Dr. Akshay Dongre

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Research Interests

Computational Fluid Dynamics, Turbulence and Combustion Modeling, Lattice Boltzmann Method, Quantum Computing for CFD, Hypersonic Flows, High-Performance Computing

Education

Ph.D. in Mechanical Engineering — September 2018 – July 2024
Michigan Technological University, Houghton, MI — GPA: 3.97
Dissertation: Modeling Pulsatile Flows Using Incompressible Finite Volume Lattice Boltzmann Model

M.Tech. in Aerospace Engineering — July 2011 – July 2013
Indian Institute of Technology Kanpur, Kanpur, India
Thesis: Assessment of Turbulence-Chemistry Interaction Models in MILD Combustion

B.Engg. in Mechanical Engineering — July 2007 – May 2011
University of Pune, Pune, India
Project: Assembly Mechanism of Oil Filter Casting using Pneumatic Press

Publications

Journal Publications

1. **Dongre, A.**, Patel, K., Fisher, R., Poludnenko, A., Gamezo, V., Ugalino, M., Byrohl, C. "First-Principles Turbulence-Driven Detonation Mechanism Predicts Near-Chandrasekhar Mass White Dwarf Progenitors Produce Normal SN1990N-like Event". (Manuscript in preparation.)
2. Murdock, J., **Dongre, A.**, Yang, S.-L. "Lattice Boltzmann Method for Unsteady Incompressible Flows". (Manuscript in preparation. First draft completed.)
3. **Dongre, A.**, Yang, S.-L. "Numerical Investigation of Pulsatile Blood Flow through Arteries Afflicted with Aneurysm". (Manuscript under review.)
4. **Dongre, A.**, Yang, S.-L. (2025). "Finite Volume Incompressible Lattice Boltzmann Method Simulation of Pulsatile Blood Flow in Arteries with Multiple Stenosis: A Hemodynamic Analysis" *Physics of Fluids*, 37(11), 113116.
5. **Dongre, A.**, Murdock, J., Yang, S.-L. (2025). "Finite Volume Incompressible Lattice Boltzmann Framework for Non-Newtonian Flow Simulations in Complex Geometries", *Mathematics*, 13(10), 1671.
6. De, A., **Dongre, A.** (2015). "Assessment of Turbulence-Chemistry Interaction Models in MILD Combustion Regime", *Flow, Turbulence, and Combustion*, 94(2), 439-478.
7. **Dongre, A.**, De, A., Yadav, R. (2014). "Numerical Investigation of MILD Combustion Using Multi-Environment Eulerian Probability Density Function Modeling", *International Journal of Spray and Combustion Dynamics*, 6(4), 357-386.
8. De, A., **Dongre, A.**, Yadav, R. (2013). "Numerical Investigation of Delft-Jet-in-Hot-Coflow (DJHC) Burner Using Probability Density Function (PDF) Transport Modeling", *Turbo Expo: Power for Land, Sea, and Air*, GT2013-95390, V01BT04A030.

Conference Papers

1. **Dongre, A.**, De, A., De, S. (2015). "Large Eddy Simulation of Turbulent Lifted Hydrogen Flames in a Vitiated Coflow Using Steady Flamelet Approach", *Proceedings of First International ISHMT-ASTFE Heat and Mass Transfer Conference*, Thiruvananthapuram, India.
2. **Dongre, A.**, De, A. (2014). "Numerical Investigation of Pilot-Stabilized Turbulent Flames Using Steady Flamelet Model", *ASME 2014 Gas Turbine India Conference*, New Delhi, India.
3. Yadav, R., De, A., **Dongre, A.** (2013). "Modeling of A Turbulent Lifted Methane-Air Jet Flame in Vitiated Co-Flow Using Multi-Environment Eulerian PDF (MEPDF) Transport Approach", *Ninth Asia-Pacific Conference on Combustion*, Gyeongju, Korea.
4. De, A., **Dongre, A.**, Yadav, R. (2012). "Eulerian PDF Transport Modeling of Delft-Jet-in-Hot-Coflow (DJHC) Burner", *Fourth International Congress on Computational Mechanics and Simulation (ICCMS)*, Hyderabad, India.

Conference Talks

- **Dongre, A.**, Patel, K., Fisher, R., Poludnenko, A., Gamezo, V., Ugalino, M., Byrohl, C., Tanvir, T. (2025). "Three-Dimensional Hydrodynamic Simulations of Turbulence-Driven Deflagration-to-Detonation Transition in Unconfined Reactive Flows", *APS Division of Fluid Dynamics Annual Meeting*, Houston, TX.
- **Dongre, A.**, Fisher, R., Poludnenko, A., Gamezo, V. (2025). "Three-Dimensional Hydrodynamical Full-Star Simulations of Turbulence-Driven Deflagration-to-Detonation Transition (tDDT) in Thermonuclear Supernovae", *APS Global Physics Summit*, Anaheim, CA.
- **Dongre, A.**, Yang, S.-L. (2023). "Finite Volume Lattice Boltzmann Scheme on Unstructured Meshes for Simulating Incompressible Flows", *76th Annual Meeting of the APS Division of Fluid Dynamics*, Washington, D.C.

Workshops and Summer Schools

- **Princeton-Combustion Institute Summer School on Combustion and the Environment** *June 22-27, 2025*
  Princeton University, Princeton, NJ, USA

Professional Experience

Postdoctoral Researcher August 2024 – Present
University of Massachusetts Dartmouth, Dartmouth, MA

- Conduct the first ever full-star, three-dimensional simulations of near-Chandrasekhar-mass white dwarfs incorporating experimentally validated turbulence-driven deflagration-to-detonation transition (tDDT) mechanism. Using `FLASH`'s block-structured AMR framework with compressible hydrodynamics, Helmholtz equation of state, and multipole self-gravity, these simulations eliminate the ad hoc detonation triggers that have constrained Type Ia supernova simulations for decades.
- Replace prescribed detonation conditions with first-principles-based experimentally validated DDT criteria: detonation initiates when the ratio of the filter scale to the Chapman-Jouguet length scale (L/L_{CJ}) exceeds unity, directly linking turbulence intensity to transition physics. This approach lets initial conditions determine explosion outcomes naturally, rather than imposing when and where detonations occur.
- Systematically explore how progenitor central density, ignition topology, and turbulent conditions influence explosion energetics and nucleosynthesis. By varying ignition bubble configurations

and testing progenitors across the near-M_{Ch} range, this work establishes which initial states can produce successful detonations and what observational signatures they generate—questions that parameter-tuned models cannot address.

- Generate synthetic observables that reproduce observed spectra without tuning detonation parameters. Tracer-based nucleosynthesis with extended reaction networks yields ^{56}Ni mass and intermediate-mass elements, while Monte Carlo radiative transfer produces angle-dependent light curves and spectra showing good agreement with the normal Type Ia supernova SN 1990N. This end-to-end validation connects progenitor physics to observations.
- Quantify turbulence-flame coupling through diagnostic analysis of Damköhler number, flame surface density, packing statistics, and scalar dissipation using custom Python/`YT` pipeline. These diagnostics reveal how turbulence amplifies burning surface area and compresses reaction zones into confined regions capable of triggering detonation.

Surface Meshing Intern May 2023 – August 2023

Siemens Digital Industries Software, Austin, TX

- Executed testing of newly developed surface wrapper meshing feature in STAR-CCM+ software. This work was crucial for ensuring the feature's stability, accuracy, and readiness for production release.
- Designed and implemented new test cases to expand the coverage of the automated testing suite. These contributions were essential for identifying critical edge-case scenarios and ensuring the robustness of the meshing feature against a wider range of user inputs and geometries.
- Optimized the team's testing processes and enhanced quality assurance efficiency by developing Python scripts to automate migration of local testing suites to a standardized, centralized framework. This automation streamlined workflows, reduced manual effort, and established a more consistent testing environment.

Volume Meshing Intern May 2022 – August 2022

Siemens Digital Industries Software, Austin, TX

- Conducted rigorous testing on new volume meshing features developed by the STAR-CCM+ volume meshing team. This work was essential for ensuring the functional integrity, stability, and production readiness of the software's core capabilities.
- Leveraged extensive computational fluid dynamics simulations on Linux high-performance computing clusters to systematically evaluate the practical utility and performance advantages of specific meshing features and workflows. This provided critical insights into their real-world application and efficiency.
- Performed detailed feature profiling and performance analysis to identify and address computational bottlenecks. These contributions directly enhanced the overall efficiency and effectiveness of STAR-CCM+ for complex engineering simulations.

Project Engineer August 2013 – June 2015

Computational Propulsion Laboratory, IIT-Kanpur, Kanpur, India

- Spearheaded a combustion modeling project focused on the meticulous simulation and examination of two distinct non-premixed flames: the Sydney pilot-stabilized flames and the Cabra lifted flames. Utilizing the Steady Flamelet model to simulate combustion, RANS-based turbulence models were applied to the Sydney flames, while a Large Eddy Simulation (LES) methodology was used for the Cabra lifted flames to accurately capture their unique flow dynamics.
- Contributed to an industry-funded project for Pratt & Whitney Canada (PWC) by generating a high-fidelity 3D volume mesh for a PWC combustor. The resulting mesh, which consisted of 6.3 million cells, was critical for enabling subsequent thermo-acoustic combustion analysis.

Teaching Experience

Graduate Teaching Assistant

Michigan Technological University, Department of Mechanical Engineering-Engineering Mechanics

MEEM 2911: Mechanical Engineering Practices September 2020 – December 2023

- Served as Instructor for an experimental methods course training students in data acquisition, analysis, system design, and performance validation.
- Supervised two major engineering design projects:
  - **Adaptation of Autonomous Crane**: Guided design and testing of a cantilever crane for payload transfer, integrating dynamic control with safety link mechanisms. Oversaw experimental verification of proportional–integral control gains and mechanical failure limits through 3D printed safety link prototypes.
  - **HVAC System for Mobile NICU**: Mentored students in design, calibration, and testing of an HVAC system for a mobile neonatal intensive care unit (NICU). Supervised four design phases involving pressure transducers, thermocouples, flow sensors, and fan performance. Mentored students in MATLAB-based data processing, including computation of flow rates, Reynolds number, discharge coefficients, and uncertainty analysis.
- Provided mentorship in professional technical communication through weekly reports and memos, emphasizing clarity, documentation standards, and engineering presentation.
- Facilitated conflict resolution and team-building exercises, helping teams establish collaborative charters and accountability frameworks to enhance productivity.
- Conducted weekly office hours and help sessions to address conceptual challenges and reinforce applied learning.
- Developed instructional materials including laboratory manuals, assignments, and multimedia presentations to strengthen course delivery and student engagement.
- Collaborated with faculty to align laboratory content with lecture materials, ensuring curriculum coherence and effective integration of experimental learning outcomes.

MEEM 2110: Statics September 2019 – May 2020

- Served as Grader and proctor for quizzes, midterms, and final examinations, maintaining academic integrity and timely evaluation.
- Provided detailed, constructive feedback to support student understanding and mastery of fundamental statics concepts.

MEEM 3201: Fluid Mechanics and Heat Transfer September 2018 – May 2019

- Conducted weekly office hours to support students with conceptual and practical aspects of fluid mechanics and heat transfer.
- Delivered guest lectures on thermal boundary layers, demonstrating advanced subject knowledge and effective instruction.

Honors and Awards

Outstanding Graduate Student Teaching Award February 2021

Department of Mechanical Engineering, Michigan Technological University

Professional Memberships

American Physical Society (APS) November 2023 – Present

Early career scientist member

Service and Outreach

Student Success Council, Michigan Tech September 2023 – May 2024

- **Student Advisory Group:** Offered valuable feedback based on firsthand experiences to the Council, providing insights into factors influencing student success at Michigan Tech. Actively participated in discussions and deliberations, sharing perspectives on the impact of procedures, policies, practices, and courses on student success. Collaborated with diverse stakeholders within the advisory group to identify challenges and propose innovative solutions to enhance the overall student experience.
- **Academics/Advising/Teaching core group:** Collaborated with fellow members to contribute valuable insights and perspectives on faculty and graduate student training initiatives. Advocated for and contributed to discussions on work-life balance initiatives within the academic community. Promoted mental health awareness and support by actively participating in initiatives that address the well-being of faculty and graduate students. Contributed to the planning and implementation of initiatives that prioritize the holistic development and well-being of academic community members.

PhD Dissertation: Modeling Pulsatile Flows Using Incompressible Finite Volume Lattice Boltzmann Model

The lattice Boltzmann Equation (LBE) has been adapted to the finite volume approach to enable LBM implementation on irregular grids. A novel incompressible Lattice Boltzmann Method (iLBM) model has been integrated to address challenges associated with the compressible nature of LBE. The convective fluxes have been discretized using two approaches: Monotonic Upstream-centered Scheme for Conservation Laws (MUSCL) scheme and the Linear Reconstruction (LR) scheme. This framework combined LBM's strengths—explicit time integration, parallel scalability, and simplicity in modeling complex physics—with the geometric flexibility of unstructured meshes. This finite volume iLBM framework has been applied to simulate unsteady pulsatile blood flow in arteries with multiple stenoses and aneurysms, capturing non-Newtonian effects and hemodynamic indices such as wall shear stress and oscillatory shear index. The findings elucidate how Reynolds and Womersley numbers, Carreau number, and geometric factors like stenosis severity and configuration, and aneurysm size influence arterial flow patterns associated with atherosclerotic disease progression.

Master's Thesis: Assessment of Turbulence-Chemistry Interaction Models in MILD Combustion

Non-premixed flames issuing from two different burners, Delft-Jet-in-Hot-Coflow (DJHC) burner and Adelaide JHC burner, which imitate Moderate and Intense Low oxygen Dilution (MILD) combustion have been studied. A numerical investigation of the MILD combustion regime has been carried out, using both presumed shape PDF approach and transported PDF approach, in order to understand the accuracy and applicability of PDF transport models in the MILD regime. Different micro-mixing models have been integrated into Lagrangian PDF model to analyze the effects of molecular diffusion on flame characteristics. Results have been compared with experimental measurements, demonstrating good agreement for axial velocity, major species, and turbulent kinetic energy profiles. However, temperature profiles were over-predicted and limitations in capturing CO and OH radical profiles were identified.

B. Engg. Project: Assembly Mechanism of Oil Filter Casting using Pneumatic Press

Design and development of assembly mechanism for oil filter casting using a pneumatic press for MAHLE Filter Systems (India) Limited located in Pune, India. The oil filter casting consisted of two pipe joints inserted using an assembly mechanism. The previous assembly mechanism could insert only a single pipe joint during a single cycle. In addition to that, only a single type of angular orientation of pipe joint could be assembled in a single batch at a time leaving the assembly of the second pipe joint for the next batch. This resulted in increased cycle time to finish a single filter casting. This involved more manual work increasing fatigue in operator. The new assembly mechanism inserted both the pipe joints, having different angular orientation, in a single operational cycle in a single stroke of the press which reduced the manufacturing cycle time and increased the number of castings assembled in a single work shift.

Technical Skills

Programming Languages: C, C++, FORTRAN, MATLAB, Python, JAVA, CUDA

CFD Solvers: FLASH, STAR-CCM+, ANSYS FLUENT, OpenFOAM, CHEMKIN

CAD Software: ANSYS ICEM-CFD, Gmsh, Siemens NX

Parallel Computing: High Performance Computing (HPC), MPI, OpenMP

Visualization Tools: Tecplot, CFD Post, VisIT, ParaView

Version Control: Git, JIRA, Confluence

Other Software: Simulink, LabVIEW

Operating Systems: Windows, Linux (Ubuntu, CentOS, Red Hat)

References

Dr. Robert Fisher
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Dr. Jeffrey S. Allen
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Dr. Gowtham
Research Associate Professor
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