Saurabh S. Sawant, Ph.D.

Center for Computational Sciences and Engineering (CCSE)
Applied Mathematics and Computational Research Division (AMCRD)
Lawrence Berkeley National Laboratory, Berkeley, CA 94720.

☎ +1-(814)-777-7497
✉ SaurabhSawant@lbl.gov
saurabh-s-sawant.github.io

Summary

- 10+ years of experience in developing highly scalable software using C++, message-passing-interface (MPI), and GPUs for diverse scientific applications:
  - Specialization in hypersonic flows during Ph.D. projects.
  - Focus on nanoelectronics while contributing to open-source software during postdoctoral work.
- Skilled in diverse modeling techniques, including:
  - Specialization in kinetic methods for high-temperature gas dynamics.
  - Expertise in matrix-based algorithms for quantum transport in nanomaterials.
  - Experience in linear stability analyses of compressible flows.
- 7+ years of experience contributing to collaborative, interdisciplinary projects.

Education

Ph.D. *May 2022*
Department of Aerospace Engineering, University of Illinois Urbana-Champaign
Thesis: **The development of kinetic models and simulation methods to study molecular fluctuations, modal response, and shock-laminar separation bubble instabilities**
https://www.ideals.illinois.edu/items/124505
Cumulative GPA: 3.76 on a scale of 4

M.S. *Dec. 2015*
Department of Aerospace Engineering, University of Illinois Urbana-Champaign
Thesis: **Development of AMR octree Direct Simulation Monte Carlo (DSMC) approach for shock dominated flows.**
https://www.ideals.illinois.edu/items/91247
GPA: 3.87 on a scale of 4

B.E. *Aug. 2011*
Department of Mechanical Engineering, Vidyavardhini's College of Engineering & Tech., Mumbai University, India.
Thesis: **Efficiency analysis of Aerospike nozzles.**
Class: First Class

Research Experience

Postdoctoral Scholar *Jan. 2022- Present*
Center for Computational Sciences and Engineering (CCSE)
Applied Mathematics and Computational Research Division (AMCRD)
Lawrence Berkeley National Laboratory, Berkeley, CA-94709, USA.
Supervisor: Dr. Andrew Nonaka

I contribute to a DOE-funded project, "Codesign and Integration of Nanosensors on Complementary Metal-Oxide-Semiconductor (CMOS)", focused on developing a CMOS chip as a nanoscale photon sensor with carbon nanotubes integrated with quantum dots. In my computational role, I conduct nanoscale modeling of Carbon Nanotube Field-Effect Transistor (CNTFET) configurations and microscale modeling of transmission lines on the chip

for electromagnetic wave propagation.

- **(Ongoing) A GPU-Accelerated Self-Consistent Quantum Transport Framework for Modeling Nanomaterials.** Description
  - Developed a 3D open-source framework for **ele**ctrostatic-**q**uantum **tr**ansport **m**odeling **o**f **n**anomaterials at **ex**ascale (ELEQTRONeX), built using the AMReX library, modern C++, GPUs, MPI. https://github.com/AMReX-Microelectronics/eXstatic
  - Quantum transport is modeled using the nonequilibrium Green's function (NEGF) method, and self-consistency is achieved using a novel MPI/GPU parallelized Broyden's modified second algorithm.
  - Conducted weak-scaling studies up to 512 NVIDIA A100 GPUs on NERSC's Perlmutter, and solver is used to model carbon nanotube field effect transistors with aperiodic arrangement of nanotubes.
- **Characterization of microscale transmission lines using Maxwell's equations.** Description
  - Developed a workflow to compute scattering ($\boldsymbol{S}$) parameters for microscale transmission lines and implemented it in the open-source finite difference time domain Maxwell solver, ARTEMIS.
    https://github.com/AMReX-Microelectronics/artemis
  - Demonstrated application on part of proposed transmission line for carbon nanotubes to IC inputs.
  - Conducted weak-scaling studies of ARTEMIS up to 2048 NVIDIA A100 GPUs on NERSC's Perlmutter supercomputer.

Graduate Research Assistant *Aug. 2014- Dec. 2021*
Department of Aerospace Engineering
University of Illinois Urbana-Champaign, Champaign, IL-61801, USA
Advisor: Professor Deborah Levin

During M.S. & Ph.D., I have contributed to multiple projects in the field of hypersonics, funded by AFOSR, ONR, DoD, and NASA. A brief overview of these is provided below.

- **Kinetic Modeling of Shock-Wave/Boundary-Layer Interactions.**
  Description
  - Developed a 3-D DSMC solver, SUGAR (Scalable Unstructured Gas-dynamic Adaptive mesh-Refinement), using C++11 & MPI, with features including adaptive mesh refinement (AMR) for octree grids, 3D embedded boundaries with cut-cell algorithm, Morton-based load balance, and thermal non-equilibrium models.
  - Achieved ideal strong scaling speed-up up to 4096 processors and 87% weak scaling efficiency for 8192 processors in hypersonic flow simulations with shocks.
  - Conducted 3-D simulations of shock-wave/boundary-layer interactions over a double wedge using 20,000 processors, exceeding two million node-hours on supercomputers such as NSF's Bluewaters, TACC's Stampede2, FRONTERA, and DoD's Onyx.
- **DSMC Study of Linear Instability Mechanism in Laminar Hypersonic Separated Flow.** Description
  - Conducted spanwise periodic DSMC simulations of Mach 7 nitrogen flow over a 30°-55° double wedge at $Re_1 = 5.22 \times 10^5$ m^{-1} (altitude above 60 km).

- Investigated coupling of 3-D laminar separation bubble's linear instability with separation and detached shocks, identifying spanwise corrugation of shocks and low-frequency unsteadiness of the triple point at $St \sim 0.02$.
- Employed data-driven techniques like proper-orthogonal decomposition for noise reduction and dominant mode extraction. Description

- **Kinetic Study of Low-Frequency Fluctuations in One-Dimensional Shock.** Description
  - Studied shock structure fluctuations in argon, revealing two-order lower frequency variations compared to freestream, with consistent Strouhal numbers ($St = 0.002 - 0.02$) across Mach 2-10.
  - Developed Lotka-Volterra two-energy-bin model, attributing shock frequency differences to bimodal energy density functions.
  - Derived analytical formula for bimodal energy distribution as non-central chi-squared (NCCS) distributions, establishing semi-analytical model to predict shock fluctuation frequencies.

- **Modeling of multi-scale thermal response of an AVCOAT-like thermal protection system.** Description
  - Carried out DSMC simulations of gas transport through the microstructure of an AVCOAT-like ablative heatshield.
  - Obtained permeability and tortuosity for the AVCOAT material.
  - Developed a random walk model for coupled convection, conduction, and radiation through the microstructure.
  - Studied the thermal response of AVCOAT material with spatially varying thermophysical properties at high temperatures using the loosely-coupled DSMC-random walk model and compared it with finite-volume approaches.

- **Modeling of shock-induced dust lifting.** Description
  - Implemented capability to model dust particles in the open-source FLASH solver, used to model charged particle-fluid interactions by a junior graduate student.

Achievements

Argonne Training Program on Extreme Scale Computing Certificate *2022*
Argonne National Laboratory

Recipient of FRONTERA Leadership Resource Allocation *2020-2022*
University of Illinois Urbana-Champaign

Recipient of AE Outstanding Graduate Student Fellowship *2020*
University of Illinois Urbana-Champaign

MAVIS Future Faculty Fellows (MF3) Program *Fall 2019–2020*
University of Illinois Urbana-Champaign

Recipient of the Best Undergraduate Project *2011*
Vidyavardhini's College of Engineering, Mumbai University, India

Teaching Experience

Teaching Assistant (TA)
Department of Aerospace Engineering
University of Illinois Urbana-Champaign, Champaign, IL-61801, USA.

- **Incompressible Flows (AE 311)** *Spring 2020*
  Instructor: Professor Laura Villafane Roca
- **Aerospace Flight Mechanics (AE 202)** *Fall 2019*
  Instructor: Professor Huy Tran
- **Incompressible Flows (AE 311)** *Spring 2019*
  Instructor: Professor Theresa Saxton-Fox

- **Rocket Propulsion (AE 434)** *Spring 2018*
  Instructor: Professor Deborah Levin
  Duties for last four TAs: Preparing homework and exam solutions, holding office hours, conducting python workshops, and lectures when instructor is traveling.

Research Associate *Dec. 2012–July 2013*
Department of Mechanical Engineering,
Indian Institute of Technology Bombay, Mumbai, Maharashtra-400076, India

- **Created open-source tutorials and conducted workshops on OpenFOAM & Salome software.**
  Advisor: Professor Shivasubramanian Gopalakrishnan
  Project: FOSSEE, National Mission on Education through Information and Communication Technology, Sponsored by MHRD, Government of India.
  Link: http://www.spoken-tutorial.org/list_videos?view=1&foss=OpenFOAM&language=English

Lecturer
Atharva College of Engineering, Mumbai University, India. *Jan.–July. 2012*

- **Engineering Drawing and CAD software packages**
  Duties: Teaching first-year students of Mechanical Engineering, conducting workshops for CAD software packages, holding office hours, preparing homework and exams.

Journal Publications

Sawant, S. S., Yao, J., Jambunathan, R., & Nonaka, A. (2023) **Characterization of Transmission Lines in Microelectronic Circuits Using the ARTEMIS Solver.** ***IEEE Journal on Multiscale and Multiphysics Computational Techniques***, vol. 8, pp. 31-39. doi:10.1109/JMMCT.2022.3228281

Sawant, S. S., Theofilis, V., & Levin, D. A. (2022) **On the synchronisation of three-dimensional shock layer and laminar separation bubble instabilities in hypersonic flow over a double wedge.** ***Journal of Fluid Mechanics***, 941, A7. doi:10.1017/jfm.2022.276

Sawant, S. S., Levin, D. A., & Theofilis, V. (2022) **Analytical prediction of low-frequency fluctuations inside a one-dimensional shock.** ***Theoretical and Computational Fluid Dynamics.***, 36, 25-40. doi:10.1007/s00162-021-00589-5

Klothakis, A., Quintanilha, H., & Sawant S. S., Protopapadakis, E., Theofilis V., & Levin D. A. (2022) **Linear stability analysis of hypersonic boundary layers computed by a kinetic approach: a semi-infinite flat plate at** $4.5 \leq M_\infty \leq 9$**.** ***Theoretical and Computational Fluid Dynamics.***, 36, 117-139. doi:10.1007/s00162-021-00601-y

Sawant, S. S., Levin, D. A., & Theofilis, V. (2021) **A kinetic approach to studying low-frequency molecular fluctuations in a one-dimensional shock.** ***Physics of Fluids***, 33 (10), 104106. doi:10.1063/5.0065971

Marayikkottu, V. A., Sawant, S. S., & Levin, D. A. (2021) **Study of particle lifting mechanisms in an electrostatic discharge plasma.** ***International Journal of Multiphase Flows***, 137, 103564. doi:10.1016/j.ijmultiphaseflow.2021.103564

Sawant, S. S., Rao, P., Harpale, A., Chew, H. B., & Levin, D. A. (2019) **Multi-scale thermal response modeling of an AVCOAT-like thermal protection material.** ***International Journal of Heat and Mass Transfer***, 133, 1176-1195.
doi:10.1016/j.ijheatmasstransfer.2018.12.182

Harpale, A., Sawant, S. S., Kumar, R., Levin, D. A., & Chew, H. B. (2018) **Ablative thermal protection systems: Pyrolysis modeling by scale-bridging molecular dynamics.** ***Carbon***, 130, 315-324. doi:10.1016/j.carbon.2017.12.099

Sawant, S. S., Tumuklu, O., Jambunathan, R., & Levin, D. A. (2018) **Application of adaptively refined unstructured grids in DSMC to shock wave simulations.** ***Computers & Fluids***, 170, 197-212. doi:10.1016/j.compfluid.2018.04.026

Refereed Conference Proceedings

Sawant, S. S., Tumuklu, O., Theofilis, V., & Levin, D. A. (2022). **Linear Instability of Shock-Dominated Laminar Hypersonic Separated Flows. In: Sherwin, S., Schmid, P., Wu, X. (eds)** ***IUTAM Laminar-Turbulent Transition.*** IUTAM Bookseries, vol 38. Springer, Cham. doi:10.1007/978-3-030-67902-6_57

Conference Publications

Klothakis, A., Sawant S. S., Quintanilha, H., Theofilis V., & Levin, D. A. (2021). **Slip Effects on the Stability of Supersonic Laminar Flat Plate Boundary Layer.** ***AIAA Scitech 2021 Forum*** (Paper No. 1659).

Sawant, S. S., Tumuklu, O., Theofilis, V., & Levin, D. A. (2020). **Analysis of Spanwise Perturbations in Laminar Hypersonic Shock-Boundary Layer Interactions.** ***AIAA Scitech 2020 Forum*** (Paper No. 0108).

Marayikkottu, V. A., Sawant, S. S., Levin, D. A., Huang, C., Schoenitz, M., & Dreizin, E. (2020). **Comparison of numerical simulations of inert particle transport in an electrostatic discharge with experimental results.** ***AIAA Scitech 2020 Forum*** (Paper No. 1798).

Marayikkottu, V. A., Sawant, S. S., Rao, P., & Levin, D. A. (2019). **Study of inert simulated particle transportation in a moving shock/pressure wave generated by electrostatic discharges.** ***AIAA Scitech 2019 Forum*** (Paper No. 0631).

Sawant, S. S., Rao, P., Harpale, A., Chew, H. B., & Levin, D. A. (2018). **Micro-scale thermal response modeling of Avcoat-like TPS.** ***2018 AIAA Aerospace Sciences Meeting*** (Paper No. 0495).

Sawant, S. S., Harpale, A., Jambunathan, R., Beng Chew, H., & Levin, D. A. (2017). **High fidelity and multi-scale thermal response modeling of an Avcoat-like TPS.** ***55^{th} AIAA Aerospace Sciences Meeting*** (Paper No. 0438).

Sawant, S. S., Tumuklu, O., Jambunathan, R., & Levin, D. A. (2017). **Novel use of AMR Unstructured Grids in DSMC Compressible Flow Simulations.** ***47^{th} AIAA Thermophysics Conference*** (Paper No. 4028).

Sawant, S. S., Jambunathan, R., Tumuklu, O., Korkut, B., & Levin, D. A. (2016). **Study of shock-shock interactions using an unstructured AMR octree DSMC code.** ***54^{th} AIAA Aerospace Sciences Meeting*** (Paper No. 0501).

Sawant, S. S., Korkut, B., Tumuklu, O., & Levin, D. A. (2015). **Development of an amr octree dsmc approach for shock dominated flows.** ***53^{rd} AIAA Aerospace Sciences Meeting*** (Paper No. 0070).

Presentations and Talks

Sawant, S. S., Léonard F., Yao, J., & Nonaka, A. (2023). **A Coupled Electrostatic - Quantum Transport Framework for Exascale Systems.** ***Intl. Workshop on Comput. Nanotech. (IWCN), Barcelona, Spain.*** Abstract pg. 84-85.

Sawant, S. S., Yao, J., Jambunathan, R., Léonard F., & Nonaka, A. (2019). **A Highly Scalable NEGF Solver for Modeling Time-Dependent Quantum Transport in**

Nanomaterials. ***The APS March Meeting 2023, Las Vegas, Nevada, USA***.

Sawant, S. S., Yao, J., Jambunathan, R., Léonard F., & Nonaka, A. (2019). **Multiscale Modeling of Carbon Nanotube Field Effect Transistors (CNTFETs) for Photodetection.** ***Fourth CS-Area Postdoc Symposium, Lawrence Berkeley National Laboratory, Berkeley, USA***. Video

Sawant, S. S., Tumuklu, O., Theofilis, V., & Levin, D. A. (2019). **Linear instability of shock-dominated laminar hypersonic separated flows.**, ***IUTAM Symposium on Laminar-Turbulent Transition 2019, London, UK***.

Sawant, S. S., Rao, P., Harpale, A., Chew, H. B., & Levin, D. A. (2019). **Multi-scale thermal response modeling of an AVCOAT-like thermal protection material.**, ***11^{th} Ablation Workshop, University of Minnesota, Minneapolis, MN***.

Rao, P., Sawant, S. S., Harpale, A., Chew, H. B., & Levin, D. A. (2017). **Hybrid Walker Approach to Conduction-Radiation Coupling in Micro-Scale Ablation Modeling**, ***9^{th} Ablation Workshop, Montana State University, Bozeman, MT***.

Sawant, S. S., Jambunathan R., and & Levin, D. A. (2018). **Multi-scale Gas Dynamic and Thermal Response Modeling of Ablative Thermal Protection Systems**, ***31^{st} Rarefied Gas Dynamics Conference, Glasgow, Scotland***.

Professional Service

Reviewed two journal articles for the *Theor. and Comput. Fluid Dyn.* *2021-2022*
Reviewed a journal article for *Acta Astronautica* *2022*
Reviewed a conference article for the *31st Rarefied Gas Dynamics* conference *Spring 2019*