Manjul Sharma

Ph.D.
Applied Mathematics

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Research Interests

- **Computational Fluid Dynamics:** High-performance computing, High-fidelity simulations, GPU offloading, Multiphysics modeling, reduced-order modeling, Machine learning methods for fluid dynamics, Coordinate-free numerics, Object-Oriented programming.
- **Theoretical fluid dynamics:** Incompressible and compressible flows, asymptotic analysis, nonlinear dynamics, chaotic advection and mixing, Lagrangian Coherent Structures, Double Diffusion.

Current Position

- **Research Faculty** **2021 - present**
  Dept. of Applied Mathematics
  University of Colorado, Boulder, CO, USA

Education

- **Ph.D.** **2020**
  Aerospace Engineering,
  Indian Institute of Technology Madras (IITM), Chennai, India

- **Master of Science (M.S.)** **2020**
  Aerospace Engineering,
  Indian Institute of Technology Madras (IITM), Chennai, India

- **Bachlor of Engineering (B.E.)** **2009**
  Aeronautical Engineering,
  The Aeronautical Society of India (AeSI), New Delhi, India

Publications

- C. Liu, **Manjul Sharma**, K. Julien, and E. Knobloch : **Fixed-flux Rayleigh-Bénard convection in doubly periodic domains**. J. Fluid Mech. (revision submitted).
- **Manjul Sharma**, K. Srikanth, T. Jayachandran, and A. Sameen : **DNS of buoyancy-driven flows using EDAC formulation solved by high-order method**. Comp. Fluids (accepted).
- **Manjul Sharma**, KA Nair, R. Vishnu, and A. Sameen : **Near-wall vortical structures in domains with and without curved surfaces**. Phil. Trans. R. Soc. A, 381 (2246), 20220136.
- R. Vishnu, **Manjul Sharma**, and A. Sameen : **Effect of heating on topology of vortex breakdown in Vogel–Escudier flow**. Phys. Fluids, 33(10):107111, 2021.
- **Manjul Sharma**, and A. Sameen : **Synopsis of Vogel-Escudier flow**. Phys. Fluids, 33(6):064105, 2021.
- **Manjul Sharma**, and A. Sameen : **On the correlation between vortex breakdown bubble and planar helicity in Vogel-Escudier flow**. J. Fluid Mech., 888:A6, 2020.
- **Manjul Sharma**, and A. Sameen : **Axisymmetric vortex breakdown: a barrier to mixing**. Phys. Scr., 94(5):054005, 2019.

Conferences (only last 5 years)

- S. N. Dhurandhar, **Manjul Sharma**, V. Mohan, and A. Sameen : **Vortex Breakdown Analysis in Compressible Flow**. 14th Asian Computational Fluid Dynamics Conference (ACFD), Bengaluru, Karnataka, India, October 2023.
- C. Liu, **Manjul Sharma**, K Julien, E. Knobloch : **Fixed-flux Rayleigh-Benard convection in doubly periodic domains**. 76th Annual Meeting of the American Physical Society Division of Fluid Mechanics (APS-DFD), Washington, DC, USA, November 2023.
- K. Srikanth, **Manjul Sharma**, V. Mohan, and A. Sameen : **Application of entropically damped artificial compressibility formulation in simulation of non-Boussinesq buoyancy-driven flows**. Oberbeck - Boussinesq hypothesis and beyond in stratified turbulence (EUROMECH 619), Vienna, Austria, July 2022.

- S. N. Dhurandhar, **Manjul Sharma**, V. Mohan, and A. Sameen : **Compressibility effects on vortex breakdown in a lid-rotating cylinder**. The 14th European Fluid Mechanics Conference (EFMC), Athens, Greece, September 2022.
- S. N. Dhurandhar, V. Mohan, **Manjul Sharma**, and A. Sameen : **Effects of rarefaction on axial vortex using Direct Simulation Monte Carlo**. International Symposium on Rarefied Gas Dynamics, RGD-32, Seoul, South Korea, September 2022.
- A. Sameen, **Manjul Sharma**, and R. Vishnu : **Dynamics of transition to turbulence in axial vortex breakdown**. The 17th European Turbulence Conference (ETC), Torino, Italy, September 2019.

Skills

- **Programming languages**: Modern Fortran (2003, 2018 standards), C
- **Scripting languages**: Python, Matlab/Octave, Mathematica
- Parallel environments like MPI, OpenMP, GPU offloading using OpenACC, Coarray Fortran for large-scale simulations, Heterogeneous parallelism (CPU+GPU)
- **ML Tools**: Tensorflow2, PyTorch
- **Visualization tools**: Tecplot, Paraview, Matplotlib, Vapor.
- HPC batch schedulers like Slurm and Torque.
- Established experience in Linux operating system with shell scripting, Github.

Research Experience

Research Faculty, Dept. of Applied Mathematics, University of Colorado, Boulder, CO, USA (August 2021 – Present)

Research focuses on developing a reduced-order model valid in the oceanic regime of small salinity to thermal diffusivity ratio. This is accomplished by utilizing

1. novel asymptotically reduced models that extrapolate to extreme parameter settings.
2. a new reformulation of the Navier-Stokes equations that extends the stability and computational capabilities of direct numerical simulations, and
3. theoretical analysis that dissects the flow morphology, energetics and multiscale nature of turbulent salt fingers

Postdoctoral Fellow, Theoretical and Computational Fluid Dynamics Lab, Department of Aerospace Engg., IITM, Chennai, India (October 2020 – July 2021)

PI: Dr. A Sameen

1. Lead developer of a high-order Navier-Stokes solver in generalized curvilinear coordinates to simulated flow problems with and without thermal stratification in complex domains.
2. The solver is developed using OOP and modern Fortran concepts for a modular and generic design.
3. The solver can simulate both Boussinesq and Non-Boussinesq flows.

Project Associate, Theoretical and Computational Fluid Dynamics Lab, Department of Aerospace Engg., IITM, Chennai, India (August 2018 – September 2020)

PI: Dr. A Sameen

1. Developed an incompressible Navier-Stokes solver in the cylindrical coordinates. The solver employs fractional-step algorithm and uses a central difference scheme on a fully staggered grid.
2. Developed a generic postprocessing code to compute Finite Time Lyapunov Exponent, which is used to compute Lagrangian Coherent Structures for three-dimensional flows.

Project Associate, Theoretical and Computational Fluid Dynamics Lab, Department of Aerospace Engg., IITM, Chennai, India (October 2009 – December 2011)

PI: Dr. A Sameen

1. Co-developed a Navier-Stokes solver in Cartesian coordinates to simulate the three-dimensional wall jet problem.
2. Used the velocity data obtained from the simulations to perform a stability analysis of the flow.

Teaching Experience

APPM2360 Introduction of Differential Equations with Linear Algebra, Dept. of Applied Mathematics, University of Colorado, Boulder, CO, USA (Fall 2021 – Spring 2023)

Role: Instructor
Introduces ordinary differential equations, systems of linear equations, matrices, determinants, vector spaces, linear transformations, and systems of linear differential equations.

Fundamentals of Gas Dynamics, Dept. of Aerospace Engineering, Indian Institute of Technology Madras, Chennai, India (2017, 2018, 2019)
Role: Teaching Assistant
Instructor: Dr. A Sameen
This is a MOOC offered by NPTEL, India. Introduces compressible flow and its constitutive equations. Discusses the physical concepts behind isentropic flows, area-Mach number relation, etc., with practical problems in mind. Properties of shocks and expansions are important parts of this course.

Programming Experience

Over the years, I have developed a few Navier-Stokes solvers to suit my research.

CDS3D:
A high-order, high-fidelity solver for compressible Navier-Stokes equations in generalized curvilinear coordinates. The code uses a high-order compact difference scheme for spatial discretization with filtering operators

InCurvCDS:
An incompressible version of CDS3D. It solves incompressible Navier-Stokes in the generalized curvilinear coordinates. InCurvCDS uses a high-order compact difference scheme and filtering operators. It can simulate flow problems with and without thermal stratification in complex domains using body-fitted grids. The code is written in modern Fortran using derived data types to keep it generic. It is further enhanced to simulate the Non-Boussinesq flows. Currently, the solver is being extended to simulate the multiphase flows.

VEflow:
An incompressible Navier-Stokes solver in the cylindrical coordinates written in Fortran90. The solver employs a fractional-step algorithm and a central-difference scheme on a fully staggered grid.

FTLE3D:
A Fortran90 program to compute the three-dimensional Finite Time Lyapunov Exponent from raw velocity data.

Participation in Events

Workshop on 'Climate Modeling' **2019**
Divecha Centre for Climate Change, Indian Institute of Science, Bangalore, India.

International Summer School on "Coherent Structures in Unsteady Flows: Mathematical and Computational Methods" **2019**
International Centre for Mechanical Sciences (CISM), Udine, Italy.
Presented a poster titled "*Dynamics of axial vortex breakdown*" during the poster session.

CISM advanced course on Turbulent Mixing in Stratified Flows **2018**
International Centre for Mechanical Sciences (CISM), Udine, Italy.

Turbulence from Angstroms to light years **2018**
International Centre for Theoretical Sciences (ICTS), Bangalore, India.

Summer school and Discussion Meeting on Buoyancy-driven flows **2017**
International Centre for Theoretical Sciences (ICTS), Bangalore, India.

Collaborations

The list is in approximate reverse chronological order.

- **Prof. Keith Julien** (University of Colorado Boulder, Colorado, USA)
- **Prof. Edgar Knobloch** (University of California, Berkeley, California, USA)
- **Prof. Chang Liu** (University of Connecticut, Connecticut, USA)
- **Prof. Vinod Narayanan** (IIT Gandhinagar, India)
- **Prof. Manikandan Mathur** (IIT Madras, India)
- **Dr. Vishnu Mohan** (Newcastle University, UK)
- **Dr. Vishnu R.** (Okinawa Institute of Science & Technology, Japan)
- **Prof. A. Sameen** (IIT Madras, India)