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

EDUCATION

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

2016 **M.A. in 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 Physical Learning; Clogging in Granular Flows; ML 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, 2024)

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 30+ 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 for 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, Soft Matter

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

Submitted // arXiv

[1] JM Hanlan†, **S Dillavou**†, AJ Liu, DJ Durian. *Cornerstones are the Key Stones: Using Interpretable Machine Learning to Probe Clogging in Granular Hoppers.* arXiv 2407.05491

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

[3] 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

[4] **S Dillavou**, B Beyer*, M Stern, AJ Liu, MZ Miskin†, DJ Durian†. *Machine Learning Without a Processor: Emergent Learning in a Nonlinear Analog Network* Proceedings of the National Academy of Sciences (2024)

[5] **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)

[6] AJ Gerra†*, CC Jones†*, **S Dillavou**, JM Hanlan, J Radzio, PE Arratia, DJ Durian. *The Equation of Motion for Taut-Line Buzzers.* Physical Review Applied (2024)

[7] 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)

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

[9] 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)

[10] 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)

[11] 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)

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

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

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

[15] 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)

[16] 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)

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

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

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

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

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

[22] 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

[23] **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)

[24] 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)

[25] **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)

[26] 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 – a Python deep learning package for image segmentation, designed for researchers with no coding required. Download available here.

PRESENTATIONS and PRESS

[some titles truncated for space]

Invited Talks

Emergent Machine Learning	Inaugural klogW Future Series Seminar, Virtual, 2024
The Metamaterial that Trains Itself	SIAM: Mathematical Aspects of Mat Sci, Pittsburgh, PA, 2024
Emergent Learning in Electronic Networks	Physics Dept Special Seminar, U Chicago, 2024
Supervised Learning as an Emergent Property	Argonne Nat'l Lab Applied AI Series, Virtual, 2023
Evolution of a Learning Material	9th IDMRCS, Chiba, Japan, 2023
Decentralized, Physics-Driven Learning	SPIE Photonics West, San Francisco, CA, 2023
A Physics-Driven Learning Network	Alternative Computing Group Seminar, NIST, 2023
Demonstration of Decentralized, Physics-Driven Learning	Phys Rev Journal Club, Virtual, 2022
Hijacking Physics to Learn for Us	Weekly Seminar, Google Brain, 2022
Using Physics to Learn without a Processor	APS March Meeting, Chicago, IL, 2022
Decentralized Physics-Driven Learning	Physics Seminar, Bucknell U, 2021
Hidden Dynamics of Static Friction	Applied Math Seminar, NYU, 2020
Hidden Dynamics of Static Friction	Soft Matter Coffee Hour, Princeton U, 2020

Hidden Dynamics of Static Friction — Soft Matter Theory Group (U Pennsylvania), Virtual, 2020
Static Friction: Aging and Memory — Geomechanics Seminar, Pennsylvania State U, 2018
Memory in Solid-Solid Interfaces — Mechanical Engineering Seminar, EPFL, 2018

Selected Press

On Physical & Emergent Learning

How a simple circuit could offer an alternative to energy-intensive GPUs — MIT Tech Review, 2024
A first, physical system to learn nonlinear tasks without a traditional processor — Penn Today, 2024
How to make the universe think for us — Quanta Magazine, 2022
Simple electrical circuit learns on its own – with no help from a computer — Science News, 2022
Programming matter to a computer's job — American Physical Society News, 2021

On the Virtual Frame Technique

Imaging technique lets ordinary cameras capture high-speed images of crack formation — Phys.org 2019
How to mod a smartphone camera so it shoots a million frames per second — MIT Tech Review, 2018

On Memory in Frictional Interfaces

Friction Remembers Its Origins — American Physical Society Physics Focus, 2018
Friction Remembers Its Past — Physics Today, 2018

Contributed Talks

Studying Granular Clogging with ML as an Experimental Guide — NE Granular Mat, Holy Cross, 2024
Emergent Learning Via Sequential Error Mode Reduction — APS March Mtg, Minneapolis, MN, 2024
1st Prize Statistical & Nonlinear Physics Postdoctoral Speaker Award
Transistor-Based Self-Learning Networks — APS March Meeting, Las Vegas, NV, 2023
A Physics-Driven Self-Learning Transistor Network — Coherent Network Comp., Stanford U, 2022
Contact Distribution Encodes Frictional Strength — APS March Meeting, Chicago, IL, 2022
Decentralized Physics-Driven Learning — Rising Stars in Soft & Biological Matter, U Chicago, 2021
Building a Physical Learning Network — APS March Meeting, Virtual, 2021
Memory in Solid-Solid Interfaces — APS March Meeting, Boston, MA, 2019
Hidden Dynamics of Static Contact and Static Friction — Dynamics Days, Northwestern U, 2019
Extreme Mechanics of Elastomer Impact — NORA & BASF Collab. Days, U Mass Amherst, 2019
Two Solids Make a Glass: Memory in Solid-Solid Interfaces — APS March Mtg, Los Angeles, CA, 2018
Elastomer Wear: The NBA's Shoe Problem — NORA & BASF Collab. Days, U Mass Amherst, 2017
Memory in the Frictional Interface — Physics Dept Mini-Symposium, Weizmann Inst, 2017

Posters/Rapid Talks

Nonlinear Classification Without a Processor — Ctr for Soft and Living Matter Kickoff, UPenn 2024
Self-Learning Electronic Networks — Mid Atlantic Soft Matter Workshop, Georgetown U 2024
Nonlinear Classification Without a Processor — Computing with Physical Systems, Aspen, CO 2024
A Physics-Driven Self-Learning Transistor Network — APS March Meeting, Las Vegas, NV 2023
1st Prize in the APS March Meeting Postdoctoral Poster Competition
Physical Learning Machines — Cracking the Glass Problem Simons Mtg, New York, NY 2022
Building a Physical Learning Network — Northeast Complex Fluids Workshop, Virtual 2021
Tabletop Nucleation — Southern California Earthquake Center Annual Mtg, Palm Springs, CA 2019
The Hidden Dynamics of Static Friction — Gordon Conf: Soft Matter Phys., New London, NH 2019
The Virtual Frame Technique — 77th New England Complex Fluids, Harvard U 2018
Memory in the Frictional Interface — 73rd New England Complex Fluids, Harvard U 2018
Memory in the Frictional Interface — Jay (Fineberg) Fest, Hebrew U in Jerusalem, 2017
Beyond Rate and State: Frictional Memory — Inst. for Study of the Continents Conf, Cornell U, 2017

Wear in Basketball Shoes	NORA & BASF Challenges, U Mass Amherst, 2017
Visualizing Frictional Interfaces	69th New England Complex Fluids, Harvard U 2016
Visualizing Frictional Interfaces	67th New England Complex Fluids, MIT 2016
Loading History of Frictional Interfaces	Phys + Mech of Soft Complex Mat, Cargese, France, 2016
Loading History of Frictional Interfaces	Gordon Conference: Tribology, Lewiston, ME, 2016
Visualizing Growth of a Multi-contact Interface	65th NE Complex Fluids, Harvard U 2015
Aging of Multi-Contact Interfaces	Soft Matter: Friction, Rheology, Tribology, U Florida 2015