# Vishwanath Shukla

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## Personal

Born on August 5, 1986.

Indian Citizen. Married.

## Current Position

Assistant Professor, Department of Physics, IIT Kharagpur

## Education

2009-2015 **Ph.D. Physics**, Indian Institute of Science, Bangalore, India.
(Submitted Aug 2014, defended Jan 2015, Awarded, 28th March 2015.)
THESIS TITLE *Particles and Fields in Superfluid Turbulence: Numerical and Theoretical Studies*
ADVISER Rahul Pandit

2007-2009 **Master of Science**, Indian Institute of Technology, New Delhi, India.
THESIS TITLE *Mean Field Treatment Of Bose-Einstein Condensate in a Rotating Optical Lattice*
ADVISER Sankalpa Ghosh

2003-2007 **Bachelor of Science**, Banaras Hindu University, Varanasi, India.

## Research Interests

*Broad research area*: Statistical Physics and Theoretical Condensed Matter Physics
*Theme*: Nonlinear, non-equilibrium and multi-scale processes. Hydrodynamic turbulence.

Classical and quantum fluids: Applications to astrophysical, condensed matter and geophysical flow systems.

Complex biological systems and active fluids.

Quantum many-body dynamics of Bose and Fermi fields, Quantum spin systems.

Physics & Computing: High performance computing & Machine Learning.

**Statement** Our focus is on identifying the common themes that occur in a wide variety of turbulent systems, ranging from flows on astrophysical to quantum scales. In particular, our major emphasis is on the study of various dynamical and statistical properties of turbulence and other non-equilibrium states at zero- and finite-temperatures in different quantum fluids, e.g., weakly interacting Bose-Einstein condensates both neutral and charged, superfluid $^4$He, analogous nonlinear optical systems, etc. The ideas

developed and tested for these systems are useful for other quantum fluids as well, at least in bits and pieces, viz. polariton condensates inside semiconductor microcavities, $^3$He, unitary Fermi gas, neutron stars, etc. On the more classical side, we are interested in the phenomena of irreversibility; singularities in viscous and inviscid three-dimensional turbulent flows; all within the scope of incompressible Navier-Stokes equations. We are also interested in the dynamics of large scales and bifurcation of the mean flow on a strongly turbulent background, which has applications in geophysical flows. We occasionally also work on transport of (phoretic) particles in turbulent flows.
We are also interested in exploring the physics of active matter systems in fluid environment.
We make good use of numerical simulations, including high-performance-computing, in our endeavor to understand the above physics.
In summary, we are driven by a grand vision of evolving a coherent story of turbulence described by the two most widely studied partial differential equations: the Navier-Stokes equation and the non-linear Schrödinger equation (and their variants).

# Experience

## *Research Positions*

| | |
|---|---|
| Apr 2018–Apr 2019 | **Postdoctoral Fellow**, L'Institut de Physique de Nice (INPHYNI), Université Côte d'Azur, Nice, France. |
| Apr 2017–Mar 2018 | **Postdoctoral Fellow**, SPHYNX, Service de Physique de l'Etat Condensé, CEA Saclay, France. |
| May 2016–Mar 2017 | **Postdoctoral Fellow**, Laboratoire de Physique, École Normale Supérieure de Lyon, Lyon, France. |
| Mar 2016–Apr 2016 | **Postdoctoral Fellow**, Department of Physics, Indian Institute of Science, Bangalore, India. |
| Mar 2015–Feb 2016 | **Postdoctoral Fellow**, Laboratoire de Physique Statistique, École Normale Supérieure, Paris, France. |
| Aug 2014–Feb 2015 | **Research Associate**, Department of Physics, Indian Institute of Science, Bangalore, India. |

## *Professional Experience*

Referee for the journals such as *Physical Review Letters*, *Physical Review B*, *Physical Review E*, *Fluid Dynamics Research*.

## *Recent Research Visits*

Visitor, Center for Nonlinear Studies, Los Alamos National Laboratory, USA. April 2019.

Visitor, School of Engineering and Applied Sciences, Harvard University, USA. March 2019.

Visitor, Institute of Nuclear Theory, University of Washington, Seattle, USA. March/April 2019.

Visitor, Laboratoire de Physique Statistique, Ecole Normale Supérieure, Paris, France. 21 - 30 July 2018.

Visitor, Nordita Stockholm, Sweden, 9 - 13 July 2018.

## *Teaching*

Courses taught: Statistical Physics II, Mathematical Methods II, Condensed Matter Physics II, Computational Methods, Pattern Forming Instabilities - Turbulence module.

### *Ph.D. Student Guidance*

1. Sudip Das, July 2019 – present.
2. Maheswar Maji, July 2020 – present.
3. Chandra Sekhar Lohani, July 2020 – present. (Jointly with R. Lakkaraju)
4. Suraj Kumar Nayak, July 2020 – present. (Jointly with K. Seshasayanan)
5. Sudipto Bagchi, September 2021 – present. (Jointly with A. Gupta, IIT Hyderabad)
6. Arunava Das, September 2021 – present.
7. Balbeer Singh, September 2021 – present. (Jointly with K. L. Panigrahi)

### *M.Tech. Student Guidance*

Ongoing: Ranit Bose. Completed: Dipanwita Mitra

### *M.Sc./B.Tech. Student Guidance*

Ongoing: Shobhit Saheb Dey, Debarpita Jyoti, Seemran Panigrahi, Diganata Samanta, Bhupendra Gupta. Completed: Aditya Vikram Singh, Karthik S. Eswaran, Viraj R. Nayak, M. Amarnath Reddy, Sreyan Saha, Subhadeep Bej, Niles Mondal, Debasish Bag, Anirban Kopty, Rimo Das, Pooja Bhagwan Arakh, Archak Raghavendra Kaushik, D. Pavan Kumar, Mohit Singh, Sandeepkrishna S, Ankush Kumar Patel

## Fellowships

2011–2014 **Senior Research Fellow**, Council of Scientific and Industrial Research, India.
2009–2011 **Junior Research Fellow**, Council of Scientific and Industrial Research, India.

## Publications

### *Journal Articles and preprints*

1. V Shukla and S. Nazarenko. Non-equilibrium Bose-Einstein Condensation. Phys. Rev. A 105 (3), 033305, 2022.. Also, available at: https://arxiv.org/abs/2105.07274
2. P Basu et al. Machine learning of Ising criticality with spin-shuffling. arXiv:2203.04012.
3. K Seshasayanan et al. Equivalence of nonequilibrium ensembles: Two-dimensional turbulence with a dual cascade. arXiv:2112.12215
4. A Griffin, V Shukla, M-E. Brachet, S. Nazarenko. Magnus-force model for active particles trapped on superfluid vortices. **Phys. Rev. A** 101, 053601 (2020).
5. V. Shukla, B. Dubrulle, S. Nazarenko, G. Krstulovic, S. Thalabard. Phase transition in time-reversible Navier-Stokes equations. **Phys. Rev. E** 100(4), 043104, 2019.
6. A. K. Verma, V. Shukla, A. Basu, R. Pandit. The Statistical Properties of Superfluid Turbulence in $^4$He from the Hall-Vinen-Bekharevich-Khalatnikov Model. **arXiv**:1905.01507.
7. V. Shukla, P. D. Mininni, G. Krstulovic, P. Clark di Leoni, M. Brachet. Quantitative estimation of effective viscosity in quantum turbulence. **Physical Review A** 99 (4), 043605, 2019.

8. D. Geneste, H. Faller, F. Nguyen, V. Shukla, J-P Laval, F. Daviaud, E-W. Saw and B. Dubrulle. Universality and Thermodynamics of Turbulence. **Entropy** 21(3), 326, 2019.

9. P. Debue, V. Shukla, D. Kuzzay, D. Faranda, E.-W. Saw, F. Daviaud, and B. Dubrulle. Dissipation, intermittency, and singularities in incompressible turbulent flows. **Phys. Rev. E**, 97(5), 053101, 2018.

10. V. Shukla, R. Pandit, and M. Brachet. Particles and Fields in Superfluids: Insights from the Two-dimensional Gross-Pitaevskii Equation. **Phys. Rev. A** 97, 013627, 2018.
https://arxiv.org/abs/1710.10107.

11. V. Shukla, M. Brachet, and R. Pandit. Superfluid Mutual-friction Coefficients from Vortex Dynamics in the Two-dimensional Galerkin-truncated Gross-Pitaevskii Equation. Submitted to Phys. Rev. B. Also available at, http://arxiv.org/abs/1412.0706.

12. R. Pandit, et al. An Overview of the statistical properties of two-dimensional turbulence in fluids wiht particles, conducting fluids, fluids with polymer additives, binary-fluid mixtures, and superfluids. **Phys. Fuids**, 29, 111112, 2017.

13. V. Shukla, R. Volk, M. Bourgoin, and A. Pumir. Phoresis in turbulent flows. **New J. Phys.** 19, 123030, Nov 2017.

14. V. Shukla, M. Brachet, and S. Fauve. Statistical theory of reversals in two-dimensional confined turbulent flows. **Phys. Rev. E, Rapid Comm.** 94, 061101(R), Dec 2016.
Also available at, https://arxiv.org/abs/1607.01038.

15. V. Shukla, M. Brachet, and R. Pandit. Sticking Transition in a Minimal Model for the Collisions of Active Particles in Quantum Fluids. **Phys. Rev. A, Rapid Comm.** 94, 041602(R), Oct 2016. Also available at, https://arxiv.org/abs/1603.05814.

16. V. Shukla and R. Pandit. Multiscaling in superfluid turbulence: A shell-model study. **Phys. Rev. E**, 94, 043101, Oct 2016. Also available at, http://arxiv.org/abs/1508.00448v2.

17. V. Shukla, A. Gupta, and R. Pandit. Homogeneous isotropic superfluid turbulence in two dimensions: Inverse and forward cascades in the Hall-Vinen-Bekharevich-Khalatnikov model. **Phys. Rev. B**, 92:104510, Sep 2015. http://link.aps.org/doi/10.1103/PhysRevB.92.104510.

18. V. Shukla, M. Brachet, and R. Pandit. Turbulence in the two-dimensional Fourier-truncated Gross-Pitaevskii equation, **New J. Phys.**, 15(11):113025, 2013.

## Externally funded projects

1. Turbulence and non-equilibrium states in quantum fluids. Agency: Start-up Research Grant (SRG), Science and Engineering Research Board. Duration: 07-12-2020 to 06-12-2022. Role: P.I.

2. Deciphering the small-scale structure of turbulent flows. Agency: National Supercomputing Mission. Duration: 15-04-2021 to 14-04-2023. Role: P.I.
Co. P.I.: Dr. Dhawal Buaria, New York University, USA.

3. Statistical Characterization of the Time-reversible Navier-Stokes Equation. Agency: Institute Scheme for Innovative Research and Development (ISIRD), IIT Kharagpur. Duration: 2021-2024. Role: P.I.

## Computational projects

**2019-2020**
32 million cpu hours on French supercomputers. Jointly with B. Dubrulle (principal investigator), CEA Saclay and S. Nazarenko, INPHYNI, Nice.

**2018-2019**
5.5 million cpu hours on French supercomputers: IDRIS IBM Blue Gene/Q Turing and Occigen, Cines for the period May 2018 to April 2019. Monetary valuation 63000 Euros. This project was jointly submitted with French permanent researchers B. Dubrulle (principal investigator), CEA Saclay and S. Nazarenko, INPHYNI, Nice.

## Conferences/Workshops organized

### *International conferences/Workshops*

1. Universal features of hydrodynamical, optical and wave turbulence. 9 – 12 Sep 2019, Nice, France. Co-organizers: Sergey Nazarenko, INPHYNI, UCA, Nice; Dario Vincenzi, LJAD, UCA, Nice; Giorgio Krstulovic, OCA, UCA, Nice; Jason Laurie, Aston. University, UK

## Talks (recent)

### *Invited talks*

1. Invited expert lecture in the Online FDP on "Research through HPC", organized at Department of Computer Science and Engineering, Birla Institute of Technology, Mesra, Ranchi, 31 January 2021.
2. Superfluid hydrodynamics at finite temperatures: Estimation of effective viscosity - Center for Nonlinear Studies, Los Alamos National Laboratory, USA, 4 April 2019.
3. Description of superfluid turbulence at finite temperatures using the GPE, two-fluid models, and the Hall-Vinen-Bekharev-Khalatnikov equations - Program on Quantum Turbulence: Cold Atoms, Heavy Ions, and Neutron Stars - The Institute for Nuclear Theory, University of Washington, Seattle, 22 March 2019.
4. Superfluid hydrodynamics at finite temperatures: Estimation of effective viscosity - School of Engineering and Applied Sciences, Harvard University, 15 March 2019. (Seminar in the group of Professor L Mahadevan).

### *Contributed talks*

1. Time-reversible Navier-Stokes Equations - European Mechanics Society, Colloquium 620 on "Extreme dissipation and intermittency in turbulence", 17 - 19 May 2021.
2. Phase transition in time-reversible Navier-Stokes equations - 7th Indian Statistical Physics Community Meeting, February 19-21, 2020 at ICTS-TIFR, Bengaluru.
3. Quantitative estimation of effective viscosity in quantum turbulence - American Physical Society, March Meeting 2019, Boston - 8 March 2019.