Saurabh S. Sawant

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Department of Aerospace Engineering
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Research Interests

- Development and application of kinetic and kinetically-informed partial differential equation (PDE)-based formulations to hypersonic and plasma-based flows.
- Receptivity of kinetically modeled shocks to freestream and induced disturbances.
- Plasma-instabilities and plasma-assisted control of shock-dominated flows.
- Machine-learning based closure for continuum formulations of fluid and plasma flows.
- Plasma processes for renewable energy and medical applications.

Education

Ph.D. *expected by Aug. 2021*
Department of Aerospace Engineering, University of Illinois at Urbana-Champaign
Tentative Thesis: **Kinetic modeling of hypersonic environment: stability analysis of shock-dominated flows and thermal response of ablative materials.**
Advisor: Professor Deborah A. Levin
Cumulative GPA: 3.76 on a scale of 4

M.S. *Dec. 2015*
Department of Aerospace Engineering, University of Illinois at Urbana-Champaign
Thesis: **Development of AMR octree Direct Simulation Monte Carlo (DSMC) approach for shock dominated flows.**
Advisor: Professor Deborah A. Levin
GPA: 3.87 on a scale of 4

B.E. *Aug. 2011*
Department of Mechanical Engineering, Vidyavardhini's College of Engineering & Technology,
Mumbai University, India.
Thesis: **Efficiency analysis of an aerospike nozzle.**
Guide: Professor Dipak Choudhary
Class: First Class

Achievements

AE Outstanding Graduate Student Fellowship *2020*
University of Illinois at Urbana-Champaign.
MAVIS Future Faculty Fellows (MF3) Program *Fall 2019–2020*
University of Illinois at Urbana-Champaign.
Best Undergraduate Project *2011*
Vidyavardhini's College of Engineering, Mumbai University, India.

Research Experience

Research Assistant at the Department of Aerospace Engineering,
University of Illinois at Urbana-Champaign *Aug. 2014-Present*
Advisor: Professor Deborah A. Levin

- **Development of scalable Direct Simulation Monte Carlo (DSMC) solver known as SUGAR (Scalable Unstructured Gas-dynamic Adaptive mesh-Refinement) to simulate hypersonic shock-boundary layer interactions.**
  - Performance improvement strategies for an adaptively refined DSMC solver.
  - Implementation of thermal non-equilibrium models.

  - Use of space-filling curves and run-time memory optimization in adaptively refined grids.
  - Ideal strong scaling speed-up for up to 4096 processors.
  - Weak scaling efficiency of 87% for 8192 processors.
  - Application to 3-D simulation of shock-wave boundary layer interactions over a double wedge using 20,000 processors.

- **Modeling of multi-scale thermal response of an AVCOAT-like thermal protection system.**
  - DSMC study of the effect of AVCOAT-like microstructure on internal gas transport.
  - Permeability and tortuosity computation for AVCOAT and comparison with fibrous TPS.
  - Coupled convection, conduction, and radiation using a random walk model.
  - Study of AVCOAT with spatially varying thermophysical properties at high temperatures.
  - Comparison of thermal response predicted by stochastic versus finite-volume approaches.

- **A kinetic approach to studying low-frequency fluctuations in a one-dimensional shock.**
  - Millisecond-scale fluctuations of macroscopic flow parameters in the shock structure of argon.
  - Role of bimodality of energy density functions in time-scales of fluctuations.
  - Two-energy bin dynamic model for collision interaction of particles in a shock.
  - Strouhal numbers at various input conditions.
  - Analytical derivation of non-central chi-squared bimodal energy distribution functions.

- **DSMC investigation of linear instability mechanism in a laminar hypersonic seperated flow.**
  - Spanwise periodic simulation of Mach 7 flow of nitrogen over a 30°-55° double wedge.
  - Linear instability of 3-D laminar separation bubble.
  - Modeling of surface rarefaction effects and the translational, rotational, vibrational nonequilibrium.
  - Expected bifurcation at unit Reynolds number below $Re_1 = 5.22 \times 10^5$ m^{-1} (above 59 km alitude).
  - Spanwise corrugation of separation and detached (bow) shocks.
  - Presence of low-frequency unsteadiness with a Strouhal number, St=0.0186.

- **(Ongoing) Development of Anisotropic Conservation Equations (ACE).**
  - Formulation revisits and corrects the assumptions made in the Navier-Stokes-Fourier constitutive relations using kinetic theory concepts.
  - Accounts for anisotropy of stresses in translational nonequilibrium zones of shocks.
  - Does not depend on the assumption of zero bulk viscosity.
  - Amenable to global linear stability analysis with DSMC-computed base flows.

- **Implementation of dust particles in an open source flow solver, FLASH, for the study of particle lifting mechanism in electrostatic discharge.**

Research Associate at the Department of Mechanical Engineering,
Indian Institute of Technology, Bombay. *Dec. 2012–July 2013*

- **Create open source tutorials and conduct workshops on OpenFOAM & Salome software.**
  Advisor: Dr. 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

Teaching Experience

Teaching Assistant (TA) at the Department of Aerospace Engineering,
University of Illinois at Urbana-Champaign.

- **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: To prepare homework and exam solutions, hold office hours, conduct python workshops, and lectures when instructor is traveling.

- **Aerospace Propulsion (AE 433)** *Fall 2018*
  Instructor: Professor Joshua Rovey
  Duties: To make sure that the lectures are recorded for online students.

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

- **Engineering Drawing and CAD software packages**
  Duties: To teach engineering drawing to first-year students of engineering, conduct workshops for AUTOCAD, SolidWorks, and CATIA software, hold office hours, prepare homework and exams.

Professional Service

Reviewed a paper submitted for Rarefied Gas Dynamics conference. *Spring 2019*

Journal Publications

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

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

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

Marayikkottu, V. A., Sawant, S. S., & Levin, D. A. **Numerical study of the particle lifting mechanism in electrostatic discharge.** ***International Journal of Multiphase Flows.*** **(submitted)**

Sawant, S. S., Levin, D. A., & Theofilis, V. **A kinetic approach to studying low-frequency molecular fluctuations in a one-dimensional shock.** ***Journal of Fluid Mechanics.*** **(submitted)**
arXiv:2012.14593 Video presentation

Sawant, S. S., Levin, D. A., & Theofilis, V. **Analytical prediction of low-frequency molecular fluctuations inside a one-dimensional shock.** ***Theoretical and Computational Fluid Dynamics. Special Issue on Fluid Mechanics and Hypersonic Flight.*** **(submitted)**
arXiv:2101.00664

Sawant, S. S., Theofilis, V., & Levin, D. A. **Linear global instability of three-dimensional shock / laminar separation bubble interaction on a double wedge at hypersonic conditions. (in preparation)**
Video presentation

For potential updates, please visit: www.saurabhsawant.net/publications

Refereed Conference Proceedings

Sawant, S. S., Tumuklu, O., Theofilis, V., & Levin, D. A. (2019). **Linear instability of shock-dominated laminar hypersonic separated flows.** ***IUTAM Proceedings on Laminar-Turbulent Transition 2019.*** **(accepted and forwarded to the publisher)**

Conference Publications

Sawant, S. S., Tumuklu, O., Theofilis, V., & Levin, D. A. (2020). **Analysis of Spanwise Perturbations in Laminar Hypersonic Shock-Boundary Layer Interactions.** ***In 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.** ***In 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.** ***In 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.** ***In 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.** ***In 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.** ***In 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.** ***In 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. ***In 53rd AIAA Aerospace Sciences Meeting*** (Paper No. 0070).

Poster Presentations and Talks

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.**, ***11th 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**, ***9th 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**, ***31st Rarefied Gas Dynamics Conference, Glasgow, Scotland***.

References

Professor Deborah A. Levin
Professional relationship: M.S. and Ph.D. advisor.
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Professor Huck Beng Chew
Professional relationship: Ph.D. co-advisor and collaborator for the ablation work.
Affiliation: Department of Aerospace Engineering
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Urbana, IL-61801, USA
☎ +1-217-333-9770
✉ hbchew@illinois.edu

Professor Vassilios Theofilis
Professional relationship: Ph.D. co-advisor and collaborator for the project on linear stability analysis.
Affiliation 1: Chair of Aerospace Engineering
School of Engineering, University of Liverpool
The Quadrangle, Brownlow Hill
L69 3GH, UK
Affiliation 2: Professor in the School of Aeronautics
The Escola Politécnica, Universidade São Paulo
Av. Professor Mello Moraes 2231, CEP 5508-900
São Paulo-SP, Brasil
☎ +44 (0) 151 794 4849
✉ V.Theofilis@liverpool.ac.uk

Professor Craig Dutton
Professional relationship: Mentor for the MAVIS Fellowship program.
Affiliation: Department of Aerospace Engineering
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