

Affiliation

Founding Faculty
Applied Mathematics
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Past Affiliation

Assistant Professor (from June 2018 to June 2021)
School of Mathematics
Thapar Institute of Engineering & Technology, Patiala
Punjab, India

Education

1. University of Colorado & National Center for Atmospheric Research, Boulder, USA

- **PhD**, Applied Mathematics. (May, 2014)
 - Thesis title: **A Tale of Waves and Eddies in a Sea of Rotating Turbulence**
(published: https://scholar.colorado.edu/appm_gradetds/46/)
Modeling and theoretical analysis of nonlinear wave dynamics in fluid flows that involved building massively parallel computational code, visualization modules, analyzing large data and theoretical investigation of data. Thesis resulted in the development of a new wave turbulence theory for rotating helical flows. The thesis involved extensive experience with developing and modifying Large Eddy-Simulation (LES) pseudo-spectral code and DNS code.

- **MS**, Applied Mathematics. (*December, 2009*)

2. National Institute of Technology, Silchar, India

- **BTech**, Electrical Engineering. (May, 2006)

Awards & Grants

- **Ministry of Science & Technology-DBT Research Grant in Aid**, December 2020, research grant: **42,21,760 INR** as project coordinator (**PC**) and principal investigator (**PI**) in charge of a multi-university research grant on developing a COVID pandemic management technology for airborne contamination of hospitals by coronavirus (by *Ministry of Science & Technology*, India)
- **Thapar-Virginia Tech. research consortium Research Grant award**, March 2020, research grant: **25,10,000 INR** as co-principal investigator (**co-PI**) for developing a mathematical model for hyperthermia induced innate immunity strategy for gastric cancer treatment (by *Thapar-Virginia Tech. joint consortium through Center of Excellence in Emerging Materials*, India)
- **Thapar University Seed Grant award**, October 2020, research grant: **4,50,000 INR** as principal investigator (**PI**) to construct of a new family of mathematical models to simulate quasicrystal growth (by *Thapar University*, India)

- **DST-SERB Early Career Research Award**, October 2019, research grant: **32,91,520 INR** as principal investigator (**PI**) to investigate the role of wave turbulence in dispersion of atmospheric pollutants (by *Department of Science and Technology*, India)
- **Fields MITACS fellowship**, summer 2009 (by *Fields Institute & Carleton University*, Canada)
- **Visiting fellowship on fluid turbulence**, summer 2011 (by *Inst. of Theoretical Physics, Cargese, Corsica, France, University of Colorado, Boulder, and NCAR, Boulder*)

Professional expertise

- **Administration:** Member of technical advisory & evaluation committee, for establishing High Performance Supercomputing Infrastructure at Thapar Institute, Patiala; member of School Planning and Policy Committee, School of Mathematics, Thapar Institute, Patiala; organizer of invited lectures series by Dr. Carlos Perelman on special and general relativity at Thapar University, Punjab (September-October 2019).
- **Research:** dynamics of complex systems, asymptotic & complex analysis, singular perturbation theory, fluid turbulence, high-performance computing.
- **Teaching:** probability and statistics (PG), complex analysis (PG), numerical analysis (UG), calculus (UG), differential equations (UG).
- **Teaching Pedagogy:** Certified teacher by the New Directions Program (NDP) and the Advanced Directions Program (ADP), Thapar-Trinity Academic Practice - a joint collaboration between Thapar University and Trinity College, Dublin to contemporize academic activities at Thapar University. NDP and ADP were a three year long academic training program (Fall 2018 to Spring 2021).
- **Industry:** software automation suite development.
- **Post doctoral experience:** California State University, Northridge, CA, USA and Tata Institute of Fundamental Research, Hyderabad, India.

Technical and computing skills

- Programming: competent- **C, Matlab, MPI** (parallel computing), working knowledge- C++, Fortran, Python.
- Software Code Resource Management: **ADELE, GIT**(working knowledge).
- Markup language: **L^AT_EX**.
- Modeling and visualization: **VAPOR, VISIT**.

Professional experience (in reverse chronological order)

Research

Research Publications (in peer-reviewed international journals)

1. **Sen, A.;** and Perelman, C. *A Hamiltonian model of the Fibonacci quasicrystal using non-local interactions: simulations and spectral analysis*, **Eur. Phys. J. B**, 93, 67, 2020.
(indexed in SCI)

2. **Sen, A.** *Anisotropic Wave Turbulence for Reduced Hydrodynamics with Rotationally Constrained Slow Inertial Waves*, **Fluids**, 2, 28, 2017.
(indexed in Web of Science, ACS, Inspec)
3. **Sen, A.**; Aschheim, R.; Irwin, K. *Emergence of an Aperiodic Dirichlet Space from the Tetrahedral Units of an Icosahedral Internal Space*, **Mathematics**, 5, 29, 2017.
(indexed in SCI, SCOPUS, zbMATH)
(appeared as the journal cover page article)
4. Pouquet, A.; **Sen, A.**; Rosenberg, D.; Mininni, P.; Baerenzung, J. *Inverse cascades in turbulence and the case of rotating flows*, **Phys. Scr. T** 155, 014032, 2013.
(indexed in SCI, ACS, SCOPUS, Inspec, MathSciNet, NASA db)
5. **Sen, A.**; Mininni, P.; Rosenberg, D.; Pouquet, A. *Anisotropy and nonuniversality in scaling laws of the large-scale energy spectrum in rotating turbulence*, **Phys. Rev. E** 86, 036319, 2012.
(indexed in SCI, ACS, Inspec)
6. **Sen, A.**, *Analysis of fractal representation of genetic sequences*, Essays in Chaotic Dynamics, Spring 2010, **Technical Report CUCS 106610, Boulder**, ed.: Elizabeth Bradley.
7. **Sen, A.**; Ananthakrishnan, G.; Sundaram, S.; Ramakrishnan, A. G. *Dynamic Space Warping of Strokes for Recognition of Online Handwritten Characters*, **Intl. Jour. of Patt. Recog. and Art. Intell.**, Vol. 23, No. 5, pp: 925-943, 2009.
(indexed in SCI, SCOPUS, CompuMath)

Publications in Conference Proceedings

1. **Sen, Amrik**, et. al., *Hamiltonian wave turbulence theory on the genesis of eddies from waves in rotating flows*, American Geophysical Union, Spring Meeting 2013, Denver, Colorado, USA.
2. **Sen, Amrik**, *Poisson Approximation & its Application in Pattern Matching Problems*, Fields-MITACS meet, School of Applied Probability (Fields Institute & Carleton University, Canada), May 11-21, 2009.
3. Ananthakrishnan, G., **Sen, Amrik**, et. al., *Dynamic Space Warping of Sub-Strokes for Recognition of Online Handwritten Characters*, International Graphonomics Society (IGS2007) 13th IGS conference: 11-14 Nov. 2007, Melbourne, Australia.

Manuscripts in Preparation

1. *Riemann-Hilbert formulation of wave turbulence closure and generalized solutions* (with Carlos Perelman).
2. *Birth and death induced state transitions of swarms*.
3. *Multi-scale characterization of radio-frequency driven plasma antenna* (with Rana Pratap Yadav).

Talks and Poster presentations

- *New Directions Program: Developing Student Centered Learning*, **invited lecture**, Centre for Academic Practices and Student Learning (CAPSL) convention on academic best practices, jointly organized by Thapar University and Trinity College, Dublin, (February, 2020).
- *A Tale of Waves and Eddies in a sea of Rotating Turbulence*, **invited lecture**, Institute of Mathematical Sciences, Chennai, India. (November, 2015).
- *Symmetry breaking and the onset of turbulence in multi-phase flows*, **Institute colloquium**, Tata Institute of Fundamental Research, Hyderabad, India. (August, 2015).

- *Hamiltonian wave dynamics on the genesis of eddies from waves in rotating flows*, **Dynamics Days conference**, Denver, USA. (January, 2013).
- *Inverse Cascades at Small Rossby Number*, **Theme Of the Year (TOY) conference**, jointly organized by Univ. of Colorado, Boulder & NCAR, Boulder, USA. (May, 2012).
- *Physics of rapidly rotating fluid flow with helical forcing at small scales*, ANISO 2011 on *Morphology and dynamics of anisotropic flows*, **Institute of Theoretical Physics, Cargese**, Corsica, France. (July, 2011).
- *Flow past an airfoil via conformal mapping and elliptic grid generators*, Computational mathematics seminar, **Dept. of Applied Mathematics, University of Colorado, Boulder**, USA. (November, 2010).
- *Poisson Approximation and its Application in Pattern Matching Problems*, Fields-MITACS Summer School in Applied Probability, School of Mathematics and Statistics, **Carleton University, Ontario**, Canada. (May, 2009).

Research projects

- Current research (in progress) - Gravity-Fluid correspondence with Carlos Castro Perelman.
- Current research (in progress) - Hamiltonian dynamics of aperiodic complex systems: theoretical development and testing of the scientific project is complete in one dimension. This included developing a novel mathematical model based on statistical mechanics and Hamiltonian framework, developing a Monte-Carlo simulation code on a cluster computing node and rigorous verification modules. Current work on two dimensions shows promising general results. The results will be published in a top tier international journal soon.
- Current research (in progress) - Extension of swarming and flocking models from two dimensions to three dimensions. Comprehensive results will be published soon in a top tier international journal.
- Sr. Research Scientist and manager - Quantum Gravity Research, Los Angeles, CA, (January 2016 - present, also consultant from September - October 2015)
 - project: **Mathematical physics modeling** - I am currently leading a project on a Hamiltonian model for fluids on aperiodic lattices. This project involves both analytical (statistical physics) as well as developing computational code using Monte Carlo methods. The second project involves developing a connection between unification physics models like E_8 , E_6 and $SU(5)$ gauge theories with a three dimensional quasicrystalline substrate using techniques from representations of Lie Algebra and Clifford algebra spinors.
 - project: **Modeling of synchronized tunneling** - Mentoring and supervising a team working on modeling synchronized correlated tunneling using the coupled Gross-Pitaevskii equations. Tasks involve creating project proposals and roadmap for the project and explaining the strategy to the team members to build the computational model.
- Post-doctoral scientist - Tata Institute of Fundamental Research, Hyderabad, (April, 2015 - November 2015)
 - project: **multi-phase flow dynamics** - Analysis of multi-phase flow dynamics that involved quantitative study of the onset of turbulent motion by investigating spontaneous symmetry breaking in the phase field geometry. The work involved a novel reduced model derivation based on multi-scale perturbation theory to study scaling law behavior of concentration field and kinetic energy. The computational aspect of the project was based on building on a CUDA code for binary fluid mixtures.

- Post-doctoral scientist - The University Corporation and California State University, Northridge, Los Angeles, (*April, 2014 - February 2015*)
 - project: **mathematical modelling of swarming patterns** - Developed a software suite to model the kinematics of self-organizing swarming agents in C programming language. Visualization modules were built to display the swarming motion dynamic. The novelty in the model stems from the fact that real time birth and death mechanisms have been incorporated in the kinetic model. The nature of phase transition in the swarming states on account of the dynamic perturbations induced by the regenerative mechanism are currently under investigation.
- Visiting research scholar - Lab. for Atmospheric and Space Physics, Boulder, Colorado, (*January-March, 2014*)
 - project: **fundamental investigation of planet formation** - preliminary investigation on the theory of planet-planet gravitational wave interaction and obtained fundamental understanding of how these interactions affect planetary orbital ellipticity and migration of planetoids.
- Intern - Research & Development (software), CGM Development Team, **Dassault Systèmes Inc.** (*June-November, 2013*).
 - project: **instrumentation and development of geometric modeling kernel.** Developed an automatic software suite in Python that is integrated with the geometric modeling software pool. The Python suite was based on the MediaWiki software and was geared towards maintaining a fully-automated documentation of *live code snippets* of the CGM development code. This project involved working on both windows and linux platforms.
- Graduate research assistant
 - project: **Hamiltonian wave turbulence theory**, dept. of Applied Mathematics, **University of Colorado, Boulder** (*Summer 2012 - June 2013*), sponsor: NSF.
 - project: **analysis and modeling of rotating turbulent flows**, **National Center for Atmospheric Research (NCAR)**, Boulder, Colorado (*January 2011 - June 2013*), sponsor: NSF, CMG.
 - project: **Wind tunnel experiments on airfoil**, **ITLL, University of Colorado, Boulder**, conducted laboratory experiments on boundary layer analysis of different air foil shapes in a wind tunnel, Fall 2010, supervisor: Trudy Schwartz.
 - project: **pattern matching in genetic sequences**, dept. of Applied Mathematics, **University of Colorado, Boulder** (*Summer 2009*).
 - project: **implementing SVM machine learning algorithm to real time pattern recognition**, machine learning graduate project, CU Boulder, (*Spring 2008*).
 - project: **developing models in econometrics with the Bellman equation for stock prediction**, dept. of Economics, **University of Colorado, Boulder** (*Spring-Summer 2007*).
- Research engineer, Dept. of Electrical Engineering, **Indian Institute of Science (IISc)**, Bangalore (*June 2006 - June 2007*).
 - project: **online handwritten recognition**, sponsors: MHRD, India. The project involved developing algorithms in image processing and pattern recognition. Mentor: Dr. A. G. Ramakrishnan.

Simulation and visualization modules

Visualization of high performance simulation modules developed by me are available on my youtube channel: <https://www.youtube.com/user/amriksen>

- **Fluid turbulence**
https://www.youtube.com/watch?v=7tYiL9_RRvw
<https://www.youtube.com/watch?v=uv9a9B8iwpM>
<https://www.youtube.com/watch?v=FebFayDhnJY>
- **Multi-phase flows**
<https://www.youtube.com/watch?v=bsjs010rQa8>
- **Self organizing complex systems in biology**
<https://www.youtube.com/watch?v=FAOvr-fqFxo>
https://www.youtube.com/watch?v=_KiP_n6oTUI
https://www.youtube.com/watch?v=YIOEao__mq0
<https://www.youtube.com/watch?v=peuhuRmCChA>
- **Complex systems and aperiodic order**
<https://www.youtube.com/watch?v=MirQPchbo7Q>
https://www.youtube.com/watch?v=N85_aDD_lUI

Independent projects

- *A parallelized suite for Lagrangian particle dynamics in a 2D field using domain decomposition.*

Teaching

- **Instructor of Mathematics and Statistics for UG and PG courses at Thapar University**
 - Design and development of PG statistics course with computer aided laboratory experiments with diverse applications in engineering sciences and social sciences. Development of PG course on complex analysis and conducting lectures on this course for two academic years. Delivered lectures for several UG courses, development of course content and examination material, grading and evaluation of answer scripts, analysis of student performance and learning outcomes.
- **Instructor of special topics course for scientists**
 - Developed a comprehensive course on **Clifford Algebra** for senior scientists at Quantum Gravity Research. Lectures were delivered weekly as a special topics course during summer 2016. This project involved additional responsibility as part of continued program development scheme at Quantum Gravity Research and included coordinating academic consultation with offsite scientists.
 - Coordinated lecture series by eminent scientist Prof. Carlos Perelman on Lie Algebra at Quantum Gravity Research. This included working with the lecturer on developing a curriculum and facilitating the lecture delivery on site. These lectures are available on the Quantum Gravity Research youtube channel (link available upon request).
- **Instructor of Mathematics**

- Course: **Vector calculus** (at **Univ. of Colorado, Boulder** during summer semester 2010) - *responsibilities included lecturing a 5 credit hour course, re-designing a regular semester course work to suit a 7 week summer program, constructing a typographical booklet in L^AT_EX for the course that included well organized lecture notes (available on request), writing exams and creating grading schemes for the summer program and co-ordinating with the laboratory instructor for designing project models for the course.*
- Course: **Probability and statistics** (at **Front Range Community College** during summer semester 2010) - *lecturing a 5 credit hour course to nursing graduates, writing exams and creating grading schemes.*
- Course: **Calculus for engineers and scientists** (at **Front Range Community College** during fall semester 2010) - *lecturing a 5 credit hour course to freshmen and sophomore years students, writing exams and creating grading schemes.*
- **Laboratory designer for dynamical systems**
 - Course: **Differential equations using linear algebra** - *designed 2 new labs for the undergraduate dynamical systems course, the labs were modeled on chaos in nonlinear dynamics and modeling an integrated radio tuner using ordinary differential equations and tested on a thorough parameter study of the models (the labs are available on the course archive and also available on request). The newly designed labs were also tested as lab projects during regular semesters.*
- **Teaching Assistant**
 - Courses: Calculus 1, Calculus 2, Calculus 3, Differential equations and linear algebra (Dept. of Applied Mathematics, **University of Colorado, Boulder** from August 2008 to December 2013) - *responsibilities included lecturing a 1 credit hour recitation class weekly, grading homeworks and tests and conducting exam reviews.*
- **Tutor**
 - Courses: **physics and mathematics** (at **Student Academic and Success Center, Univ. of Colorado, Boulder**) - *tutored undergraduate students in freshmen and sophomore years.*
 - Courses: **physics and mathematics** (at **Skyline high school, longmont, CO** during fall 2013) - *tutored high school students for their advanced placement tests.*

References

- **Dr. Michael Wride**, Lead educator of Transformative Pedagogies, Centre for Transformative Learning, University of Limerick, Ireland.
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- **Dr. Carlos Perelman**, Theoretical physicist, Clark Atlanta University, Georgia and Ronin Institute, New Jersey, USA.
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