Nek Sharan

CONTACT INFORMATION

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RESEARCH INTERESTS

Numerical methods for partial differential equations, turbulent flows, large-eddy simulations, combustion, overset-grid/AMR methods, high-performance computing

EDUCATION

University of Illinois at Urbana-Champaign, USA

Ph.D., Aerospace Engineering, December 2016

- Dissertation Topic: "Time-stable high-order finite difference methods for overset grids"
- Advisors: Daniel J. Bodony & Carlos Pantano
- GPA: 4.0/4.0

Indian Institute of Technology Bombay, India

M. Tech & B. Tech (Dual Degree), Aerospace Engineering, August 2011

- Dissertation Topic: "Numerical Simulation of Axisymmetric Jets"
- Advisor: Avijit Chatterjee
- GPA: 8.9/10.0

HONORS AND AWARDS

CTO Pathfinder Award for exceptional innovation leadership at Procter & Gamble Co. (P&G), 2012

IIT Bombay Heritage Fund Scholarship for exemplary academic performance in years 2006-07, 2008-09 and 2009-10

Undergraduate Research Opportunity (UROP) for academic excellence and research skills (awarded to 5 out of 600 students) in 2008

Certificate of Merit (national top 1%) in Indian National Physics Olympiad (INPhO) 2006

Science & Technology Merit Certificate (national top 0.1%) in All India Secondary School Examination (AISSE) 2004

ACADEMIC EXPERIENCE

Los Alamos National Laboratory, USA

Postdoctoral Research Associate **April 2019 - Present**

- Developed high-order, conservative, and energy-stable cut-cell method for direct numerical simulation (DNS) of fluid-structure interactions in high-Reynolds-number turbulent flows
- Diverse linear and non-linear numerical tests conducted to ascertain the accuracy, stabiliy, and conservation properties of the new method
- Programming the developed method in a 3D parallel compressible-flow solver to simulate shock-particle interactions

California Institute of Technology, USA

Postdoctoral Scholar **October 2016 - April 2019**

- Performed turbulent-jet DNS and LES to study multicomponent species diffusion in high-pressure reacting flows encountered in diesel, gas turbine, and liquid rocket engines
- Developed finite-volume/-difference schemes to ensure passive and active scalar boundedness with uniform high-order accuracy and conservation in large-eddy simulations (LES)
- Programmed the developed method in a 3D parallel incompressible-flow LES solver
- Optimized reactant mixing in turbulent shear flows by exploiting mixing sensitivity to initial perturbation modes and boundary conditions

Guest Lecturer **April 2018 - June 2018**

Delivered multiple guest lectures on turbulence modeling for practical applications

- Ae239b Turbulence

University of Illinois at Urbana-Champaign, USA

Graduate Research Assistant **August 2012 - September 2016**

- Developed a provably time-stable overset-grid/AMR method for fluid-flow simulations
- Programmed a parallel compressible-flow solver using C++ and MPI to assess accuracy and stability of the developed overset method
- Performed an overset-grid LES of flow over a cosine-shaped (FAITH) hill using Lagrangian dynamic eddy-viscosity model
- Simulated a Mach 1.3 NASA supersonic nozzle jet DNS using overset grids to predict the acoustic field from a turbulent-jet flow

Teaching Assistant **January 2016 - May 2016**

Duties included holding office hours every week, conducting tutorials on scientific programming, preparing homeworks, and grading.

- AE410 Computational Aerodynamics

Indian Institute of Technology Bombay, India

Research Assistant **July 2010 - July 2011**

- Parallelized, using a hybrid OpenMP and MPI approach, an in-house axisymmetric LES solver
- Performed underexpanded and overexpanded supersonic-jet simulations to determine the jet screech frequency
- Developed an axisymmetric compressible-flow solver in Python and optimized its performance using Cython to achieve an execution time equivalent to the in-house C code

Teaching Assistant **July 2010 - April 2011**

Duties included organizing classroom lessons, activities and presentations; assigning homeworks, projects, and grading.

- AE310 Engineering Design Optimization
- AE207 Introduction to Engineering Design

FH Aachen - Aachen University of Applied Sciences, Germany

Assistant Engineer **May 2009 - July 2009**

- Modeled a H_2 combustion chamber with direct injection fuel system and a fully variable electric valve train system
- Generated a dynamic mesh in *Gambit* to represent moving piston and valve components
- Performed an in-cylinder fluid flow and partially-premixed combustion simulation using *Fluent*
- Investigated combustion chamber temperature and the amount of NO_x, CO and CO_2 in exhaust

Publications

N. Sharan and J. R. Bellan. Numerical study of high-pressure turbulent jets using direct simulation. *Journal of Fluid Mechanics* (Under review).

N. Sharan, P. T. Brady and D. Livescu. Time-stable strong boundary conditions in finite-difference schemes for hyperbolic systems. *Journal of Computational Physics* (Under review).

N. Sharan, G. Matheou and P. E. Dimotakis. Turbulent shear-layer mixing: initial conditions, and direct-numerical and large-eddy simulations. *Journal of Fluid Mechanics*, 877 (2019): 35-81.

N. Sharan, G. Matheou and P. E. Dimotakis. Mixing, scalar boundedness, and numerical dissipation in large-eddy simulations. *Journal of Computational Physics*, 369 (2018): 148-172.

N. Sharan, C. Pantano and D. J. Bodony. Time-stable overset grid method for hyperbolic problems using summation-by-parts operator. *Journal of Computational Physics*, 361 (2018): 199-230.

N. Sharan. Time-stable high-order finite difference methods for overset grids. *Doctoral Dissertation*, University of Illinois at Urbana-Champaign, 2016.

Conference Proceedings

N. Sharan and J. R. Bellan. Turbulent mixing in supercritical jets: effect of compressibility factor and inflow condition, AIAA Paper 2020-1156, *AIAA Scitech 2020 Forum*.

N. Sharan, P. T. Brady and D. Livescu. Stable and conservative boundary treatment for difference methods, with application to cut-cell discretizations, AIAA Paper 2020-0807, *AIAA Scitech 2020 Forum*.

N. Sharan and J. R. Bellan. Numerical aspects for physically accurate Direct Numerical Simulations of turbulent jets, AIAA Paper 2019-2011, *AIAA Scitech 2019 Forum*.

N. Sharan, C. Pantano and D. J. Bodony. Energy stable overset grid methods for hyperbolic problems. AIAA Paper 2014-2924, *7th AIAA Theoretical Fluid Mechanics Conference*.

N. Sharan and D. J. Bodony. High-order provably stable overset grid methods for block-structured adaptive mesh refinement. AIAA Paper 2013-2872, *21st AIAA Computational Fluid Dynamics Conference*.

N. Sharan and A. Chatterjee. Parallel Computation of Axisymmetric Jets. *Proceedings of the Python for Education and Scientific Computing (SciPy.in) 2010*.

Talks

"Free-shear flow mixing computations: initial conditions, scalar boundedness and subgrid-scale effects", *GALCIT Colloquium*, California Institute of Technology, Pasadena, May 2020

"High-order energy-stable boundary treatment for finite-difference cut-cell method", 72^{nd} *American Physical Society Division of Fluid Dynamics (APS DFD) Annual Meeting*, Seattle, November 2019

"Direct numerical simulation of high-pressure mixing in turbulent jets", 11^{th} *US National Combustion Meeting*, Pasadena, March 2019

"Stable, high-order methods for overset grids and turbulent mixing in large-eddy simulations", Computational Physics and Methods (CCS-2), Los Alamos National Laboratory, Los Alamos, November 2018 (Invited)

"Low-dissipation methods for overset/AMR grids and scalar boundedness in turbulent mixing simulations", Computational Engineering Division, Lawrence Livermore National Laboratory, Livermore, October 2018 (Invited)

"Effects of numerical dissipation and unphysical excursions on scalar-mixing estimates in large-eddy simulations", 70^{th} *American Physical Society Division of Fluid Dynamics (APS DFD) Annual Meeting*, Denver, November 2017

"Time-stable and conservative high-order finite difference methods for overset grids", *UIUC AE Department Seminar*, Urbana, April 2016.

"High-order provably stable overset grid methods for hyperbolic problems, with application to the Euler equations", 68^{th} *American Physical Society Division of Fluid Dynamics (APS DFD) Annual Meeting*, Boston, November 2015

"Stable interface treatment in overset grid methods", *67th American Physical Society Division of Fluid Dynamics (APS DFD) Annual Meeting*, San Francisco, November 2014.

"Intermittent Communication in Parallel Computation", *23rd International Conference on Parallel Computational Fluid Dynamics*, Barcelona, May 2011.

"Axisymmetric Navier Stokes solver using Python and Cython", *12th Annual CFD Symposium*, IISc Bangalore, August 2010.

Industry Experience

Procter & Gamble Co. (P&G), Bengaluru, India

Pack(ag)ing Analyst, Modeling & Simulation Group **August 2011 - July 2012**

Developed CFD and FEA models to simulate manufacturing process and packaging of consumer goods at production plants. Other projects included assessment of different nozzle designs for a new bottle-filling line, and automation of existing work processes for a faster turnaround time.

Jet Airways (India) Ltd., Mumbai, India

Management Trainee, Engineering Materials Department **December 2008 - January 2009**

Programmed a *Visual Basic for Applications (VBA)* tool to ensure a 95% service level of reusable aircraft parts. Developed an automated system for planning and scheduling of maintenance work for aircraft fleet, which saved 12 man-hours weekly.

Services and Leadership roles

- **Reviewer** for AIAA Journal (AIAA), Journal of Applied Acoustics (Elsevier), Journal of Hydro-environment Research (Elsevier), Sensors (MDPI Open Access), Energies (MDPI Open Access)
- **Organizer** for Caltech K-12 Outreach Activities (2016–Present)
  - Conducted introductory workshops on Linux at Southern California Linux Expo (SCaLE-16x) 2018, Pasadena, CA
  - Engaged K-12 students in STEM research through events like Caltech Science for March, TeachWeek etc.
- **Work-Culture Team Lead** at Procter & Gamble Co. (P&G), India (2011–2012)
  - Partnered with local NGOs to conduct classes and trips for less-privileged children
- **Institute Student Mentor** at IIT Bombay, India (2009–2011)
  - Advised five students to help them overcome multiple backlogs through comprehensive course planning
  - Guided 24 freshmen to ensure their smooth transition into campus life
- **Teaching Associate** for National Social Service (NSS) at IIT Bombay, India (2006–2011)
  - Taught Mathematics, Science, and English classes to disadvantaged school children
  - Visited rural areas to conduct computer literacy sessions

Computer Skills

- Languages: C/C++, Fortran, Python, MATLAB, Visual Basic for Applications(VBA), Unix Shell Scripting, MPI and OpenMP parallel processing libraries, Git version control
- Softwares: Mathematica, ANSYS Fluent/Gambit, ABAQUS, LS-Dyna, HyperMesh, AcuSolve, VisIt, Tecplot, EnSight, LaTeX
- Operating Systems: Unix/Linux, Windows, Mac OS X