**Shukai Du** **Curriculum Vitae**

Visiting Assistant Professor
Department of Mathematics
University of Wisconsin-Madison

Email: sdu49@wisc.edu
Website: https://shukaidu.github.io

## RESEARCH INTERESTS

- Scientific machine learning and data-driven methods
- Computational inverse and ill-posed problems
- Finite element and discontinuous Galerkin methods
- Numerical methods for radiative transfer
- Electromagnetic and elastic/viscoelastic waves

## EDUCATION

### University of Delaware

- **Ph.D** in **Applied Mathematics** May 2020
  Advisor: Dr. Francisco-Javier Sayas
  Thesis: Generalized projection-based error analysis of hybridizable discontinuous Galerkin methods

### Wuhan University

- M.S. in Computational Mathematics 2015
- B.S. in Pure Mathematics 2012

## PUBLICATIONS

### Submitted

15. **S. Du**, and S. N. Stechmann. Element learning: a systematic approach of accelerating finite element-type methods via machine learning, with applications to radiative transfer. arXiv: 2308.02467.

### Peer-reviewed

14. **S. Du**, and S. N. Stechmann. Inverse radiative transfer with goal-oriented hp-adaptive mesh refinement: adaptive-mesh inversion. *Inverse Probl. 39 (2023), no. 11*.
    DOI: 10.1088/1361-6420/acf785
13. B. Cockburn, **S. Du**, M. A. Sánchez. A priori error analysis of new semidiscrete, Hamiltonian HDG methods for the time-dependent Maxwell's equations. *ESAIM: M2AN 57 (2023), no.4, 2097 – 2129.*
    DOI: 10.1051/m2an/2023048
12. **S. Du**, and S. N. Stechmann. Fast, low-memory numerical methods for radiative transfer via hp-adaptive mesh refinement. *J. Comput. Phys. 480 (2023)*.
    DOI: 10.1016/j.jcp.2023.112021
11. **S. Du**, and S. N. Stechmann. A universal predictor-corrector approach for minimizing artifacts due to mesh refinement. *J. Adv. Model. Earth Syst. (2023), in press.*
10. B. Cockburn, **S. Du**, M. A. Sánchez. Combining finite element space-discretization with symplectic time-marching schemes for linear hamiltonian systems. *Front. Appl.*

*Math. Stat. 9 (2023).*
DOI: 10.3389/fams.2023.1165371

9. M. A. Sánchez, **S. Du**, B. Cockburn, N.-C. Nguyen, J. Peraire. Symplectic Hamiltonian finite element methods for electromagnetics. *Comput. Methods Appl. Mech. Engrg. 396 (2022).*
   DOI: 10.1016/j.cma.2022.114969
8. B. Cockburn, M. A. Sánchez, **S. Du**. Discontinuous Galerkin methods with time-operators in their numerical traces for time-dependent electromagnetics. *Comput. Meth. Appl. Math. (2022).*
   DOI: 10.1515/cmam-2021-0215
7. **S. Du**, and F.-J. Sayas. A note on devising HDG+ projections on polyhedral elements. *Math. Comp. 90 (2021), 65-79.*
   DOI: 10.1090/mcom/3573
6. **S. Du**. HDG methods for Stokes equation based on strong symmetric stress formulations. *J. Sci. Comput. 85, 8 (2020).*
   DOI: 10.1007/s10915-020-01309-7
5. **S. Du**, and F.-J. Sayas. A unified error analysis of hybridizable discontinuous Galerkin methods for the static Maxwell equations. *SIAM J. Numer. Anal. 58 (2020), no. 2, 1367–1391.*
   DOI: 10.1137/19M1290966
4. **S. Du**, and F.-J. Sayas. New analytical tools for HDG in elasticity, with applications to elastodynamics. *Math. Comp. 89 (2020), 1745-1782.*
   DOI: 10.1090/mcom/3499
3. **S. Du**, and N. Du. A factorization of least-squares projection schemes for ill-posed problems. *Comput. Meth. Appl. Math. 20 (2020), no. 4, 783-798.*
   DOI: 10.1515/cmam-2019-0173
2. T.S. Brown, **S. Du**, H. Eruslu, and F.-J. Sayas. Analysis of models for viscoelastic wave propagation. *Appl. Math. Nonlin. Sci. 3 (2018), no. 1, 55-96.*
   DOI: 10.21042/AMNS.2018.1.00006

### Books

1. **S. Du**, and F.-J. Sayas. An invitation to the theory of the Hybridizable Discontinuous Galerkin Method. *SpringerBriefs in Mathematics (2019).*
   DOI: 10.1007/978-3-030-27230-2

## GRANTS

- NSF (DMS–2324368): Breaking the 1D Barrier in Radiative Transfer: Fast, Low-Memory Numerical Methods for Enabling Inverse Problems and Machine Learning Emulators. Senior personnel. $498,832 total, $350,000 at UW (2023–2026).
- NSF (AGS–2326631): Convective Processes in the Tropics Across Scales. Senior personnel. $768,471 total, $471,155 at UW (2024–2026).

## PRESENTATION

### Invited talks

22. Element learning: a systematic approach of accelerating finite element-type methods via machine learning, with applications to radiative transfer
    *Scientific Computing Seminars, University of Houston* — Nov 2023

21. Element learning: a systematic approach of accelerating finite element-type methods via machine learning, with applications to radiative transfer
*Applied Math seminar, University of Louisiana at Lafayette* Oct 2023
20. Element learning: a systematic approach of accelerating finite element-type methods, with applications to radiative transfer
*Numerical analysis and PDE seminar, University of Delaware* Sep 2023
19. Energy-conserving discontinuous Galerkin methods with time-operators in their traces for time-dependent electromagnetics
*17th UCNCCM, Albuquerque, NM* July 2023
18. Fast, low-memory methods for radiative transfer through hp-adaptive mesh refinement
*13th AIMS meeting, Wilmington, NC* June 2023
17. Unified analysis of HDG methods for the static Maxwell equations
*CILAMCE-PANACM 2021, Brazil* Nov 2021
16. Generalized projection-based error analysis of hybridizable discontinuous Galerkin (HDG) methods
*CEDYA2021, Spain* June 2021
15. Projection-based analysis of hybridizable discontinuous Galerkin (HDG) methods
*Wenbo Li Prize Talk, U of Delaware* Feb 2020
14. Unified analysis of HDG methods for the static Maxwell equations
*SIAM CSE2021, Virtual Meeting* Mar 2021
13. New analysis techniques of HDG+ method
*SIAM Sectional Meeting, Iowa State U* Oct 2019
12. Uniform-in-time optimal convergent HDG method for transient elastic waves with strong symmetric stress formulation
*WAVES2019, TU Wien, Vienna* Aug 2019
11. Hybridizable Discontinuous Galerkin schemes for elastic waves
*ICIAM2019, Valencia* July 2019
10. HDG for transient elastic waves
*WONAPDE2019, U of Concepcion* Jan 2019

**Contributed talks**

9. Element learning: accelerating finite element methods via operator learning
FEM Circus, U of Notre Dame Oct 2023
8. Three-dimensional radiative transfer: fast, low-memory numerical methods
*Collective Madison Meeting, Madison, WI* Aug 2022
7. Projection-based analysis of HDG methods with reduced stabilization
*DelMar Num Day 2019, U of Maryland* May 2019
6. Projection-based error analysis of HDG methods for transient elastic waves
*FEM Circus, U of Delaware* Nov 2018
5. Devising a tailored projection for a new HDG method in linear elasticity
*FEM Circus, U of Tennessee* Mar 2018
4. A new HDG projection and its applications
*Mid-Atlantic Numerical Analysis Day, Temple U* Nov 2017

**Poster presentation**

3. Fast, low-memory numerical methods for radiative transfer: forward and inverse problems
*New Trends in Computational and Data Sciences, Caltech* Dec 2022
2. Hybridizable Discontinuous Galerkin methods in transient elastodynamics
*FACM2018, New Jersey Institute of Technology* Aug 2018
1. Building a computational code for 3D viscoelastic wave simulation
*Mid-Atlantic Numerical Analysis Day, Temple U* Nov 2016

**TEACHING**

**Instructor**

- Linear Algebra and Differential Equations (Math320) Spring 2023

**Teaching Assistant**

- Analytic Geometry and Calculus C (Math243) 2016&2017 Fall
- Analytic Geometry and Calculus B (Math242) 2017 Spring
- Calculus I (Math221) 2018 Spring
- Review of Advanced Mathematical Problems
(summer courses offered to incoming graduate students) 2018 Fall

**MENTORING ACTIVITIES**

**Graduate mentorship**

- Jason Torchinsky (co-mentored with Samuel N. Stechmann) 2022 – 2023

**Undergraduate mentorship**

- WISCERS project at the University of Wisconsin-Madison 2023
– a research-focused mentorship program for undergraduate students
- GEMS summer research project at the University of Delaware Fall 2016

**JOURNAL REFEREE**

Journal of Scientific Computing
SIAM Multiscale Modelling and Simulation
ESAIM: Mathematical Modelling and Numerical Analysis
Computers and Mathematics with Applications
Frontiers in Applied Mathematics and Statistics

**AWARDS AND HONORS**

Wenbo Li Prize 2020
University Doctoral Fellowship Award at the University of Delaware 2019
ICIAM2019 travel grant 2019
Graduate Enrichment Fellowship at the University of Delaware 2018
GEMS project fund at the University of Delaware Summer 2016
National Scholarship for Graduate Students of China 2013
People's Scholarship of Wuhan University 2011
Outstanding Student of Wuhan University 2009-2011

**CODING PROJECTS**

Fast, low-memory methods for radiative transfer 2020 - current

- Build a cell-based structured adaptive mesh refinement (AMR) data structure

- Implement discontinuous Galerkin (DG) methods with $hp$-adaptivity for the full radiative transfer equation

Hybridizable Discontinuous Galerkin (HDG) methods 2016 - 2020
(based on HDG3D library: github.com/team-pancho/HDG3D)

- Build Matlab codes of high order HDG methods on computing cluster for transient elastic/viscoelastic waves and Maxwell equations
- Write documentation with detailed implementation procedures for HDG methods for Maxwell equations

Finite Element Method (FEM) 2016
(based on Team Pancho FEM library: team-pancho.github.io)

- Build Matlab codes of high order FEM methods on computing cluster for simulation of viscoelastic waves.

Multiscale modeling 2013 - 2015

- Implement algorithms to calculate Cauchy stress tensor based on micro-scale molecular dynamics information

**COMPUTER SKILLS**

*Theory*
Data Structures • Algorithm • Object Oriented Programming
*Languages & Software*
Matlab • Python • C • C++ • Fortran • openMPI • LISP • Linux Shell