Shailendra Kumar Rathor

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RESEARCH INTERESTS

- Rotating Turbulence, Stratified-Rotating Turbulence, 2D Turbulence, Rotating Rayleigh-Bénard Convection(RBC), Astrophysical Flows, MHD Turbulence, RBC of Conducting Fluids
- Machine Learning and Data-driven Physics, Nonlinear Dynamics and Complex Systems
- Soft Matter Physics, Non-equilibrium Statistical Systems, Information Dynamics of Turbulence

SKILLS and TECHNIQUES

- Fluid Mechanics, Turbulence, and Nonlinear Dynamics
- Scientific computing: Mathematical modeling of a physical problem, designing numerical algorithm and its implementation suitable for High Performance Computing (HPC)
- Data analysis: Experience of working with data in text format and in binary formats (HDF5 and NetCDF), statistical analysis and inference, and appropriate representation of data and inferred results
- Programming ability with proficiency in C++, Python, Fortran, Matlab, shell scripting (for writing utilities and automation), with application of version control (using git)
- Parallel programming with MPI and OpenMP, and experience of working in a High Performance Compute environment
- Working knowledge of Mathematica and symbolic computation in python using SymPy library
- Multifractal analysis: Computation of the spectrum of scaling exponents of a dataset, interpretation, and modeling of a multiplicative process, and experience of applying it in Turbulence
- Wavelet analysis: For computing multifractal spectrum using methods like wavelet leaders, WTMM etc., and for determining the variability of a time series and space data
- Machine learning: Trained to develop machine learning models and implement them using accelerated (GPU) computing with CUDA
- Others: Scientific writing with LaTex, Working in Linux environment, Proficiency in English

EDUCATION

- Ph.D. in Physics — May 2022(expected)
  Indian Institute of Technology Kanpur, India
  Dissertation: Spatial and Temporal Statistics of Rotating Turbulence
  Supervisor: Prof. Sagar Chakraborty

- M.Sc. in Physics — Jun. 2012
  Indian Institute of Technology Kanpur, India

- B.Sc. Physics and Mathematics — Nov. 2009
  MJP Rohilkhand University, Bareilly, India

RESEARCH EXPERIENCE

Indian Institute of Technology Kanpur Kanpur, India
***Graduate Researcher with* Prof. Sagar Chakraborty** 2013-present

- ***Predictability time in rotating turbulent flows***: (in preparation)
  Measured the chaotic strength of a turbulent system in a rotating frame of reference in terms of predictability time. Performed shell model simulations and showed the increase of predictability in rotating turbulence. Performed direct numerical simulations with various rotation rates to foster the results.
- ***Dynamic scaling in rotating turbulence***: (arxiv:2112.06475)
  Showed that time scales in the range of scales dominated by the Coriolis force are scale independent. Observed a simple dynamic scaling (instead of expected dynamic multiscaling) in forced rotating turbulence from the multifractal approach. Subsequently verified with detailed shell model simulations.
- ***Statistics of dissipation rate in rotating turbulence***: (Phys. Fluids 32, 095104 (2020))
  Proposed and established a relation to bridge the inertial and dissipation range statistics (determined using a structure function and multifractal approaches, respectively) in rapidly rotating turbulence, from shell model (a low dimensional model mimicking the dynamics inherit to Naviér–Stokes equation) as well as DNS studies. Used multifractal character of dissipation field to quantify spatial intermittency and showed that intermittency decreases with increasing rotation rate.
- ***Astrophysical flows: Stability analysis of convection in the intracluster medium*** (Physics Letters A 380, 2407, 2016)
  Performed stability analysis of convection induced by the magnetothermal instability and the heat-flux-buoyancy-driven-instability in the weakly-collisional magnetized plasma permeating the intracluster medium. Studied the onset of Rayleigh–Bénard convection in hydro-and magnetohydro-dynamic settings. Derived the conditions for the onset of these instabilities. Characterized the modes that are first to become unstable. Showed that oscillatory marginal stable states are possible for both the heat-flux-buoyancy-driven-instability and the magnetothermal instability.
- ***Lyapunov exponent using phase space reconstruction technique***:
  Performed nonlinear time-series analysis to understand, characterize, and predict underlined nonlinear dynamical system using the technique of phase space reconstruction. Determined the time delay from mutual information and embedding dimension from Takens' embedding theorem. Calculated Lyapunov exponent from the attractor so constructed. Introduced myself to the reality, that is, nonlinear dynamics and learnt it in great detail.
- ***Miscellaneous projects***:
  The problems which failed to manifest as publishable works include effects of concentration gradient in HBI(Heat-Flux driven Buoyancy Instability) in intracluster medium (astrophysical flows) (dropped), numerical study of sunspots (solar physics) (dropped), and shell model study of helicity in rotating turbulence (dropped).
  The problems, currently incomplete but potentially publishable, include the onset of dynamo from the perspective of a shell model (MHD turbulence) (ongoing), shell model study of kicked turbulence (ongoing), information content of rotating turbulence (ongoing), low-dimensional model of rotating RBC of magneto-fluids (ongoing), and stochastic resonance conditions of a coupled oscillator (ongoing).

International Center for Theoretical Sciences Bangalore, India
***Summer Research Program with* Prof. Samriddhi S. Ray** 2016

- Investigated dual scaling in the energy spectrum of decaying as well as forced rotating turbulence. Introduced myself to anisotropic turbulence and investigated two-dimensionalisation of rapidly rotating turbulence. Learnt fortran and simulated a low dimensional model of turbulence (i.e., shell model) and compared two-dimensional and rapidly rotating turbulence in terms of the scaling of energy spectrum and the energy flux.

Indian Institute of Technology Kanpur Kanpur, India
***Masters research projects with* Prof. H. Wanare** 2012-2013

- Simulated the dynamics of a trapped particle in the field of a pair of optical tweezers. Implemented the simulation in python.
- Introduced myself to quantum optics and investigated the following in great detail: Quasi-probability distributions, bistable behaviour of circulating light intensity with the laser detuning due to coupling of optical and mechanical modes in an optomechanical cavity, and squeezed state of light and its generation using a nanomechanical oscillator.

PUBLICATIONS

- **Shailendra K. Rathor**, Sagar Chakraborty, and Samriddhi Sankar Ray, "Dynamical Scaling in Rotating Turbulence: A Shell Model Study," arxiv:2112.06475 (Submitted).
- **Shailendra K. Rathor**, Manohar K. Sharma, Samriddhi Sankar Ray, and Sagar Chakraborty, "Bridging Inertial and Dissipation Range Statistics in Rotating Turbulence," Phys. Fluids 32, 095104 (2020).
- Himanshu Gupta, **Shailendra K. Rathor**, Martin E. Pessah, and Sagar Chakraborty, "Stability analysis of convection in the intracluster medium", Physics Letters A 380, 2407, 2016.

CODES DEVELOPED

The codes developed are available on my github page.

- Helical Shell Model of Turbulence (in C++ parallelized with MPI)
- Multifractal Analysis using Chhabra-Jensen Scheme (package *multifracturb* in Python)
- Multifractal Analysis using Wavelet Leader (module *mfawl* in Python)
- A DNS solver for predicting turbulence implemented in code TARANG (in C++ and MPI)
- Code for Stochastic Resonance (in Python parallelized with mpi4py)
- Code for Synthetic Turbulence (in C++ and MPI)

CONFERENCES ATTENDED

- *GDR Dynamos 2015* held at ICTS-TIFR, IISc campus, Bangalore
- Oral presentation in the *Dynamics of Complex Systems 2016* held at ICTS Bangalore
- Poster presentation in the Conference on *Nonlinear System and Dynamics 2019* held at IIT Kanpur

TEACHING EXPERIENCE

Department of Physics, IIT Kanpur Kanpur, India

Teaching Assistant in

- Electrodynamics (Prof. R C Budhani, Prof. Krishnacharya) Fall 2016
- Nonlinear System and Dynamics (Prof. S Chakraborty) Spring 2015
- UG Physics Laboratory 2013-2015
- Quantum Physics (Prof. Avinash Singh, Prof. A K Gupta) Spring 2013
- Modern Optics (Prof. R Vijaya) Fall 2012

NPTEL-MOOC (Massive Open Online Course)

- Teaching Assistant and Tutor, Engineering Mechanics
- Teaching Assistant, Introduction to Electrodynamics

SELECT COURSES

Credited courses:

- Classical Mechanics (PHY401), Statistical Mechanics (PHY412), Computational Physics (PHY473), Classical Electrodynamics (PHY552 & PHY553)
- Physics of Turbulence (PHY672), Nonlinear System & Dynamics(PHY695), Soft Matter Physics (PHY616)

Other courses:

- Introduction to Astrophysical Fluids (PHY651) (*audited*)
- Accelerated Computing with CUDA and Deep Learning (under National Supercomputing Mission, Govt. of India) (*certificate course*)

REFERENCES

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Samriddhi Sankar Ray
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