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

EDUCATION

Ph.D. in Physics, **Harvard University** — **Ph.D. Thesis**: Hidden Dynamics of Static Friction — 2020
M.A. in Physics, **Harvard University** — **Ph.D. Advisor**: Shmuel M Rubinstein — 2016
B.A. in Physics, **Cornell University** — **Undergraduate Research Advisor:** Itai Cohen — 2012

RESEARCH EXPERIENCE

Postdoctoral Fellow University of Pennsylvania with Douglas J Durian & Andrea J Liu — 2020-Present
Topics: Emergent Physical Learning | Granular Flows | ML in Experimental Science

Visiting Researcher EPFL, Switzerland with John M Kolinski — 2018
Topic: Developed ultrafast (≥ MHz) imaging technique for any camera

FUNDING and AWARDS

Grants & Fellowships

ARIA Opportunity Seed Grant	£500,000 (~$650,000) 2025-2027
Data Science Postdoctoral Fellow, U Pennsylvania	$5,000/year, 2022-Present
Smith Family Fellowship, Harvard U	$90,000, 2015-16
Purcell Fellowship, Harvard U	$90,000, 2014-15

Research & Teaching Recognition

1st place GSNP Postdoctoral Presentation Awards	APS March Meeting 2024
1st place Meeting-Wide Postdoctoral Poster Competition	APS March Meeting 2023
Herbert B. Callen Memorial Prize	University of Pennsylvania 2023
2nd place, title: Learning Networks on the Radio	MRSEC National Science Slam 2022
Editor's Suggestion, Physical Review Applied	Dillavou et. al. 2022
Rising Stars in Soft and Biological Matter Honorarium	University of Chicago 2021
Physical Review Letters Editor's Suggestion	Dillavou & Rubinstein 2018
Bok Center Certificate of Teaching Excellence	Harvard University Spring 2018

TEACHING and MENTORING EXPERIENCE

Research Mentorship	Career Stage, University	[Coauthored Publications]	Year(s)
Alex Roseman	Undergraduate, Yale U		2024
Juan Mendez	Undergraduate, Williams		2024
Evan Stocker	Undergraduate, Pennsylvania State U		2024
Benjamin D Beyer	Undergraduate, U of Pennsylvania	[5][24][26]	2021-24
Jesse M Hanlan	Ph.D. Student, U of Pennsylvania	[1][2][6][7][12]	2020-24
Josue D Ruiz	Undergraduate, U of Pennsylvania		2022-23
Jacob F Wycoff	Undergraduate, U of Pennsylvania	[b][16]	2021-23
Courtney C Jones	Undergraduate, U Maryland	[7]	2022
Alex Gerra	Undergraduate, Moravian U	[7]	2022
Kwame Markin	Undergraduate, Swarthmore	[17]	2021
Adrian Portales	Undergraduate, U Texas Rio Grande	[17]	2021
Sylvia CL Durian	Undergraduate, U Chicago	[17]	2021
Mary Agajanian	Undergraduate, Harvard U	[10]	2019-21
Tom Pilvelait	Undergraduate, Harvard U	[20]	2018-20

Updated 11/24

Vincent Stin	Undergraduate, ESPCI, Paris	2019
Aijie Xu	Ph.D. Student, Tsinghua U	2017-18
Evgeni Shirman	Undergraduate, Hebrew U, Jerusalem	2016

Teaching

Substitute Lecturer: Analytical Mechanics, Douglas Durian - 30 Undergrads — U Penn, Spring 2024

TA: Introduction to Fluid Mechanics, Shmuel Rubinstein - 60 Undergrads — Harvard U, Spring 2018
Develop new materials, in-class demos, grade assignments, supervise labs and final projects
Received Bok Center Certificate of Teaching Excellence

TA: Introduction to Soft Matter – Shmuel Rubinstein - 20 Grad Students — Harvard U, Fall 2015
Write problem sets, develop new materials, teaching section, grading

Short Courses / Workshops / Tutoring

Improving Presentation & Discussion Through Improvisation - 15 Grad. — Harvard U, Winter 2019
Intro to Long-Form Improvisation - 15 Graduate Students — Harvard U, Winter 2016
Developed and taught custom curricula for both mini-courses
Improvisational Theater Workshops — Harvard, Tufts, Yale, Cornell, Deloitte, 2012-Present
Designed & taught for 5-50 participants, 6th grade to grad, business professionals, faculty.
High school/college math/physics, SAT prep. tutored 100s of hours for 30+ students 2010-Present

Pedagogical Training

Teaching and Communicating Physics — Harvard U, Spring 2015

PROFESSIONAL SERVICE

Journal Referee

Science, Nature Communications, Soft Matter, Physical Review [B, E, Applied, and Letters], US Geological Survey Internal, J of Geophysical Res - Solid Earth, NeurIPS Workshops

Outreach

Philly Materials Day (K-12), design, construct and demo trainable elastic material 2024
Design and teach U Penn REU Machine Learning (ML) Workshop 2022, 2023, 2024
Design and teach U Penn Data Driven Discovery Initiative ML Workshop 2023, 2024
DEEPenn STEM (see below), volunteer, mentor, presenter 2023
Science Café speaker, Wilmington, Delaware. "*Friction: The surprising unsolved science behind earthquakes and tire treads*" 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, Harvard U 2016-17
Splash at Yale Instructor, grades 7-9 and 10-12, Yale U 2016, 2017

Professional Membership

American Physical Society 2016-Present
APS March Meeting session organizer, chair, and sorter 2023, 2024

Misc: Part of a collaboration developing a 3D Printer-as-Ventilator during COVID-19 outbreak 2020

PUBLICATIONS

‡*Equal Contribution* †*Worked performed as an undergraduate*

In Preparation

[a] **S Dillavou**‡, M Guzman‡, AJ Liu, DJ Durian. *Forgetting is Emergent from Physical Imperfection.*

[b] **S Dillavou**, JW Rocks, JF Wycoff†, AJ Liu, DJ Durian. *Phase Transitions in Physical Learning.*

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* (In Revision, PNAS) arXiv2407.05491

[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 Revision, PRL) arXiv 2312.01194

[3] KA Murphy, **S Dillavou**, DS Bassett. *Comparing the information content of probabilistic representation spaces* (Submitted) arXiv 2405.21042

Published

[4] **S Dillavou**, *Harnessing Machine Learning to Guide Scientific Understanding* Physics Magazine, 2024

[5] **S Dillavou**, B Beyer†, M Stern, AJ Liu, MZ Miskin‡, DJ Durian‡. *Machine Learning Without a Processor: Emergent Learning in a Nonlinear Analog Network* PNAS, 2024

[6] **S Dillavou**, JM Hanlan, H Xiao, AT Chieco, S Fulco, K Turner, DJ Durian. *Bellybutton: Accessible & Customizable Deep-Learning Image Segmentation* Nature Sci Reports, 2024

[7] 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

[8] T Martin, **S Dillavou**. *Calculations Without Math: "Smart instruments" & the transposition of complex shapes in the wooden boat workshop* J of Cultural Cognitive Science, 2024

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

[10] 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

[11] A Srivastava … **S Dillavou** … Z Wu (100s of authors). *Beyond the Imitation Game: Quantifying & extrapolating the capabilities of language models* Transactions on ML Research, 2023

[12] M Pasquet, … 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

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

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

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

[16] 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

[17] SCL Durian†, **S Dillavou**, K Markin†, A Portales†, BOT Maldonado, WTM Irvine, PE Arratia, DJ Durian. *Spreading Dynamics for Partially Wetting Droplets* Physics of Fluids, 2022

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

[19] **S Dillavou** and SM Rubinstein. *Shear Controls Frictional Aging by Erasing Memory*

Physical Review Letters, 2020

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

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

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

[23] JL Silverberg, **S Dillavou**†, L Bonassar, and I Cohen. *Anatomic Characterization of Depth-Dependent Mechanical Properties in Neonatal Bovine Articular Cartilage* J Orthopaedic Res, 2012

Conference Workshop Proceedings

[24] **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

[25] 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

[26] **S Dillavou**, B Beyer†, M Stern, MZ Miskin, AJ Liu, DJ Durian. *Circuits that train themselves: decentralized, physics-driven learning*, Proceedings SPIE, AI & Optical Data Sciences IV, 2023

[27] M Stern, **S Dillavou**, MZ Miskin, DJ Durian, AJ Liu. *Out of Equilibrium Learning Dynamics in Physical Allosteric Resistor Networks*, NeurIPS ML & the Physical Sciences Workshop, 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. Associated publication: [6]

PRESENTATIONS and PRESS

[some titles truncated for space]

Invited Talks

The Effects of Physicality on Emergent Learning	APS March Meeting, Anaheim, CA, **[upcoming]**
How to Construct a Learning 'Material' (Tutorial)	APS March Meeting, Anaheim, CA, **[upcoming]**
Emergent Physical Learning	Applied Physics Special Seminar, Cornell U, 2024
Emergent Physical Learning	Tufts Condensed Matter Seminar, 2024
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
Training neural networks using physical equations of motion — PNAS Physics Commentary 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