Daniel Ames Messenger September, 2024

Research Associate, University of Colorado at Boulder daniel.messenger@colorado.edu
Department of Applied Mathematics

Personal wesbite: https://dm973.github.io Github: https://github.com/MathBioCU
Google Scholar: https://scholar.google.com/citations?user=bg1DXKOAAAAJ

Education

Aug. 2019 - Aug. 2022	**PhD** Applied Mathematics	University of Colorado Boulder (UCB)
Aug. 2017 - July 2019	**MS** Applied Mathematics	Simon Fraser University (SFU)
Sept. 2011 - May 2015	**BS** Mathematics, **BA** Physics	University of Puget Sound (UPS)

Research Experience

08/2023 - (current)	**Research Assoc.**, Applied Math, UCB; Bortz lab
08/2022 - 08/2023	**Postdoc Research Assoc.**, Applied Math, UCB; Bortz lab
08/2020 - 08/2022	**Research Assistant**, Applied Math, UCB; Advisor: Dr. Bortz
Summers 2018, 2019	**Research Assistant**, Math, SFU; Advisors: R. Fetecau, R. Wittenberg
Summer 2014	**Research Intern**, Pacific Northwest National Lab (PNNL)

Publications

- Daniel A Messenger, April Tran, Vanja Dukic, and David M Bortz. The weak form is stronger than you think. *(Accepted)* arXiv preprint arXiv:2409.06751, 2024
- Reuben RW Wang and Daniel Messenger. Physics-guided weak-form discovery of reduced-order models for trapped ultracold hydrodynamics. (*In review*) arXiv preprint arXiv:2406.07519, 2024
- Daniel Messenger, Greg Dwyer, and Vanja Dukic. Weak-form inference for hybrid dynamical systems in ecology. (*Accepted*) arXiv preprint arXiv:2405.20591, 2024
- Christophe Bonneville, Xiaolong He, April Tran, Jun Sur Park, William Fries, Daniel A Messenger, Siu Wun Cheung, Yeonjong Shin, David M Bortz, Debojyoti Ghosh, et al. A comprehensive review of latent space dynamics identification algorithms for intrusive and non-intrusive reduced-order-modeling. (*In review*) arXiv preprint arXiv:2403.10748, 2024
- Gina Vasey, Daniel Messenger, David Bortz, Andrew Christlieb, and Brian O'Shea. Influence of initial conditions on data-driven model identification and information entropy for ideal mhd problems. *(In revision)* arXiv preprint arXiv:2312.05339, 2023
- Daniel A Messenger and David M Bortz. Asymptotic consistency of the WSINDy algorithm in the limit of continuum data. *(Accepted)* arXiv preprint arXiv:2211.16000, 2022

1. Daniel A Messenger, Joshua W Burby, and David M Bortz. Coarse-graining Hamiltonian systems using WSINDy. Scientific Reports, 14(1):14457, 2024
2. David M. Bortz, Daniel A. Messenger, and April Tran. Weak form-based data-driven modeling: Computationally Efficient and Noise Robust Equation Learning and Parameter Inference. In Siddhartha Mishra and Alex Townsend, editors, Numerical Analysis Meets Machine Learning, volume 25 of Handbook of Numerical Analysis, pages 54–82. Elsevier, 2024

3. April Tran, Xiaolong He, Daniel A Messenger, Youngsoo Choi, and David M Bortz. Weak-form latent space dynamics identification. Computer Methods in Applied Mechanics and Engineering, 427:116998, 2024

4. David M Bortz, Daniel A Messenger, and Vanja Dukic. Direct estimation of parameters in ODE models using WENDy: Weak-form estimation of nonlinear dynamics. Bulletin of Math. Bio., 80, October 2023

5. Daniel A Messenger, Graycen E Wheeler, Xuedong Liu, and David M Bortz. Learning anisotropic interaction rules from individual trajectories in a heterogeneous cellular population. Journal of the Royal Society Interface, 19, October 2022

6. Razvan C. Fetecau, Hui Huang, Daniel Messenger, and Weiran Sun. Zero-diffusion limit for aggregation equations over bounded domains. Discrete & Continuous Dynamical Systems, Oct. 2022

7. Daniel A. Messenger, Emiliano Dall'Anese, and David Bortz. Online weak-form sparse identification of partial differential equations. In PMLR, 15–17 Aug 2022

8. Daniel A. Messenger and David M. Bortz. Learning mean-field equations from particle data using WSINDy. Physica D: Nonlinear Phenomena, page 133406, July 2022

9. Daniel A. Messenger and David M. Bortz. Weak SINDy For Partial Differential Equations. Journal of Computational Physics, 443:110525, October 2021

10. Daniel A. Messenger and David M. Bortz. Weak SINDy: Galerkin-Based Data-Driven Model Selection. SIAM Multiscale Modeling & Simulation, 19(3):1474–1497, Sept. 2021

11. Daniel Messenger and Razvan C. Fetecau. Equilibria of an aggregation model with linear diffusion in domains with boundaries. Mathematical Models and Methods in Applied Sciences, 30(04):805–845, April 2020

Awards & Scholarships

2024	Director's Postdoctoral Fellowship, T-5 Division	Los Alamos National Labs
2024	(Declined) Mathematical Sciences Postdoctoral Research Fellowship	NSF
2023	10th Heidelberg Laureate Forum Young Researcher	HLFF
2022	Graduate Student Travel Award (MDS22)	SIAM
2019	Special Entrance Scholarship	UCB
2019	MSc Thesis Certificate with Distinction	SFU
2018	Best Poster Award	SFU Summer Symposium
2018	Graduate Fellowship	SFU
2017	Special Entrance Scholarship	SFU

Press

[1] "On Data-Driven Equation Discovery", George Miloshevich, Dec. 1, 2023. Towards Data Science. `https://towardsdatascience.com/on-data-driven-equation-discovery-5069795d239d`.

[2] "Researchers strive to help models learn from 'noisy' data". Oct. 23, 2023. University of Colorado Boulder Arts & Sciences Magazine. `https://www.colorado.edu/asmagazine/2023/10/23/researchers-strive-help-models-learn-noisy-data`.

[3] "APPM Research Associate Daniel Messenger selected for Heidelberg Laureate Forum", Patrick McCreery, July 24, 2023. Applied Mathematics News, CU Boulder. https://www.colorado.edu/amath/2023/07/24/appm-research-associate-daniel-messenger-selected-heidelberg-laureate-forum.

[4] "New study shows how to learn the equations of cell migration", Daniel Strain. Oct 26, 2022. CU Boulder Today. https://www.colorado.edu/today/2022/10/26/new-study-shows-how-learn-equations-cell-migration.

[5] "CU Boulder joins national effort to advance nuclear fusion research". Oct 19, 2022. University of Colorado Boulder Arts & Sciences Magazine. https://www.colorado.edu/asmagazine/2022/10/19/cu-boulder-joins-national-effort-advance-nuclear-fusion-research.

Presentations

[1] (Invited) **Recent advances in weak-form equation learning with applications to multiscale phenomena**. WCCM 2024, Vancouver, Canada. July. 23rd, 2024.

[2] (Invited) **Recent Advances in Weak-form Equation Learning**. SIAM Annual Meeting 2024, Spokane, WA. July. 10th, 2024.

[3] (Invited) **Weak-form equation learning with applications to cell migration and general multiscale phenomena**. Applied Mathematics Seminar, University of Waterloo, Ontario, CA. Feb. 1st, 2024.

[4] (Contributed) **Recent advances in Weak-Form Equation Learning with applications to collective cell migration**. Mathematical Biology Seminar, University of Colorado, Boulder, CO. Oct. 31, 2023.

[5] (Invited) **Weak-form equation learning using WSINDy**. Presentation for T-5 Group, Theoretical Division, Los Alamos National Laboratory, NM. Sept. 1st, 2023.

[6] (Invited) **Weak Form Equation Learning for Interacting Particle System Models of Collective Motion**. ICIAM 2023, Tokyo. Aug. 23, 2023.

[7] (Invited) **Recovery guarantees and statistical efficiency in weak-form system identification**. Center for Stochastic Dynamics Summer Seminar, Illinois Institute of Technology, July 26, 2023.

[8] (Invited) **Weak-Form Equation Learning for Interacting Particle System Models of Collective Motion**. SIAM Dynamical Systems 2023, Portland, OR. May 17, 2023.

[9] (Invited) **A Crash Course in Differential Geometry, Hamiltonian Systems, and Adiabatic Invariants in the Context of Data-Driven Modeling**. SIAM Graduate Student Chapter Seminar, University of Colorado, Boulder, CO. April 20, 2023.

[10] (Invited) **Towards recovery guarantees and statistical efficiency in weak-form system identification**. Computational Mathematics Seminar, University of Colorado, Boulder, CO. April 17, 2023.

[11] (Contributed) **Weak-form System Identification: Computational Efficiency and Applications to MHD**. SIAM CSE23, Amsterdam, NL. Mar. 1st, 2023.

[12] (Invited) **Weak-Form Sparse Identification of Models for Cell Biology at Single-Cell and Population Level Descriptions**. Joint Mathematics Meetings, Boston, MA. Jan. 6, 2023.

[13] (Invited) **Weak-form sparse identification of differential equations from noisy measurements**. SFU Applied and Computational Math Seminar, Burnaby, BC. Oct. 7, 2022.

[14] (Invited) **Using WSINDy to Learn Anisotropic Interaction Rules from Individual Trajectories in a Heterogeneous Cellular Population**. SIAM Conference on Mathematics of Data Science (MDS22), San Diego, CA. Sept. 28, 2022.

[15] (Contributed) **Online Weak-form Sparse Identification of Partial Differential Equations**. Mathematical and Scientific Machine Learning 2022 (MSML2022), Beijing, China. Aug. 16, 2022.

[16] (Invited) **Data-Driven Model Selection using Weak SINDy**. T-5 Reading Group, Theoretical Division, Los Alamos National Laboratory, NM. Aug. 6, 2021.

[17] (Invited) **Data-Driven Model Selection using Weak SINDy**. APPM Recruitment Symposium, University of Colorado, Boulder, CO. March 5, 2021.

[18] (Invited) **Data-Driven Model Selection using Weak SINDy**. Mathematical Biology Seminar, University of Colorado, Boulder, CO. Sept. 21, 2020.

[19] (Contributed) **Aggregation-Diffusion Phenomena in Domains with Boundaries**. SIAM Front Range Student Conference, University of Colorado, Denver, CO. March 7, 2020.

[20] (Invited) **Aggregation-Diffusion Phenomena in Domains with Boundaries**. Mathematical Biology Seminar, University of Colorado, Boulder, CO. Dec. 10, 2019.

[21] (Contributed) **Aggregation-Diffusion Phenomena in Domains with Boundaries**. Canadian Applied and Industrial Mathematics Society (CAIMS), Annual Meeting, Whistler, BC. June 10, 2019.

[22] (Invited) **Self-Organization in Domains with Boundaries**. Math Graduate Seminar, Simon Fraser University, Burnaby, BC. July 12, 2018.

[23] (Invited) **Normal and Enhanced Vibrational Spectroscopy**. Fall Physics Research Symposium, University of Puget Sound, Tacoma, WA. Oct. 17, 2014.

[24] (Invited) **Normal and Enhanced Vibrational Spectroscopy**. Summer Intern Research Symposium, Pacific Northwest National Laboratory, Richland, WA. July 28, 2014.

Posters

[1] (Contributed) **Coarse-Graining Hamiltonian Systems Using WSINDy**. APPM Graduate Student Recruitment Poster Session, CU Boulder. March. 13, 2024.

[2] (Invited) **Coarse-Graining Hamiltonian Systems Using WSINDy**. ChaRMNET Annual Meeting, MSU, East Lansing, MI. Dec. 4, 2023.

[3] (Invited) **Data-Driven Model Selection using Weak SINDy**. Inaugural Workshop: AI for Dynamic Systems, University of Washington, Seattle, WA. March. 16, 2022.

[4] (Invited) **Data-Driven Model Selection using Weak SINDy**. APPM Recruitment Symposium, University of Colorado, Boulder, CO. March. 11, 2022.

[5] (Contributed) **Weak SINDy: Galerkin-Based Data-Driven Model Selection**. SAMM 2020, Max Planck Institute for Dynamics of Complex Systems, Magdeburg, GE. July 27, 2020.

[6] (Contributed) **Interacting Particle Systems: Numerics for the Zero-Diffusion Limit**. Canadian Mathematical Society (CAS), Winter Meeting, Vancouver, BC. Dec. 7, 2018.

[7] (Contributed) **Random Interacting Particle Systems: Numerics for the Zero-Diffusion Limit**. SFU Symposium on Mathematics and Computation, Burnaby, BC. Aug. 14, 2018.

[8] (Contributed) **Normal and Enhanced Vibrational Spectroscopy**. Fall Research Poster Session, University of Puget Sound, Tacoma, WA. Sept. 11, 2014.

Workshops

[1] **Adventures of an Applied Mathematician** (Workshop leader). Calculus A/B, Peak-to-Peak High School. Lafayette, CO. May 17, 2024.

[2] **Interacting Particle Systems: Analysis, Control, Learning and Computation**. ICERM, Providence, RI. May 6-10, 2024.

[3] **CHaRMNET Annual Meeting**. MSU, East Lansing, MI. Dec. 4-6, 2023.

[4] **Weak-form system identification and parameter estimation**. Workshop organized by N. Mangan, virtual, Aug. 8, 2023.

[5] **Weak Derivatives and the real world** (Workshop leader). Calculus A/B, Peak-to-Peak High School. Lafayette, CO. May 15, 2023.

[6] **WENDy tutorial in MATLAB**. Guest lecture and workshop, APPM 4720 Data-Driven Modeling, UCB. Mar. 23 & April 4, 2023.

[7] **WSINDy_PDE tutorial in MATLAB**. Guest lecture and workshop, APPM 4720 Data-Driven Modeling, UCB. Feb. 16, 2023.

[8] **Mathematical modeling with differential equations** (Workshop leader). Calculus A/B, Peak-to-Peak High School. Lafayette, CO. Dec 9, 2022.

[9] **WSINDy MATLAB tutorial: ODEs & PDEs**. Guest lecture and workshop, APPM 4720 Data-Driven Modeling, UCB. April 5 & 7, 2022.

[10] **Learning Models from Data: Model Reduction, System Identification and Machine Learning**, GAMM Juniors' Summer School on Applied Mathematics and Mechanics (SAMM 2020), Max Planck Institute for Dynamics of Complex Systems, Magdeburg, GE. July 27, 2020.

Teaching

2020–2021	**Co-Instructor**, Department of Applied Mathematics, UCB
	APPM 7400 Teaching Excellence (Fall 2020)
2019– 2020	**Teaching Assistant**, Department of Applied Mathematics, UCB
	APPM 1350 Calculus I (Fall 2020)
	APPM 2360 Differential Equations (Spring 2020)
	APPM 2350 Calculus III (Fall 2019)
2017–2019	**Teaching Assistant**, Department of Mathematics, SFU
	MACM 316 Numerical Analysis (Spring 2019)
	MATH 303 Set Theory and Logic (Fall 2018)
	Math 310 Differential Equations (Spring 2018)
	Calculus I,II,III (Fall 2017)
2015	**Lab Assistant**, Physics Department, UPS
	PHYS 110 College Physics 2 (Spring 2015)

Professional Service

(ongoing)	**Reviewer** (10+ journals)
May 10^{th}, 2023	**Calculus workshop leader**, Peak to Peak High School, Colorado
Dec. 9^{th}, 2022	**Calculus workshop leader**, Peak to Peak High School, Colorado
Fall 2021 - Spring 2022	**President**, SIAM graduate student chapter, UCB
Fall 2021 - Spring 2022	**Peer mentor**, Department of Applied Mathematics, UCB
Fall 2021	**Organizer, Co-creator**, APPM Graduate Student Seminar, Department of Applied Mathematics, UCB
Summer 2020 - Spring 2021	**Lead Teaching Assistant**, Center for Teaching and Learning & Department of Applied Mathematics, UCB
Spring 2020, Spring 2021, Spring 2022	**Organizer**, SIAM Front Range Student Conference
Fall 2019	**Secretary**, SIAM graduate student chapter, UCB
Fall 2018 - Summer 2019	**Vice President**, grill master, ski-trip organizer, Math Graduate Caucus, SFU
Spring 2019	**Councilor**, Graduate Student Society, SFU
Fall 2019 - Spring 2019	**Committee Member**, Internal Relations Committee, Teacher and Support Staff Union, SFU