

Gaurav Kumar

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RESEARCH INTERESTS

Computational Fluid Dynamics; Shear layer instabilities and transition; Separated flow control; Turbulence modelling; Modal analysis and reduced order models.

EDUCATION

- 2016–2021 **Ph.D in Aerospace Engineering**, Indian Institute of Technology, Kanpur,
GPA – 9.0/10.0.
Thesis title: *Numerical study of viscous interaction between shock waves and separation region over a double wedge in hypersonic flows*
- 2011–2016 **M.Tech in Aerospace Engineering**, Indian Institute of Technology, Kanpur,
GPA – 10.0/10.0.
Thesis title: *Investigation of turbulent separated flow using hybrid RANS-LES models*
- 2011–2016 **B.Tech in Aerospace Engineering**, Indian Institute of Technology, Kanpur,
GPA – 7.7/10.0.

AWARDS AND FELLOWSHIPS

- **National Postdoctoral Fellowship** (2022) awarded by Department of Science and Technology – Science and Engineering Research Board, India

JOURNAL PUBLICATIONS

1. **Gaurav Kumar**, Vaisakh Sashidharan, Akshaya G. Kumara and Subrahmanyam Duvvuri. "Oscillations type unsteadiness in shock-wave/separation region interaction." (Manuscript under preparation)
2. Sushmitha Janakiram, **Gaurav Kumar** and Subrahmanyam Duvvuri. "Starting characteristics of curved compression intakes with overboard spillage." (Manuscript under preparation)
3. Subrahmanyam Duvvuri, **Gaurav Kumar** and Vaisakh Sashidharan. "On shock-wave unsteadiness in separated flows." (Submitted for review, March 2022)
4. **Gaurav Kumar** and Ashoke De. "An improved density based compressible flow solver in OpenFOAM for unsteady flow calculations." *Advances in Fluid Mechanics*, Springer, Singapore (2022): 43-66

5. **Gaurav Kumar** and Ashoke De. "Modes of unsteadiness in shock wave and separation region interaction in hypersonic flow over a double wedge geometry." *Physics of Fluids* 33.7 (2021): 076107
6. **Gaurav Kumar** and Ashoke De. "Role of corner flow separation in unsteady dynamics of hypersonic flow over a double wedge geometry." *Physics of Fluids* 33.3 (2021): 036109
7. Mitesh Thakor, **Gaurav Kumar**, Debopam Das, and Ashoke De. "Investigation of asymmetrically pitching airfoil at high reduced frequency." *Physics of Fluids* 32.5 (2020): 053607
8. Alok Mishra, **Gaurav Kumar**, and Ashoke De. "Prediction of separation induced transition on thick airfoil using non-linear URANS based turbulence model." *Journal of Mechanical Science and Technology* 33.5 (2019): 2169-2180
9. **Gaurav Kumar**, Ashoke De, and Harish Gopalan. "Investigation of flow structures in a turbulent separating flow using hybrid RANS-LES model." *International Journal of Numerical Methods for Heat & Fluid Flow* 27.7 (2017): 1430-1450
10. **Gaurav Kumar**, Saravanan K. Lakshmanan, Harish Gopalan and Ashoke De. "Investigation of the sensitivity of turbulent closures and coupling of hybrid RANS-LES models for predicting flow fields with separation and reattachment." *International Journal for Numerical Methods in Fluids* 83.12 (2017): 917-939

--- CONFERENCE PAPERS (PEER-REVIEWED)

1. Vaisakh Sashidharan, **Gaurav Kumar**, Akshaya G. Kumara and Subrahmanyam Duvvuri. "Shock-wave and shear-layer oscillations over a double cone in high-speed flow", 12th International Symposium on Turbulence and Shear Flow Phenomena (TSFP12), July 19 - 22, Osaka, Japan, 2022
2. **Gaurav Kumar** and Ashoke De. "Self-induced oscillations of the shock structures in a hypersonic flow over double wedge", 25th International Congress of Theoretical and Applied Mechanics (25th ICTAM), August 23 - 28, Milano, Italy, 2021
3. **Gaurav Kumar**, Ashoke De "Effect of turbulence in unsteady shock interaction and heat transfer mechanism in a hypersonic flow over double wedge", "32nd International Symposium on Shock Waves", Conference proceedings ISSW32, Singapore, 2019
4. **Gaurav Kumar**, Ashoke De "A density based compressible flow solver in OpenFOAM with Mach number preconditioning and Low-diffusive Flux Splitting Scheme" 7th International and 45th National Conference on Fluid Mechanics and Fluid Power (FMFP2018), Mumbai, India, 2018
5. **Gaurav Kumar**, Harish Gopalan, Dominic Chandar, Vinh-Tan Nguyen, and Ashoke De. "Verification of length scale effects on solution accuracy of hybrid RANS-LES methods." 35th International Conference on Ocean, Offshore and Arctic Engineering, American Society of Mechanical Engineers (ASME2016), Busan, South Korea, 2016
6. **Gaurav Kumar**, Saravanan K. Lakshmanan, Harish Gopalan and Ashoke De. "Comparative study of hybrid RANS-LES models for separated flows.", AIP Conference Proceedings. Vol. 1738. No. 1. AIP Publishing, 2016

POSTDOCTORAL RESEARCH

Title Unsteady characteristics of bluff-body wakes and wall-bounded separation region in high-speed flows

Advisor Dr. Duvvuri Subrahmanyam

- Experimental and LES study of low-frequency unsteadiness in two flow configurations at Mach 6: bluff-body wake of a cylinder and separation region on a cone-cylinder model (a cone mounted at the flat face of a cylinder)
- The unsteadiness is observed to be generated due to instability of the shear layer. Sparsity promoting DMD and spectral POD is employed to identify the shear layer instabilities from experimental and numerical data
- Manuscripts are under preparation to communicate the novel results in peer-reviewed journals and conference proceedings

DOCTORAL THESIS

Title Numerical study of viscous interaction between shock waves and separation region over a double wedge in hypersonic flows

Advisor Prof. Ashoke De

- Designed and implemented a new density based compressible flow solver in an open-source CFD platform called OpenFOAM
- Demonstrated the improved stability and accuracy of the new solver through various test cases involving shock waves, boundary layer and separated flows
- Studied the hypersonic flow over double wedge configuration in detail to understand unsteady interactions between shock-waves and boundary layer or separation region
- Identified important flow configurations showing low frequency and high amplitude modes of instabilities called "Oscillation" and "Pulsation"

MASTERS THESIS

Title Investigation of turbulent separated flow using hybrid RANS-LES models

Advisors Prof. Ashoke De and Dr. Harish Gopalan

- Introduced a non-linear blended turbulence modeling framework for computational fluid dynamics
- Performed a comparative study to investigate the sensitivity of hybrid RANS-LES models given the choices of RANS and LES models using various interface switching criteria
- Investigated unsteady flow structures in the turbulent separated flows to examine the effectiveness of hybrid RANS-LES models in the prediction of an accurate instantaneous flow field
- Demonstrated that the newly developed hybrid RANS-LES model produces a flow field which is more accurate and less grid-sensitive for a given grid resolution among various hybrid turbulence models

INTERNSHIPS AND PROJECTS

Oct–Dec, **Research Assistant**, *Hindustan Aeronautical Limited, India.*

2017 Objective: Simulation of cabin pressure control system of an aircraft

Supervisor: Prof. Bishakh Bhattacharya, Professor, IIT Kanpur

- Developed a computer program to simulate the on and off-design performance of a cabin pressure control system
- Identified optimal design parameters for constraining the off-design performance of the cabin pressurization system within the regulations of FAA

Jan–May, **Research Assistant**, *Institute of High Performance Computing, Singapore.*

2016 Objective: Numerical simulation of flow past tandem square columns at high Reynolds number using hybrid RANS-LES models

Supervisors: Dr. Harish Gopalan, Dr. Vinh-Tan Nguyen, Scientist

- Carried out the CFD computation of flow past tandem square columns using OpenFOAM platform
- Applied the reduced order modeling techniques such as Proper Orthogonal Decomposition (POD), Dynamic Mode Decomposition (DMD) and linear regression to find out a simple force prediction method on tandem column configurations

May–July, **Research Assistant**, *National Aerospace Laboratories, Bangalore, India.*

2014 Objective: Development of endothermic fuel platform for scramjet engines and to probe Technology Readiness Levels (TRL) achieved by different countries

Supervisor: Dr. S. Venkat Iyengar, Senior Scientist, Propulsion Division

- Proposed a detailed roadmap towards the development of endothermic fuel technology for incorporation in hypersonic scramjet air vehicle
- Recommended a set of experiments and facilities required in order to realize a TRL of 4

RESEARCH WORKSHOPS/PROGRAMS

Dec, 2017 **Immersed Boundary Methods for Turbulent Incompressible Flows** organised under GLOBAL INITIATIVE FOR ACADEMIC NETWORKS (GIAN) by Indian Institute of Technology, Kharagpur, India.

SERVICES

Peer-review Physics of Fluids, International Journal of Numerical Methods for Heat and Fluid Flow.

TEACHING EXPERIENCE

Course tutor Fluid Mechanics and Rate Processes (*ESO204, IIT Kanpur; Fall, 2020*)

- Teaching assistant
- Introduction to Finite Volume Method II (*under NPTEL initiative; Spring 2019*)
 - Thermodynamics (*ESO201, IIT Kanpur; Fall 2019*)
 - Engineering Drawing (*TA101, IIT Kanpur; Spring 2018*)
 - Fluid Mechanics and Rate Processes (*ESO204, IIT Kanpur; Spring 2017*)
 - Technical Communication (*AE401, IIT Kanpur; Fall 2015*)

SKILLS

Languages English (Professional working proficiency), Hindi (Native mother tongue), German (Elementary proficiency), Chinese (Elementary proficiency).

Programming C/C++, Python, R, MATLAB, GNU Octave, gnuplot, BASH, \LaTeX .
& Scripting

Softwares & Tools Ansys CFD Tools, OpenFOAM CFD toolbox, Tecplot, Paraview, AutoCAD, MS office.

Operating systems: Windows and Linux on most distributions.

EXTRA-CURRICULARS

Playing Tennis, running, swimming, reading.

PROFESSIONAL REFERENCES

- Prof. Ashoke De
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Indian Institute of Technology, Kanpur, India
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- Dr. Duvvuri Subrahmanyam
Assistant Professor, Department of Aerospace Engineering
Indian Institute of Science, Bangalore, India
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- Dr. Harish Gopalan
Scientist, Institute of High Performance Computing
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