Opal Issan

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EDUCATION

University of California San Diego
La Jolla, CA

Ph.D. in Mechanical and Aerospace Engineering (Advisor: Boris Kramer)
Sept. 2021 – Present

Specialization in Fluid/Plasma Dynamics and Numerical Methods

GPA: 4.0/4.0

San Diego State University
San Diego, CA

B.S. in Applied Mathematics
Aug. 2017 – May 2021

Specialization in Computational Science

Major GPA: 4.0/4.0

RESEARCH EXPERIENCE

Graduate Research Assistant
La Jolla, CA

Department of Mechanical and Aerospace Engineering, University of California San Diego
Sept. 2021 – Present

Advisor: Prof. Boris Kramer

- Reduced-Order Modeling of Ambient Solar Wind Models: Developed a reduced-order model, *shifted operator inference*, to predict the ambient solar wind in the heliospheric domain. The proposed method can be extended to a wide class of advection-dominated systems described on a periodic domain [4].
- Bayesian Inference and Global Sensitivity Analysis of Ambient Solar Wind Models: Performed variance-based global sensitivity analysis of the uncertain parameters in a solar wind model chain, and learned the posterior distribution of the influential parameters via Bayesian inference [3].

Heliophysics Researcher
Remote Work

Frontiers Development Lab
June 2024 – Aug. 2024

Advisors: Dr. Mike Heyns (Imperial College London)

- SuperMAG with Quantified Uncertainties: Developed a Gaussian process spherical harmonic and spherical elementary currents interpolator with quantified uncertainty of global geomagnetic ground perturbations via nearly 600 magnetometer station measurements.

Los Alamos National Laboratory Space Weather Summer School Student
Los Alamos, NM

Applied Mathematics and Plasma Physics Theoretical Division (T-5)
June 2023 – July 2023

Advisors: Dr. Gian Luca Delzanno, Dr. Oleksandr Koshkarov, and Dr. Federico Halpern (General Atomics)

- Spectral Plasma Solver: Formulated an anti-symmetric and positivity-preserving spectral discretization for the Vlasov-Poisson equations. This novel formulation is unconditionally stable, structure-preserving, and conserves the number of particles, which is important for long-term numerical simulations of plasma processes [1–4].

Undergraduate Research Assistant
San Diego, CA

Department of Mathematics and Statistics, San Diego State University
May 2020 – Aug. 2021

Advisor: Prof. Christopher Curtis

- Deep Learning Dynamic Mode Decomposition: Developed an autoencoder that finds a finite-dimensional approximation of the Koopman operator with Tensorflow 2.0. The encoder mapping transforms the nonlinear trajectories to a space where dynamics are linear. This method is useful for estimating, predicting, and controlling nonlinear dynamical systems [5].

Solar Physics Intern
San Diego, CA

Predictive Science Inc.
Dec. 2019 – July 2021

Advisors: Dr. Pete Riley and Dr. Cooper Downs

- Coronal Hole Mapping and Analysis Pipeline (CHMAP): Developed a robust method for automatically tracking spatiotemporal properties of coronal holes as part of the CHMAP Python package.
- Heliospheric Upwind eXtrapolation (HUX): Refined the HUX model which maps solar wind proton velocity from the inner heliosphere to Earth via employing finite-difference flux-limiter higher-order schemes. The HUX model is tested on observational data from various spacecrafts, e.g. Parker Solar Probe, Ulysses, and Wind [6-7].
- Mesh Generation Software: Developed a Python package for a mesh generator that increased the efficiency of simulating coronal mass ejections by adjusting the mesh resolution in areas of the Sun's active region.

TEACHING

Teaching Assistant, Signals and Systems (MAE 143A)
San Diego, CA

Department of Mechanical and Aerospace Engineering, University of California San Diego Jan. 2024 – March 2024
Taught by Prof. Boris Kramer
- Led recitation sessions to 190+ MAE students teaching the material covered in course lectures.
- Held weekly office hours to help students with the course material/concepts and homework problems.

Course Grader, Introduction to Linear Algebra Course
San Diego, CA

Department of Mathematics, San Diego State University Jan. 2019 – May 2020
Taught by Prof. Peter Blomgren
- Graded midterm and final exams for the 'Introduction to Linear Algebra' undergraduate course.

Teaching Assistant, Precalculus
San Diego, CA

Department of Mathematics, San Diego State University Aug. 2018 – Dec. 2018
Taught by Lecturer Corey Manchester
- Led tutoring sessions to over 40 precalculus students teaching the material covered in course lectures.
- Held weekly office hours to help students with coursework in the San Diego State University Math Learning Center.

MENTORSHIP

UCSD Undergraduate Research Mentor
La Jolla, CA

Department of Mechanical and Aerospace Engineering, University of California San Diego June 2022 – Oct. 2023
- Mentored undergraduate researchers Emily Deboer and Hannah Haider under the supervision of Prof. Boris Kramer. I worked with Emily on structure-preserving non-intrusive model order reduction and with Hannah on a stable discretization of a three-dimensional hydrodynamic model of the solar wind.

OUTREACH

Hosted a 'Space Research' booth with Prof. Boris Kramer's laboratory, the Rocket Propulsion Laboratory (RPL), and Students for the Exploration and Development of Space (SEDS), at Southeast San Diego Science and Art Expo (August 12, 2023), Barrio Logan Science and Art Expo (April 15, 2023), Comienza con un Sueño / It Begins with a Dream (March 4, 2023), Barrio Logan Science and Art Expo (April 16, 2022). These events are a great opportunity to communicate our research to the San Diego community and engage with future scientists early on.

PREPRINTS

[1] Issan O, Koshkarov O, Halpern F, Delzanno GL, Kramer B (2025). Conservative data-driven model order reduction of a fluid-kinetic spectral solver (submitted). preprint doi: arXiv:2504.09682

JOURNAL PUBLICATIONS

[2] Issan O, Chapurin O, Koshkarov O, Delzanno GL (2025). *Effects of Artificial Collisions, Filtering, and Nonlocal Closure Approaches on Hermite-based Vlasov-Poisson Simulations.* Physics of Plasmas, 32:033906. doi: 10.1063/5.0252456

[3] Issan O, Koshkarov O, Halpern F, Kramer B, Delzanno GL (2025). *Conservative Closures of the Vlasov-Poisson Equations Discretized with a Symmetrically Weighted Hermite Spectral Expansion in Velocity.* Journal of Computational Physics, 524:113741. doi: 10.1016/j.jcp.2025.113741

[4] Issan O, Koshkarov O, Halpern F, Kramer B, Delzanno GL (2024). *Anti-symmetric and Positivity Preserving Formulation of a Spectral Method for Vlasov-Poisson Equations.* Journal of Computational Physics, 514:113263. doi: 10.1016/j.jcp.2024.113263

[5] Bychkov A, Issan O, Pogudin G, Kramer B (2023). *Exact and Optimal Quadratization of Nonlinear Finite-Dimensional Non-autonomous Dynamical Systems.* SIAM Journal on Applied Dynamical Systems, 23:982-1016. doi: 10.1137/23M1561129

[6] Issan O, Riley P, Camporeale E, Kramer B (2023). *Bayesian Inference and Global Sensitivity Analysis for Ambient Solar Wind Prediction.* Space Weather, 21, e2023SW003555. doi: 10.1029/2023SW003555

[7] Issan O and Kramer B (2022). *Predicting Solar Wind Streams from the Inner-Heliosphere to Earth via Shifted Operator Inference.* Journal of Computational Physics, 473:111689. doi: 10.1016/j.jcp.2022.111689

[8] Alford-Lago D, Curtis C, Ihler A, and <u>Issan O</u> (2022). *Deep Learning Enhanced Dynamic Mode Decomposition.* Chaos, 32(3):033116. doi: 10.1063/5.0073893

[9] <u>Issan O</u> and Riley P (2022). *Theoretical Refinements to the Heliospheric Upwind eXtrapolation Technique and Application to in-situ Measurements.* Frontiers in Astronomy and Space Sciences, 8:795323. doi: 10.3389/fspas.2021.795323

[10] Riley P and <u>Issan O</u> (2021). *Using a Heliospheric Upwinding eXtrapolation Technique to Magnetically Connect Different Regions of the Heliosphere.* Frontiers in Physics, 9:679497. doi: 10.3389/fphy.2021.679497

NEWS BLOG

1. <u>Issan O</u> and Kramer B (2023). *Speeding Up Solar Wind Forecasts with Reduced-order Modeling.* Society for Industrial and Applied Mathematics News Blog.

CONFERENCE PRESENTATIONS AND POSTERS

1. <u>Issan O</u>, Chapurin O, Koshkarov O, Delzanno GL (Nov. 2024). *Effects of Artificial Collisions, Filtering, and Nonlocal Closure Approaches on Hermite-based Vlasov-Poisson Simulations.* 2024 Fusion Energy and Pulsed Power Workshop, San Diego, CA. (poster)

2. <u>Issan O</u>, Koshkarov O, Halpern F, Delzanno GL, Kramer B (Sept. 2024). *Conservative reduced order modeling of the plasma kinetic equations.* Model Reduction and Surrogate Modeling (MORe), San Diego, CA. (poster)

3. <u>Issan O</u>, Koshkarov O, Halpern F, Kramer B, Delzanno GL (Aug. 2024). *Anti-symmetric and Positivity Preserving Formulation of a Spectral Method for Vlasov-Poisson Equations.* 15th International Symposium for Space Simulations (ISSS-15) and 16th International Workshop on the Interrelationship between Plasma Experiments in the Laboratory and in Space (IPELS-16), Garching, Germany. (poster)

4. <u>Issan O</u>, Koshkarov O, Halpern F, Kramer B, Delzanno GL (Aug. 2024). *Anti-symmetric and Positivity Preserving Formulation of a Spectral Method for Vlasov-Poisson Equations.* Solar Heliospheric and INterplanetary Environment (SHINE), Juneau, Alaska. (poster)

5. <u>Issan O</u>, Riley P, Camporeale E, Kramer B (Aug. 2023). *Bayesian Inference and Global Sensitivity Analysis for Ambient Solar Wind Prediction.* 10th International Congress on Industrial and Applied Mathematics, Tokyo, Japan. (presentation)

6. <u>Issan O</u>, Koshkarov O, Halpern F, Delzanno GL (July 2023). *Anti-symmetric and Positivity Preserving Formulation of the Spectral Plasma Solver.* Los Alamos National Laboratory Space Weather Summer School Seminar, Los Alamos, NM. (presentation)

7. <u>Issan O</u>, Riley P, Camporeale E, Kramer B (June 2023). *Bayesian Inference and Global Sensitivity Analysis for Ambient Solar Wind Prediction.* Geospace Environment Modeling (GEM) Workshop, San Diego, CA. (poster)

8. <u>Issan O</u> and Kramer B (April 2023). *Predicting Solar Wind Streams from the Inner-Heliosphere to Earth via Shifted Operator Inference.* U.S. Association for Computational Mechanics (USACM) Workshop on Establishing Benchmarks for Data-Driven Modeling of Physical Systems, Los Angeles, CA. (presentation)

9. <u>Issan O</u>, Camporeale E, Kramer B (March 2023). *Parameter Estimation of Ambient Solar Wind Models using ACE Observations.* Space Weather with Quantified Uncertainties Spring Meeting, Cambridge, MA. (poster)

10. <u>Issan O</u> and Kramer B (Sept. 2022). *Predicting Solar Wind Streams from the Inner-Heliosphere to Earth via Shifted Operator Inference.* Society for Industrial and Applied Mathematics (SIAM) Conference on Mathematics of Data Science (2022), San Diego, CA. (presentation)

11. <u>Issan O</u> and Kramer B (June – July 2022). *Predicting Solar Wind Streams from the Inner-Heliosphere to Earth via Shifted Operator Inference.* Geospace Environment Modeling (GEM) and Solar Heliospheric and INterplanetary Environment (SHINE) Workshop, Waikiki, HI. (poster)

12. <u>Issan O</u> and Kramer B (May 2022). *Predicting Solar Wind Streams from the Inner-Heliosphere to Earth via Shifted Operator Inference.* Southern California Applied Mathematics Symposium (SOCAMS) Conference, Los Angeles, CA. (presentation)

13. <u>Issan O</u> and Curtis C (July 2021). *Enhancing Dynamic Mode Decomposition using Autoencoder Networks.* Society of Applied and Industrial Mathematics (SIAM) Annual Meeting, virtual. (presentation)

RELEVANT COURSEWORK

• Astrophysical Fluid Dynamics   • Probabilistic Reasoning & Learning   • Model Reduction   • Hydrodynamic Instability • Potential Flow   • Computational Fluid Dynamics   • Uncertainty Quantification   • Numerical Methods   • Intro to Fluid Dynamics   • Geophysical Data Analysis   • Intro to Applied Mathematics • Intro to Plasma Physics

FELLOWSHIPS

1. Center for Space and Earth Science (CSES) Fellowship (June, 2024): This fellowship is given by the Los Alamos National Laboratory on our proposal "Effect of cold plasma on whistler waves in the magnetosphere" (with co-PI Oleksandr Koshkarov, LANL T-5) a total of $210,000$ for three years (of which $135,000$ goes towards graduate school tuition and funding).
2. Strategic Enhancement of Excellence Through Diversity (SEED) Fellowship (Aug. 2021): This award is given to outstanding doctoral students at UCSD, which provided three years of funding during graduate school.

AWARDS AND DISTINCTIONS

1. UCSD Mechanical and Aerospace Engineering **Outstanding PhD Student of the Year Award** (2024-2025)
2. UCSD Mechanical and Aerospace Engineering **Outstanding PhD Teaching Assistant of the Year Award** (2023-2024)
3. Awardee of the Los Alamos National Laboratory Vela Fellowship (July 2023): Funding for PhD students as part of the Space Weather Summer School.
4. Selected participant for NextProf Pathfinder Workshop (Oct. 2021): The workshop is intended for a selective group of Engineering Ph.D. students interested in learning about academic careers.
5. Travel Awards:

   • Geospace Environment Modeling (GEM) (June 2025).
   • Model Reduction and Surrogate Modeling (Sept., 2024).
   • CRC International Summer School 2024 on Data Assimilation (Sept., 2024).
   • Solar Heliospheric and INterplanetary Environment (SHINE) (Aug., 2024).
   • 15th International Symposium for Space Simulations (ISSS) (Aug., 2024).
   • 16th Interrelationship between Plasma Experiments in the Laboratory and in Space (IPELS) (Aug., 2024).
   • 10th International Congress on Industrial and Applied Mathematics (ICIAM) (Aug. 2023).
   • Geospace Environment Modeling (GEM) (June 2023).
   • Space Weather Quantified Uncertainties (SWQU) spring meeting (March 2023).
   • Society for Industrial and Applied Mathematics conference on Mathematics of Data Science (SIAM-MDS) (Sept. 2022).

COMPUTER SKILLS

• Programming languages: Python, Matlab, Maple, Julia, C/C++, R, Java.   • Version control tools: Git, Bitbucket. • Operating systems: MacOS, Windows, Linux.   • HPC skills: Batch scripting.