Shukai Du **Curriculum Vitae**

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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

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, U 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