Nairita Pal

Curriculum Vitae

Personal Details

Current Designation	**Assistant Professor Grade-I**, *Indian Institute of Technology, Kharagpur*, Center for Oceans, Rivers, Atmosphere and Land Science (CORAL)
Last Degree obtained	**Ph.D (Physics)**, *25th March, 2017*
Date of Birth	**2nd October, 1987**
Citizenship	**Indian**
Personal Webpage	**Webpage Link**

Education

August 2011–March 2017	**Ph.D (Physics)**, *Indian Institute of Science*, Bangalore, India, Thesis Advisor : **Professor Rahul Pandit** Thesis Title : Cahn-Hilliard-Navier-Stokes Investigations of Binary-Fluid Turbulence and Droplet Dynamics
2009–2011	**Master of Science (Physics)**, *Indian Institute of Technology*, Delhi, Master's thesis supervisor : Dr. Sankalpa Ghosh Thesis title: Atom-photon entanglement using cold atomic condensates, CGPA 8.11 out of 10
2006-2009	**Bachelor of Science (Physics)**, *Presidency College*, Calcutta University, Kolkata **63.375 % marks**
2004–2006	**Higher Secondary Examination** **(Physics, Chemistry, Mathematics, Statistics, Literature)**, *South Point High School*, Kolkata **88.8 % (Total), 87.75 % (Science) (Physics, Chemistry, Mathematics, Statistics)**
2004	**Secondary Examination**, *South Point High School*, Kolkata **91.25 % (Total), 95.75 % (Science, i.e., Mathematics, Physical Science, Life Sciences, Mechanics)**

Professional Experience

August 2022–	**Assistant Professor in IIT Kharagpur, CORAL**

Fluid Dynamics and Solid Mechanics, T-3
3200 Canyon Road Apt 4301, Los Alamos, New Mexico 87544, USA
nairita@lanl.gov

2020 March–present **Staff Scientist 2**, *Los Alamos National Laboratory*, Fluid Dynamics and Solid Mechanics Group, Theoretical Division, T–3,
Mixing in multicomponent fluids in turbulence using turbulence models, **High Performance Computing**; application to *real* systems, e.g., tidal mixing in global oceans and its impact on global climate change using **Energy Exascale Earth System Model**

2017 March–Feb 2020 **Post Doctoral Associate**, *Los Alamos National Laboratory*, Theoretical Division, **Mentor – Dr. Susan Kurien**
Turbulent multimaterial mixing using turbulence closure models

2016 **Visitor**, *Observatoire Cote D Azure, Nice, France*

June 2014, June 2015 **Visitor**, *TIFR Centre for Interdisciplinary Sciences, Hyderabad*

2014, 2015 **Teaching Assistant**, *Department of Physics, IISc, Bangalore*

May–July 2010 **Summer student**, *Department of Physics, S.N. Bose National Center for Basic Sciences, Kolkata*

Research Interests

I am interested in studying *multicomponent fluid mixing* in turbulence. To this end, I have investigated mixing, phase–separation and interfacial phenomena in *turbulence* using **High Performance Computing (HPC)** and Direct Numerical Simulations, and turbulence closure models. Currently, I am interested in applying the turbulence theories and moment closure models to study *real systems*, e.g., global oceans. In this regard, I am studying the impact of tidal mixing on the transport properties such as the *net heat flux* using the Energy Exascale Earth System Model (developed by US DOE). The net heatflux of oceans is a major driver in global climate change. I am interested in studying the effect of ocean hydrodynamics on ocean thermodynamics, and the ocean radiation properties (such as solar reflectivity).

Projects:

Experience as Staff Scientist

1. *Two–point spectral closure model for variable–density multimaterial turbulent mixing*: Developed a spectral closure model (akin to moment closure models in non–equilibrium statistical mechanics) to study spatiotemporal evolution of a multicomponent system. The density contrast in this system is high, and the system is *far from statistical equilibrium*. Model used in LANL's radiation hydrodynamics codebase **xRage**.
   Funding: DOE funded program area Advanced Scientific Computing Mix and Burn
   – **Collaborators – Dr. Susan Kurien**, **Dr. Timothy Truman Clark**, **Dr. Daniel Livescu**, **Dr. Praveen Ramaprabhu**
2. Studied tidal dynamics in global oceans using E3SM (**Energy Exascale Earth System Model**) and MPAS (Model for Prediction Across Scales).
   Funding : US DOE funded program area Biological and Environmental Research (BER) – **Collaborators – Dr. Andrew Roberts**, **Dr. Elizabeth Hunke**, **Dr. Mark Petersen**, **Dr. Brian Arbic**
3. studied wave–ice interaction in the polar regions using Wavewatch III and E3SM using a global unstructured mesh.

Post Doctoral Experience

Turbulence model to study variable-density multimaterial flows
– Mentor – **Dr. Susan Kurien**
Collaborators – **Dr. Timothy Truman Clark**, **Dr. Daniel Livescu**

1. studied a moment closure model, known as the Local Wave Number Model in literature, of variable-density homogeneous multimaterial fluid mixture. Validated the model results against fully-resolved Direct Numerical Simulation results.
2. extended the study to inhomogeneous multimaterial fluid mixtures. Validated the results against Implicit Large–Eddy Simulation results.

PhD Experience

Supervisor – **Professor Rahul Pandit**
Collaborators – **Dr. Prasad Perlekar**, **Professor John Gibbon**, **Dr. Samriddhi Sankar Ray**

- Successfully developed a massively parallel FORTRAN code to study droplet dynamics in turbulence, Rayleigh Taylor Instability, phase-separation in fluids, multiphase flows. **HPC** in **CRAY** Supercomputer Cluster (Supercomputer Education and Research Center, IISc) to execute the code developed in FORTRAN.
- **Modeling and simulation of droplets in turbulence.**
  1. studied the advection of an active, deformable, finite-size droplet by a turbulent flow via a simulation of the well-known Cahn-Hilliard-Navier-Stokes equations. In these equations, the droplet has a natural two-way coupling to the background fluid.
  2. characterized *multifractal* nature of droplet shape fluctuations.
- **Numerical simulation of turbulence in binary fluids : Spinodal decomposition and coarsening arrest**.
  1. studied spinodal decomposition and domain growth of a turbulent binary-fluid mixture
  2. identified length scale at which the phase–separation is *arrested*.
  3. Discovered a scaling law for the length scale as a function of surface tension.
- **Modelling and simulation of antibubbles in turbulence.** Antibubbles - shells of a low-density fluid inside a high-density fluid - have been known for 90 years, but a detailed understanding of antibubble dynamics continues to pose challenges because: (a) the flow is multiphase and often turbulent; (b) the antibubble affects the flow while it is advected by the flow; (c) the antibubble boundary changes in time; and (d) antibubble dynamics requires sophisticated computing for it is governed by nonlinear partial differential equations (PDEs). We develop a theoretical framework, based on the binary-fluid Cahn-Hilliard-Navier-Stokes PDEs, for antibubbles, and elucidate, by extensive direct numerical simulations, their ephemeral, but beautiful, evolution.
- **Numerical analysis of Rayleigh Taylor instability and transition to turbulence.**
  - Applied mathematical analysis of Cahn-Hilliard-Navier-Stokes equations
  - studied *regularity* of the CHNS solutions in the same spirit as the Beale–Kato–Majda theorem for the Navier-Stokes equations

Thesis Title : **Cahn-Hilliard-Navier-Stokes Investigations of Binary-Fluid Turbulence and Droplet Dynamics**
Thesis Supervisor : **Professor Rahul Pandit**

M.Sc research experience

Atom Photon Entanglement Using Cold Atomic Condensates:

- study the nature of the transmission characteristics of the photons coming out of a cavity when

we are shining light in the cavity.
- discuss the cases when the cavity is empty and when it is loaded with ultracold atoms.

From the transmission characteristics of photons from a cavity preloaded with ultracold atoms we can make an idea of the phase of the atomic system.
Thesis Supervisor – Professor Sankalpa Ghosh

Service

Reviewer in Physical Review Fluids, Physical Review Letters, Journal of Turbulence, Ocean Modeling

Impact factor list for the papers published:

- Physical Review E: 2.53
- Physical Review Letters : 9.161
- Physical Review Fluids : 2.52
- Nature Scientific Reports : 4.379
- Philosophical Transactions of the Royal Society A : 4.226
- Physics of Fluids : 3.377
- Physica D: 3.08
- Communications Physics : 8.11

Publications in Google scholar page

Journal publications

1. **Barotropic Tides in MPAS-Ocean: Impact of Ice Shelf Cavities**; **Nairita Pal**, Kristin Nicole Barton, Mark Roger Petersen, Steven Richard Brus, Darren Engwirda, Brian K Arbic, Andrew Frank Roberts, Joannes J Westerink, Damrongsak Wiraset; Geoscientific Model Development Discussions, 2022
2. **Scalable self attraction and loading calculations for unstructured ocean models**; Steven Brus; Kristin N Barton; **Nairita Pal**; Andrew F Roberts; Darren Engwirda; Mark R Petersen; Brian K Arbic; Damrongsak Wirasaet; Joannes J Westerink; Michael Schindelegger, submitted to *Ocean Modeling*, May 2022
3. **Performance of Model for Prediction Across Scales (MPAS) Ocean as a Global Barotropic Tide Model**; K. N. Barton, N. Pal, S. R. Brus, M. R. Petersen, B. K. Arbic, D. Engwirda, A. Roberts, J. J. Westerink, D. Wirasaet, M. Schindelegger; submitted to JAMES
4. **The Local Wavenumber model for computation of turbulent mixing**
   Susan Kurien, **Nairita Pal**, *Philosophical Transactions of the Royal Society A*, 380(2219), p.20210076, 2022.
5. **Local wavenumber model for inhomogeneous two–fluid mixing**
   Nairita Pal, Ismael Boureima, Noah Braun, Susan Kurien, Praveen Ramaprabhu, and Andrew Lawrie, Phys. Rev. E, **104**(2),025105 (2021).
6. **Two-point spectral model for variable-density homogeneous turbulence**
   Nairita Pal, Susan Kurien, Timothy Clark, Denis Aslangil, Daniel Livescu
   Phys. Rev. Fluids, **3** (12),2018 .
7. **Preferential Sampling of Elastic Chains in Turbulent Flows**
   Jason R. Picardo, Dario Vincenzi, **Nairita Pal**, Samriddhi Sankar Ray
   Phys. Rev. Lett. **121**, 244501 (2018).
8. **Exotic multifractal conductance fluctuations in graphene**

Kazi Rafsanjani Amin, Samriddhi Sankar Ray, **Nairita Pal**, Rahul Pandit, Aveek Bid
Communications Physics 1(1), 2018.

9. **An overview of the statistical properties of two-dimensional turbulence in fluids with particles, conducting fluids, fluids with polymer additives, binary-fluid mixtures, and superfluids**
   Rahul Pandit, Debarghya Banerjee, Akshay Bhatnagar, Marc Brachet,Anupam Gupta, Dhrubaditya Mitra, **Nairita Pal**, Prasad Perlekar,Samriddhi Sankar Ray,Vishwanath Shukla, and Dario Vincenzi
   PHYSICS OF FLUIDS 29, 111112 (2017).
10. **Two-dimensional Turbulence in Symmetric Binary-Fluid Mixtures: Coarsening Arrest by the Inverse Cascade**
    P. Perlekar, **N. Pal** and R. Pandit,
    Nature Scientific Reports 7 (2017).
11. **The role of the BKM theorem in Euler, Navier-Stokes and Cahn-Hilliard-Navier-Stokes analysis**
    J.D. Gibbon, Anupam Gupta, **Nairita Pal**, and Rahul Pandit,
    Physica D, (2017)
12. **A BKM-type theorem and associated computations of solutions of the three-dimensional Cahn-Hilliard-Navier-Stokes equations**
    J.D. Gibbon, **Nairita Pal**, Anupam Gupta, and Rahul Pandit,
    Phys. Rev. E **94**, 063103 (2016).
13. **Binary-fluid turbulence: Signatures of multifractal droplet dynamics and dissipation reduction**
    N. Pal, P. Perlekar, A. Gupta and R. Pandit,
    Phys. Rev. E **93**, 063115 (2016).

Internal Reports

1. **Local Wavenumber Turbulence Model Implementation in xRage: L3 Milestone Report**
   S. Kurien, J. Canfield, N. Pal, R. Rauenzahn, and J. Saenz, Tech. Rep. LA–UR–19–29439 (Los Alamos National Laboratory, USA, 2019).
2. **Inhomogeneous terms in the LWN b–equation,**,
   J. Canfield, S. Kurien, N. Pal, R. Rauenzahn, and J. Saenz, Tech. Rep. LA–UR–20–20776 (Los Alamos National Laboratory, USA, 2020).
3. **Improved Time-Stepping Methods in Global to Regional Ocean Modeling**,
   Mark Roger Petersen, Giacomo Capodaglio, Sara Calandrini, Siddhartha Bishnu, Nairita Pal, la–ur–21–23627 (Annual Status Report 2020) (Los Alamos National Laboratory, USA, 2021)
4. Ocean drag parametrizations: code accepted within E3SM community – "Impact of drag and dissipation on ocean tides", Nairita Pal.

Grant Proposal Writing

Proposal (for LANL internal grant) selected for final stage of review
Title of proposal : **Developing a National Tool to Track Arctic Ocean Oil Spill**
P.I: Nairita Pal; Co-PI: Andrew Roberts, Nicole Jeffery

Conference Presentations Internally Reviwed by LANL

1. **Explicit Oceanic Tides in the Energy Exascale Earth System Model**
   Nairita Pal, Kristin Barton, Mark Petersen, Steven Brus, Brian Arbic, prepared for AGU Fall 2021;

LAUR–21–30332, 2021

2. **Local Wave Number Model for Inhomogeneous Turbulence**
   Nairita Pal, Susan Kurien, Ismael Boureima, Praveen Ramaprabhu, Andrew Lawrie, LAUR–19–31628, 2019, prepared for AJKFluids 2019.
3. **A non–equilibrium turbulence model**
   J. Canfield, M. Francois, S. Kurien, N. Pal, LAUR–19–31628, R. Rauenzahn; prepared for AJKFluids 2019.
4. **Local Wave Number Model for Inhomogeneous Variable–density Turbulence**
   N Pal, S Kurien, I Boureima, P Ramaprabhu, A Lawrie
   APS Division of Fluid Dynamics Meeting, (72nd APS DFD, 2019); LAUR–19–31785
5. **Two-point spectral model for variable-density homogeneous turbulence**
   N Pal, S Kurien, T Clark, D Aslangil, D Livescu
   APS Division of Fluid Dynamics Meeting, (71st APS DFD, 2018); LAUR–18–27017

6. **Validation of a two–point spectral turbulence model for inhomogeneous flows**
   I Boureima, N. Pal, S. Kurien, P Ramaprabhu, A Lawrie; APS DFD 2018; LAUR–18–27300

Paper Under Review

1. **Ephemeral Antibubbles: Spatiotemporal Evolution from Direct Numerical Simulations** **Nairita Pal**, Rashmi Ramadugu, Prasad Perlekar and Rahul Pandit, arXiv preprint arXiv:2103.16780 (2021)(under final stage review in Physical Review Research).

Conference presentations, non-refereed

1. **Implementing Self-Attraction and Loading Calculation in the Model for Prediction Across Scales**
   Kristin Barton, Nairita Pal, Mark R Petersen, Steven R Brus, SAND-Brian K Arbic, Darren Engwirda, Andrew Roberts, Joannes J Westerink, Damrongsak Wirasaet, AGU Fall Meeting 2021
2. **The Spatiotemporal Evolution of Antibubbles: Insights from Direct Numerical Simulations**
   N Pal, R Ramadugu, P Perlekar, R Pandit
   Bulletin of the American Physical Society, 2020 (73rd APS DFD meeting)
3. **Two-point spectral model for variable-density homogeneous turbulence**
   N Pal, S Kurien, T Clark, D Aslangil, D Livescu
   APS Division of Fluid Dynamics Meeting, (70th APS DFD, 2017)
4. **Binary-fluid turbulence: Signatures of multifractal droplet dynamics and dissipation reduction**
   N Pal, P Perlekar, A Gupta, R Pandit
   European Turbulence Conference 2015

Supercomputers Used

- CRAY (IISc Bangalore)
- Turquoise network (Los Alamos National Lab internal supercomputer)
- NERSC supercomputing facility (Machine used : cori)
- Pacific Northwest National Lab (PNNL) supercomputer COMPY

PhD students guidance

1. Ongoing (co–mentor; 2021–current) – **Kristin Barton**, University of Michigan Ann Arbor; primary mentor – **Professor Brian Arbic** (University of Michigan).

2. Past (co–mentored summer student 2019–2020) – Dr. Ismael Boureima, University of North Carolina at Charlotte (primary mentor – Dr. Praveen Ramaprabhu)– currently he is a postdoc at LANL

Achievements

2016 **Awarded Research Associateship from IISC to have completed thesis within the stipulated time of 5 years**

2015 **Awarded IISc Travel Grant for presenting in the European Turbulence Conference (ETC)**

2014 **Among the top 5 finalists in the Poster Presentation Session (Physics Department, IISc Bangalore)**

2013 **Awarded UGC-CSIR SRF Fellowship**

2011 **Awarded UGC-CSIR JRF Fellowship**

2011 **All-India-Rank 36**, *Graduate Aptitude Test in Engineering (GATE)*

2011 **All-India-Rank 142**, *UGC-CSIR National Eligibility Test (NET)*

2009 **Selected among top 25 students in India**, *National Graduate Physics Examination (NGPE)*

2009 **All-India-Rank 59**, *Joint Entrance Examination (JEST)*

2009 **All-India-Rank 126**, *Joint Admission Test (JAM)*

Skills

- Expert in **Computational Fluid Dynamics** – Direct Numerical Simulation (DNSs), Large Eddy Simulations (LESs), Reynolds Averaged Navier-Stokes (RANS), turbulence models.
- DNS simulations for multiphase fluid turbulence, droplets, bubbles, low Reynolds number flows.
- Development and validation of turbulence models to study flow instability, transition to turbulence in variable-density flows.
- **Ocean modeling**, modeling of tides in global ocean, developed state-of-the-art Earth System Model used by LANL to study tides and hurricanes in the Atlantic ocean.
- **High-performance computing** (HPC) skills – developed and used parallel codes written in **FORTRAN, C++**, data analysis using **Fortran, Matlab, Python, linux bash scripts**, **github**.

REFERENCES

Dr. Susan Kurien, *skurien@lanl.gov*, Fluid Dynamics and Solid Mechanics, Theoretical Division (T–3), Los Alamos National Laboratory, Los Alamos, NM
postdoc mentor

Professor Rahul Pandit, *rahul@physics.iisc.ernet.in*, Department of Physics, Indian Institute of Science, Banglore
PhD supervisor

Dr. Prasad Perlekar, *perlekar@tifrh.res.in*, TIFR Centre for Interdisciplinary Sciences, Hyderabad
PhD collaborator

Dr. Andrew Frank Roberts, *afroberts@lanl.gov*, Fluid Dynamics and Solid Mechanics, Theoretical Division (T–3), Los Alamos National Laboratory, Los Alamos, NM
Current Program Manager and collaborator

More references to be provided on request