee, volunteer, presenter for the first annual DEEPenn STEM: weekend-long STEM PhD prep/info workshop for ~45 URM college students from around the country (2022)
2nd Place, MRSEC National Science Slam: Learning Networks on the Radio (2022)
Science in the News Writer (2016-17), Harvard U
Splash at Yale Instructor, grades 7-9 and 10-12 (2016, 2017), Yale U

Professional Membership
American Physical Society (since 2016)
APS March Meeting 2023 session organizer, chair, and sorter (2023, 2024)

Miscellaneous
Part of a collaboration developing a 3D Printer-as-Ventilator during COVID-19 outbreak

PUBLICATIONS

In Preparation

[A] JM Hanlan†, **S Dillavou**†, AJ Liu, DJ Durian, *Cornerstones are the Key Stones: Using Interpretable Machine Learning to Probe Clogging in Granular Hoppers.*

Submitted // arXiv

[1] D Hathcock†, **S Dillavou**†, JM Hanlan, DJ Durian, Y Tu. *Stochastic dynamics of granular hopper flows: a slow hidden mode controls the stability of clogs* (In Review, PRL) arXiv 2312.01194

[2] KA Murphy, **S Dillavou**, DS Bassett, *Comparing information content of representation spaces for disentanglement with VAE ensembles*, (Submitted) arXiv 2405.21042

†*Equal Contribution* *****Undergraduate student at the time work was performed*

Published // Accepted

[3] **S Dillavou**, B Beyer*, M Stern, AJ Liu, MZ Miskin†, DJ Durian†, *Machine Learning Without a Processor: Emergent Learning in a Nonlinear Analog Network* (In Press, Proceedings of the National Academy of Sciences) arXiv 2311.00537

[4] **S Dillavou**, JM Hanlan, H Xiao, AT Chieco, S Fulco, K Turner, DJ Durian, *Bellybutton: Accessible and Customizable Deep-Learning Image Segmentation*. Nature Scientific Reports (2024)

[5] AJ Gerra†*, CC Jones†*, **S Dillavou**, JM Hanlan, J Radzio, PE Arratia, DJ Durian, *The Equation of Motion for Taut-Line Buzzers* (Accepted, Physical Review Applied) arXiv 2402.19285

[6] T Martin, **S Dillavou**, *Calculations Without Math: "Smart instruments" and the transposition of complex shapes in the wooden boat workshop*, Journal of Cultural Cognitive Science (2024)

[7] M Stern, **S Dillavou**, D Jayaraman, DJ Durian, AJ Liu. *Training self-learning circuits for power-efficient solutions,* APL Machine Learning (2024)

[8] W Steinhardt, **S Dillavou**, M Agajanian*, SM Rubinstein, EE Brodsky, *Seismological Stress Drops for Confined Ruptures are Invariant To Normal Stress*, Geophysical Research Letters (2023)

[9] A Srivastava … **S Dillavou** … Z Wu (100s of authors), *Beyond the Imitation Game: Quantifying and extrapolating the capabilities of language models*, Transactions on Machine Learning Research (2023)

[10] M Pasquet, N Galvani, O Pitois, S Cohen-Addad, R Höhler, AT Chieco, **S Dillavou**, JM Hanlan, DJ Durian, E Rio, A Salonen, D Langevin, *Aqueous foams in microgravity, measuring bubble sizes,* Comptes Rendus. Mécanique (2023)

[11] **S Dillavou**, Y Bar-Sinai, MP Brenner, and SM Rubinstein, *Contact Distribution Encodes Frictional Strength,* Physical Review E (2022) Letter

[12] **S Dillavou**, M Stern, AJ Liu, DJ Durian *Demonstration of Decentralized, Physics-Driven Learning*, Physical Review Applied (2022) **Editor's Choice**

[13] M Stern, **S Dillavou**, MZ Miskin, DJ Durian, AJ Liu, *Physical Learning Beyond the Quasistatic Limit*, Physical Review Research (2022)

[14] JF Wycoff*, **S Dillavou**, M Stern, AJ Liu, DJ Durian, *Learning Without a Global Clock: Asynchronous Learning in a Physics-Driven Learning Network*, Journal of Chemical Physics (2022)

[15] SCL Durian*, **S Dillavou**, K Markin*, A Portales*, BOT Maldonado, WTM Irvine, PE Arratia, DJ Durian, *Spatters and Spills: Spreading Dynamics for Partially Wetting Droplets* Physics of

Fluids (2022)

[16] S Zheng, **S Dillavou**, JM Kolinski *Air Mediates the Impact of a Compliant Hemisphere on a Rigid Smooth Surface* Soft Matter (2021)

[17] **S Dillavou** and SM Rubinstein, *Shear Controls Frictional Aging by Erasing Memory*, Physical Review Letters (2020)

[18] T Pilvelait*, **S Dillavou**, and SM Rubinstein, *Influences of Microcontact Shape on the State of a Frictional Interface*, Physical Review Research (2020)

[19] **S Dillavou**, SM Rubinstein, and JM Kolinski, *The Virtual Frame Technique: Ultrafast Imaging With Any Camera*, Optics Express (2019)

[20] **S Dillavou** and SM Rubinstein, *Nonmonotonic Aging and Memory in a Frictional Interface*, Physical Review Letters (2018) **Editor's Choice**

[21] JL Silverberg, **S Dillavou***, L Bonassar, and I Cohen, *Anatomic Characterization of Depth-Dependent Mechanical Properties in Neonatal Bovine Articular Cartilage*, Journal of Orthopaedic Research (2012)

Conference/Workshop Proceedings

[22] **S Dillavou**, B Beyer*, M Stern, MZ Miskin, AJ Liu, DJ Durian, *Nonlinear Classification Without a Processor,* NeurIPS ML with New Compute Paradigms Workshop (2023)

[23] M Stern, **S Dillavou**, D Jayaraman, DJ Durian, AJ Liu, *Contrastive power-efficient physical learning in resistor networks,* NeurIPS ML with New Compute Paradigms Workshop (2023)

[24] **S Dillavou**, B Beyer*, M Stern, MZ Miskin, AJ Liu, DJ Durian, *Circuits that train themselves: decentralized, physics-driven learning*, Proc. SPIE 12438, AI and Optical Data Sciences IV (2023)

[25] M Stern, **S Dillavou**, MZ Miskin, DJ Durian, AJ Liu, *Out of Equilibrium Learning Dynamics in Physical Allosteric Resistor Networks*, NeurIPS, Fourth Workshop on Machine Learning and the Physical Sciences (2021)

Patents

US Patent No US-2022-0383205-A1 (Pending) **S Dillavou**, M Stern, MZ Miskin, AJ Liu, DJ Durian *Coupled Networks for Physics-Based Machine Learning* (Dec 1, 2022)

Software Packages Authored

Bellybutton – an easy-to-use Python-based deep learning toolkit for segmenting images, designed for researchers. Download available here.

PRESENTATIONS and PRESS

Invited Talks

Inaugural *klogW* Future Series Seminar (Virtual, 2024)
"Emergent Machine Learning in a Nonlinear Electronic Metamaterial"

SIAM Conf on Mathematical Aspects of Materials Science (Pittsburgh, PA, 2024)
"The Metamaterial that Trains Itself"

University of Chicago Physics Department Special Seminar (Chicago, IL, 2024)
"Emergent Learning in Electronic Networks"

Argonne National Lab Applied Artificial Intelligence Speaker Series, (Virtual, 2023)
"This Circuit Trains Itself: Supervised Learning as an Emergent Property"

9th International Discussion Meeting on Relaxation in Complex Systems, (Tokyo, Japan, 2023)
"Evolution of a Learning Material"
AI and Optical Data Sciences Conference at SPIE Photonics West, (San Francisco, CA, 2023)
"Circuits that train themselves: decentralized, physics-driven learning"
Alternative Computing Group Seminar, NIST (Gaithersburg, MD, 2023)
"Hijacking Physics to Learn For Us: A Physics-Driven Learning Network"
Physical Review Journal Club, (Virtual, 2022)
"Demonstration of Decentralized, Physics-Driven Learning"
Google Brain Weekly Seminar, (Mountainview, CA, 2022)
"Hijacking Physics to Learn for Us"
American Physical Society March Meeting, (Chicago, IL, 2022)
"Decentralized Physics-Driven Learning: Using Physics to Learn without a Processor"
Bucknell University, Physics Seminar, (Lewisburg, PA, 2021)
"Decentralized Physics-Driven Learning"
New York University, Applied Math Seminar, (New York, NY, 2020)
"Hidden Dynamics of Static Friction"
Princeton University, Soft Matter Coffee Hour, (Princeton, NJ, 2020)
"Hidden Dynamics of Static Friction"
University of Pennsylvania, Soft Matter Theory Group, (Virtual, 2020)
"Hidden Dynamics of Static Friction"
Pennsylvania State University, Geomechanics Seminar, (State College, PA, 2018)
"Static Friction: Aging and Memory"
École Polytechnique Fédérale de Lausanne, Mech Eng Seminar, (Lausanne, Switzerland, 2018)
"Memory in Solid-Solid Interfaces"

Selected Press

On Physical & Emergent Learning
MIT Technology Review, 2024
"How a simple circuit could offer an alternative to energy-intensive GPUs"
Quanta Magazine, 2022
"How to make the universe think for us"
Science News, 2022
"Simple electrical circuit learns on its own – with no help from a computer"
American Physical Society News, 2021
"Programming matter to a computer's job"
On the Virtual Frame Technique
MIT Technology Review, 2018
"How to mod a smartphone camera so it shoots a million frames per second"
American Physical Society, Phys.org, 2019
"Imaging technique lets ordinary cameras capture high-speed images of crack formation"
On Memory in Frictional Interfaces
American Physical Society Physics Focus, 2018
"Friction Remembers Its Origins"
Physics Today, 2018
"Friction Remembers Its Past"

Contributed Talks

Northeastern Granular Materials Workshop (Worcester, MA 2024) "Cornerstones are the Key

Stones: Studying Granular Clogging with Machine Learning as an Experimental Guide"
American Physical Society March Meeting (Minneapolis, MN, 2024)
"The Ensemble Peels the Onion" **1st prize GSNP Postdoctoral Speaker Award**
American Physical Society March Meeting (Las Vegas, NV, 2023)
"Transistor-Based Self-Learning Networks"
Coherent Network Computing, (Palo Alto, CA, 2022)
"A Physics-Driven Self-Learning Transistor Network"
American Physical Society March Meeting, (Chicago, IL, 2022)
"Beyond Quality and Quantity: Contact Distribution Encodes Frictional Strength"
Rising Stars in Soft and Biological Matter Symposium, U of Chicago, (Chicago, IL, 2021)
"Decentralized Physics-Driven Learning"
American Physical Society March Meeting, (Virtual, 2021)
"Building a Physical Learning Network"
American Physical Society March Meeting, (Boston, MA, 2019)
"Memory in Solid-Solid Interfaces"
Dynamics Days, Northwestern University, (Evanston, IL, 2019)
"Hidden Dynamics of Static Contact and Static Friction"
U Massachusetts, Northeast Research Alliance & BASF Collaboration Days, (Amherst, MA, 2019)
"Extreme Mechanics of Elastomer Impact"
American Physical Society March Meeting, (Los Angeles, CA, 2018)
"Two Solids Make a Glass: Memory in Solid-Solid Interfaces"
U Massachusetts, Northeast Research Alliance & BASF Collaboration Days, (Amherst, MA, 2017)
"Elastomer Wear: The NBA's Shoe Problem"
Weizmann Institute, Physics Department Symposium, (Rehovot, Israel, 2017)
"Memory in the Frictional Interface"

Posters/Rapid Talks

Nonlinear Classification Without a Processor, Center for Soft and Living Matter Kickoff Meeting, (Philadelphia, PA 2024)
Self-Learning Electronic Networks, Mid Atlantic Soft Matter Workshop, (Washington DC 2024)
Nonlinear Classification Without a Processor, Computing with Physical Systems, (Aspen, CO 2024)
A Physics-Driven Self-Learning Transistor Network, American Physical Society March Meeting, (Las Vegas, NV 2023) **1st prize in the APS March Meeting Postdoctoral Poster Competition**
Physical Learning Machines, Simons Collaboration on Cracking the Glass Problem Annual Meeting, (New York, NY 2022
Building a Physical Learning Network, Northeast Complex Fluids Workshop, Virtual, 2021
Tabletop Nucleation, Southern California Earthquake Center Annual Meeting, Palm Springs, CA 2019
The Hidden Dynamics of Static Friction, Gordon Conference: Soft Matter Physics, New London, NH, 2019
The Virtual Frame Technique, 77th New England Complex Fluids Workshop, Harvard U 2018
Memory in the Frictional Interface, 73rd New England Complex Fluids Workshop, Harvard U 2018; Jay (Fineberg) Fest, Hebrew U in Jerusalem, 2017
Beyond Rate and State: Frictional Memory, Institute for the Study of the Continents Conference, Cornell U, 2017
Wear in Basketball Shoes, Northeast Research Alliance & BASF Challenges, Cornell U, 2017
Visualizing Frictional Interfaces, 69th New England Complex Fluids Workshop, Harvard U 2018; 67th New England Complex Fluids Workshop, MIT 2016

Loading History of Frictional Interfaces, Physics & Mechanics of Soft Complex Materials, Cargese, France, 2016; Gordon Conference: Tribology, Lewiston, ME, 2016

Visualizing Growth of a Multicontact Interface (MCI), 65th New England Complex Fluids Workshop, Harvard U 2015

Aging of Multi-Contact Interfaces, Soft Matter Symposium: Friction, Rheology, Tribology U Florida, Gainesville, FL 2015