DEBOJYOTI GHOSH

Curriculum Vitae

Mathematics & Computer Science Division
Argonne National Laboratory
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RESEARCH INTERESTS

- Numerical analysis of partial differential equations; high order algorithms for hyperbolic conservations laws.
- Modeling of complex physical systems and application of numerical solution methods (compressible and incompressible fluid dynamics, aerodynamic flows, atmospheric flows).
- High-performance computing, and scalable implementation of high-order methods.
- High-order accurate and high-resolution schemes for spatial reconstruction and time integration: compact schemes, ENO and weighted ENO schemes; multi-stage time-integration schemes, implicit-explicit methods.

PROFESSIONAL EXPERIENCE

- **POSTDOCTORAL APPOINTEE – ARGONNE NATIONAL LABORATORY (Lemont, IL)**
  Mathematics and Computer Science Division (February 2013 – Present)
  Higher order time-integration schemes; implicit-explicit methods; scalable implementations of high-order time-integration and finite-difference schemes; applications to aerodynamic flows, atmospheric flows, and Fokker-Planck systems; active contributor to PETSc.
- **RESEARCH ASSISTANT – UNIVERSITY OF MARYLAND (College Park, MD)**
  Alfred Gessow Rotorcraft Center, Aerospace Engineering (Jul 2008 – Jan 2013)
  High-resolution non-oscillatory schemes for turbulent flows; application to DNS of turbulent flows, and flows around rotary and flapping wing aircraft; simulation of incompressible, vortex-dominated flows; immersed boundary methods and their applications.
- **RESEARCH ASSISTANT – INDIAN INSTITUTE OF TECHNOLOGY BOMBAY (Mumbai, India)**
  Department of Aerospace Engineering (June 2005 – June 2006)
  Numerical methods for ideal magneto-hydrodynamics; finite-volume time-domain algorithms for Maxwell's equations (electromagnetics); radar cross-section analysis of low-observable aircraft.
- **TEACHING ASSISTANT – INDIAN INSTITUTE OF TECHNOLOGY BOMBAY (Mumbai, India)**
  Department of Aerospace Engineering (July 2005 – May 2006)
  Numerical methods for conservation laws (graduate level); compressible gasdynamics (junior year level).
- **SUMMER INTERN – INFOTECH ENTERPRISES (Bangalore, India)**
  Pratt & Whitney Center of Excellence (May 2004 – Aug 2004)
  Computational analysis of effusion-cooled plate with commercial software (CFX-TASCFlow and ANSYS).

EDUCATION

- **University of Maryland, Department of Mathematics** Jan 2013
  DOCTOR OF PHILOSOPHY in Applied Mathematics (Concentration: Scientific Computing)
  Application Areas: Fluid Mechanics, Rotorcraft Aerodynamics
- **Indian Institute of Technology Bombay, Aerospace Engineering** July 2006
  MASTER OF TECHNOLOGY in Aerospace Engineering (Concentration: Computational Aerodynamics)
  BACHELOR OF TECHNOLOGY in Aerospace Engineering

OTHER COURSES AND TRAINING PROGRAMS

- **Argonne Training Program for Extreme Scale Computing** (ATPESC) (St. Charles, IL, 2014)

PUBLICATIONS

JOURNAL ARTICLES

- **Ghosh, D.**, Constantinescu, E.M., Brown, J., *Efficient Implementation of Nonlinear Compact Schemes on Massively Parallel Platforms*, SIAM Journal on Scientific Computing, 37 (3), 2015, C354–C383, doi: 10.1137/140989261.
- **Ghosh, D.,** Baeder, J.D., *Weighted Non-Linear Compact Schemes for the Direct Numerical Simulation of Compressible, Turbulent Flows*, Journal of Scientific Computing, 61 (1), 2014, 61-89, doi: 10.1007/s10915-014-9818-0.
- **Ghosh, D.** Medida, S., Baeder, J.D., *Application of Compact-Reconstruction WENO Schemes to Compressible Aerodynamic Flows*, AIAA Journal, 52 (9), 2014, 1858-1870, doi: 10.2514/1.J052654.
- **Ghosh, D.**, Baeder, J.D., *Compact Reconstruction Schemes with Weighted ENO Limiting for Hyperbolic Conservation Laws*, SIAM Journal on Scientific Computing, 34 (3), 2012, A1678–A1706, doi: 10.1137/110857659.
- **Ghosh, D.**, Baeder, J.D., *A High-Order Accurate Incompressible Navier Stokes Algorithm for Vortex Ring Interactions with Solid Wall*, AIAA Journal, 50 (11), 2012, 2408-2422, doi: 10.2514/1.J051537.

PEER-REVIEWED CONFERENCE PAPERS

- **Ghosh, D.**, Constantinescu, E.M., *Well-Balanced Formulation of Gravitational Source Terms for Conservative Finite-Difference Atmospheric Flow Solvers*, AIAA Paper 2015-2889, 7th AIAA Atmospheric and Space Environments Conference, June 22-26, Dallas, TX, doi: 10.2514/6.2015-2889.
- **Ghosh, D.,** Medida, S., Baeder, J.D., *Compact-Reconstruction Weighted Essentially Non-Oscillatory Schemes for Unsteady Navier-Stokes Equations*, AIAA Paper 2012-2832, 42nd AIAA Fluid Dynamics Conference and Exhibit, June 25-28, 2012, New Orleans, LA, doi: 10.2514/6.2012-2832.
- **Ghosh, D.**, Baeder, J.D., *Numerical Simulation of Vortex Ring Interactions with Solid Wall*, AIAA Paper 2011-675, 49th AIAA Aerospace Sciences Meeting, Jan 4-7, 2011, Orlando, FL, doi: 10.2514/6.2011-675.
- **Ghosh, D.**, Baeder, J.D., *A High Order Conservative Upwind Algorithm for the Incompressible Navier Stokes Equations*, AIAA Paper 2010-5030, 40th AIAA Fluid Dynamics Conference and Exhibit, June 28 – July 1, 2010, Chicago, IL, doi: 10.2514/6.2010-5030.

TECHNICAL REPORTS

- **Ghosh, D.**, Constantinescu, E.M., Brown, J., *Scalable Nonlinear Compact Schemes*, Technical Memorandum ANL/MCS-TM-340, Argonne National Laboratory, April 2014

THESES

- *Compact-Reconstruction Weighted Essentially Non-Oscillatory Schemes for Hyperbolic Conservation Laws***,** Ph. D. Thesis, University of Maryland, College Park, January 2013.
- *Higher Order Non-Oscillatory Schemes in Ideal Magnetohydrodynamics*, Masters Thesis, Indian Institute of Technology Bombay, July 2006.

INVITED AND MINI-SYMPOSIUM TALKS

- **Ghosh, D.**, Constantinescu, E. M., *Characteristic-Based Flux Splitting for Implicit-Explicit Time Integration of Low-Mach Number Flows*, 13th U.S. National Congress on Computational Mechanics (USNCCM13), Mini-symposium on *Advances in Implicit / Explicit (IMEX) Time integration of Multiphysics Systems*, July 26 - 30, 2015, San Diego, CA.
- **Ghosh, D.**, Constantinescu, E. M., *A Finite-Difference Algorithm with Characteristic-Based Semi-Implicit Time-Integration for the Euler Equations with Gravitational Forcing*, SIAM Conference on Mathematical & Computational Issues in the Geosciences, Mini-symposium on *Modeling and Simulation of Multiscale and Coupled Processes in Atmospheric Physics*, June 29 - July 2, 2015, Stanford, CA.
- **Ghosh, D.**, Constantinescu, E.M., *A Compact-Reconstruction WENO Scheme with Semi-Implicit Time Integration*, SIAM Conference on Computational Science and Engineering, Mini-symposium on *Recent Advances in High Order Spatial Discretization Methods for PDEs*, March 14 – 18, 2014, Salt Lake City, UT.

- Ketcheson, D., **Ghosh, D.**, *Stability-Optimized Time Integrators for WENO Discretizations*, SIAM Conference on Computational Science and Engineering, Mini-symposium on *Advances in Time-stepping Methods*, March 14 – 18, 2014, Salt Lake City, UT.
- Barajas-Solano, D.A., Tartakovsky, A., **Ghosh, D.**, Constantinescu, E.M., Abhyankar, S., *Probability Density Methods for the Analysis of Power Grids Under Uncertainty*, SIAM Conference on Computational Science and Engineering, Mini-symposium on *Distributed Cyber-Physical Systems: Modelling and Controlling the Power Grid*, March 14 – 18, 2014, Salt Lake City, UT.
- **Ghosh, D.**, Constantinescu, E.M., Brown, J., *Scalable Non-Linear Compact Schemes*, International Conference on Spectral and High Order Methods (ICOSAHOM), Mini-symposium on *Aspects of Time Stepping*, June 23 – 27, 2014, Salt Lake City, UT.
- **Ghosh, D.**, *Compact-Reconstruction WENO Schemes - Theory, Implementation and Applications*, NIA CFD Seminar, National Institute of Aerospace, Hampton, VA, June 2014

OTHER CONFERENCES/TALKS/MEETINGS

- **Ghosh, D.**, Constantinescu, E.M., Brown, J., *A Scalable, Parallel Implementation of Weighted, Non-Linear Compact Schemes*, SIAM Annual Meeting, July 7 – 11, 2014, Chicago, IL.
- Brown, J., **Ghosh, D.**, *Fast Solvers for Implicit Runge-Kutta*, Thirteenth Copper Mountain Conference on Iterative Methods, April 6 – 11, 2014, Copper Mountain, CO.
- Brown, J., **Ghosh, D.**, *Fast solvers for implicit Runge-Kutta systems*, Tenth Workshop of the INRIA-Illinois-ANL Joint Laboratory on Petascale Computing, November 25 - 27, 2013, Urbana, IL.
- Brown, J., Constantinescu, E.M., **Ghosh, D.**, McInnes, L.C., *BOUT++ and PETSc: Time integration and solver composition*, BOUT++ Workshop, September 3 - 6, 2013, Livermore, CA.
- Constantinescu, E.M., Brown, J., Smith, B., McInnes, L.C., **Ghosh, D.**, Balay, S., *Robust Implicit-Explicit Time Stepping*, DOE Applied Math PI Meeting, August 6, 2013, Albuquerque, NM.
- **Ghosh, D.,** Medida, S., Baeder, J.D., *Direct Numerical Simulation of Compressible Turbulent Flows with Weighted Non-Linear Compact Schemes*, 65th Annual Meeting of the APS Division of Fluid Dynamics, November 18 – 20, 2012, San Diego, CA
- **Ghosh, D.,** Medida, S., Baeder, J.D., *High-Order Non-Oscillatory Compact Reconstruction Scheme for Overset Grids*, 11th Symposium on Overset Composite Grids and Solution Technology, October 15 – 18, 2012, Dayton, OH
- **Ghosh, D.,** Baeder, J.D., *Application of Compact-Reconstruction WENO Schemes to the Navier-Stokes Equations*, SIAM Annual Meeting, July 9 – 13, 2012, Minneapolis, MN
- **Ghosh, D.**, Baeder, J.D., *High Order Compact Reconstruction Scheme with Weighted Essentially Non-Oscillatory Limiting*, AMS-MAA Joint Mathematics Meetings, Jan 4-7, 2012, Boston, MA
- **Ghosh, D.**, *Application of Weighted Essentially Non-Oscillatory Limiting to Compact Interpolation Schemes*, AIAA Region I Young Prof., Student & Education Conference, Nov 4, 2011, Laurel, MD
- **Ghosh, D.**, Chatterjee, A., "*Higher-Order Non-Oscillatory Schemes in 2D Ideal Magneto-hydrodynamics*", 9th Annual CFD Symposium, August 2006, Bangalore, India
- **Ghosh, D.**, Chatterjee, A., "*Higher-Order Non-Oscillatory Schemes in Ideal Magneto-hydrodynamics*", 8th Annual CFD symposium, August 2005, Bangalore, India
- **Ghosh, D.**, Vaghela, M.B., Chatterjee, A., "*Radar Cross Section Computations for Low Observable Configurations*", 18th National Conference for Aerospace Engineers, Institution of Engineers (I), November, 2004, IIT Kharagpur, India
- **Ghosh, D.**, Vaghela, M.B., Chatterjee, A., "*Characteristic Based FVTD Computations for Low Observable Configuration*", 7th Annual CFD symposium, August 2004, Bangalore, India

RESEARCH PROJECTS

- *High-Order Multistage Time Integration schemes* (ANL)
  Funded by: DOE/Office of Science – Advanced Scientific Computing Research (Project title: "*Efficient ODE/DAE/PDE Integrators with Robust Global Error Estimators"*)
  - Implemented explicit, implicit and implicit-explicit (IMEX) Runge-Kutta time-integration schemes in PETSc (a widely-used library of scientific computing tools)

- Applied high-order time-integrators in PETSc to computation physics codes (atmospheric modeling, Navier-Stokes solvers, etc.)
- Implemented semi-implicit additive Runge-Kutta and Rosenbrock time-integration methods to an operational numerical weather prediction software.

o *Scalable implementation of non-linear, non-oscillatory compact schemes for parallel domains* (ANL)
- Implemented non-linear compact schemes on massively parallel platforms (DOE Leadership-class supercomputers) and demonstrated its higher efficiency compared with standard finite-difference schemes.

o *Compact-Reconstruction Weighted ENO Schemes for Hyperbolic Conservation Laws* (UMD)
Funded by: Army Research Lab – Micro Autonomous Systems & Technology (Project title: "*DNS/LES/RANS Analysis for Rotary- and Flapping-Wing-Based Micro Air Vehicles*")
- Derived and implemented a new class of compact non-oscillatory schemes for hyperbolic conservation laws with improved spectral resolution and lower absolute errors, compared to non-compact schemes of the same order of convergence
- Extended the new schemes to the Euler and Navier-Stokes equations – direct numerical simulation of compressible turbulence and simulation of dynamic stall on rotorcraft blades.

o *Interactional Aerodynamics of Tilt-Rotor Configurations using CFD* (UMD)
Funded by: Naval Air Warfare Center – Aircraft Division (NAVAIR)
- Extended an existing compressible Navier-Stokes algorithm to simulate complete flow-field around a rotorcraft, especially tilt-rotor aircraft
- Rotorcraft wake flow simulated using a three-dimensional compressible Navier-Stokes solver on a Cartesian mesh system with high order spatial and temporal accuracy
- Implemented the immersed body boundary conditions to model complicated fuselage shapes and validated on the Robin and AGARD E-7 idealized fuselages

o *High Order Conservative Incompressible Navier Stokes Solver for Vortex Dominated Flows – Interactions of Vortical Structures with Solid Surfaces* (UMD)
Funded by: Air Force Office of Scientific Research (under the Multi-University Research Initiative titled "*Rotorcraft Brownout: Advanced Understanding, Control, and Mitigation*")
- Developed an unsteady Fractional-Step incompressible flow solver to simulate wake flow of a rotorcraft operating in ground effect and capture essential flow features related to the brown-out problem of rotorcraft operating in dusty environments
- Explored the flow physics of multiple co-axial & co-rotating vortex rings interacting with a solid wall, including effect of parameters like initial separation and Reynolds number

o *Finite Volume Time Domain Algorithms for Ideal Magnetohydrodynamics* (IIT Bombay)
- Derived, implemented and validated a stable, robust numerical algorithm for the equations of ideal magnetohydrodynamics (1D and 2D)
- Implemented a characteristic-based algorithm with the Essentially Non-Oscillatory and Weighted Essentially Non-Oscillatory schemes for spatial reconstruction
- Explore the numerical nature of the ideal MHD equations using simplified model systems with topologically similar solutions

o *Radar Cross-Section Analysis of Low Observable Configurations* (IIT Bombay)
- Applied a finite-volume characteristic based algorithm for the equations of electromagnetics to simulate the Maxwell's equations of electromagnetism in the time domain
- Generated multi-block, body-fitted grids for the B2 Stealth Bomber and the F-117 Nighthawk
- Computed radar cross-section (RCS) of these stealth aircraft (assuming perfectly conducting surfaces) and compared with available data in public domain

- *Computational Analysis of an Effusion Cooled Plate*
  - Used commercial software to simulate the effusion cooling of an interface element representing the encasing of a gas turbine engine combustion chamber.

PROFESSIONAL ACTIVITIES

- Visiting researcher at the *Numerical Mathematics Group* in Computer, Electrical and Mathematical Sciences & Engineering, King Abdullah University of Science and Technology (Host: David Ketcheson), June 2015.
- Session Co-Chair at 7th AIAA Atmospheric and Space Environments Conference (Numerical Weather Prediction) (with Dr. Nashat Ahmad, NASA LaRC).
- Session Chair at SIAM Annual Meeting 2014 (Numerical Methods in PDE VII).
- Reviewer
  - Computers & Mathematics with Applications
  - Journal of Scientific Computing
- Organizer of the LANS Informal Seminar Series at the MCS Division, Argonne National Laboratory (2013 – 2015).

GRADUATE COURSEWORK

UNIVERSITY OF MARYLAND COLLEGE PARK

- **APPLIED MATHEMATICS AND SCIENTIFIC COMPUTING**
  Partial Differential Equations; Numerical Methods for Partial Differential Equations; Mathematics of the Finite Element Method; Financial Mathematics; Scientific Computing; Computer Hardware, Organization & Programming.
- **AEROSPACE AND MECHANICAL ENGINEERING**
  Fundamentals of Fluid Mechanics; Hydrodynamics; Hypersonic Aerodynamics; High Temperature Gas Dynamics; Seminar in Plasma Physics; Helicopter Aerodynamics; Computational Fluid Dynamics; Launch and Entry Vehicle Design; Applications of Finite Element Methods; Advanced Space Propulsion.

INDIAN INSTITUTE OF TECHNOLOGY BOMBAY

- **AEROSPACE ENGINEERING**
  Grid Generation for Computational Mechanics; Matrix Computations; Aircraft Power-plant Design; Aerodynamic Design of Compressors and Turbines; Optimization for Engineering Design

HONORS AND AWARDS

- **Travel Award** to attend the International Conference on Spectral and High Order Methods 2014
- **Graduate Research Assistantship** (2008 – 2013) from the Alfred Gessow Rotorcraft Center, Department of Aerospace Engineering, University of Maryland, College Park
- **Block Grant Fellowship** (2006 – 2008) from the Dept. of Mathematics, Univ. of Maryland
- **Research Assistantship** (2005 – 2006) from Aerospace Engineering, Indian Inst. of Tech. Bombay

TECHNICAL SKILLS

- **Programming Languages:** C/C++, FORTRAN, MATLAB
- **High Performance Computing:** MPI, OpenMP, HPCToolkit, Alinea DDT
- **Scientific Visualization Software:** Tecplot, LLNL Visit
  Authoring and Publishing Software: Latex, Microsoft Office