Pankaj Popli

Curriculum Vitae

Department of Physics
Indian Institute of Science
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Research Interests

Solid mechanics, plastic deformation in amorphous materials, systems with competing ordering, colloidal crystals, crystal defects, self assembly, pattern stabilization in active flocks, identifying ways of probing the statistics of fluctuations, and citation statistics.

Positions held

Nov '21 - ⋆ **IoE Postdoctoral Fellow**, Department of Physics.
Indian Institute of Science, Bangalore, India.

May '21 - Oct '21 **Research Associate**, Department of Physics.
Indian Institute of Science, Bangalore, India.

Aug '20 - Apr '21 **Postdoctoral Fellow**, Centre for Interdisciplinary Sciences.
Tata Institute of Fundamental Research, Hyderabad, India.

Education

2013 - 2020 **Ph.D.**, Centre for Interdisciplinary Sciences.
Tata Institute of Fundamental Research, Hyderabad, India.

2009 - 2012 **Bachelor of Science (B.Sc.)**, Physics (Hons.), Hindu College.
University of Delhi, India.

Ph.D. Thesis

Title *Statistics of non-affine displacements: Defect precursors and stability of lattices*
Supervisor Prof. Surajit Sengupta (1962-2021)
Date of defense July 6, 2020

Publications

1. Translationally invariant colloidal crystal templates
   Pankaj Popli, Saswati Ganguly, and Surajit Sengupta.
   Soft Matter, 14, 104-111, 2018.
2. Exploring the link between crystal defects and nonaffine displacement fluctuations
   Pankaj Popli, Sayantani Kayal, Peter Sollich, and Surajit Sengupta
   Phys. Rev. E, 100, 033002, 2019.
3. Pattern stabilisation in swarms of programmable active matter: a probe for turbulence at large length scales
   Pankaj Popli, Prasad Perlekar, and Surajit Sengupta.
   Phys. Rev. E 104, L032601

4. Unified citation parameters for journals and individuals: Beyond the Journal Impact Factor or h-index alone

   Pankaj Popli, Subodh R Shenoy

   In review, Pramana

5. A different kind of order: Quasistatic yielding of Crystals by condensation of non-affine displacement mode.

   Pankaj Popli, Parswa Nath, Jürgen Horbach, Peter Sollich, and Surajit Sengupta.

   manuscript under preparation

6. Citation networks and scaled Hirsch curves: segmented universality from different citation mechanisms.

   Pankaj Popli, Subodh R Shenoy

   manuscript under preparation

Theoretical Techniques

Experienced in Non-affine projection formalism, lattice theory of $2d$ and $3d$ crystals, lattice defects. Good command on Monte Carlo (MC), Molecular Dynamics (MD), and Langevin Dynamics (LD) simulation techniques. Introductory knowledge in LAMMPS.

Computational Skills

Languages	Proficient in programming languages 'C', 'C++', and Mathematica scripting language.
Computation	Fair understanding of Open MP, Matlab, and Python.
OS	Fair understanding of operating systems such as Linux, Mac, and Windows.
Office	LaTeX, Open Office, Keynote, Inkscape.

Teaching Skills

2020 — **Instructor**, Classical Mechanics.
Jointly with Prof. Surajit Sengupta

2016 — **Teaching Assistant**, Solid State Physics I.
With Prof. Subodh R Shenoy

2015 — **Teaching Assistant**, Quantum Mechanics I.
With Prof. Subodh R Shenoy

Research Experience

• **Non-affine projection formalism and lattice defect precursors:**
We generalize a recently developed formulation which decompose particle displacements into affine and non-affine components to investigate several two and three dimensional lattices. In each case we show that the non-affine component (non-affine modes) of thermal fluctuations act as a precursor to the commonly observed lattice defects. The proliferation of such non-affine defect precursors leads to plastic deformations of the crystals; a result that has important implications for the stability of crystalline solids.

• **Translationally invariant colloidal crystal template:**
Exploiting the connection between non-affine modes and lattice defects, we devise an experimental protocol to stabilize (i) lattice of colloidal particles, and (ii) patterns of active robotic swarm. This is accomplished in an energy efficient way by imposing feedback controlled "non-affine forces". These restoring forces alter the particle's arrangement in order to minimize non-affine fluctuations. Our stabilization procedure/algorithm needs no awareness of inter-particle interactions or the particulars of underlying noise but the details of instantaneous and reference configuration. In colloids, the resulting colloidal lattice is translationally invariant and retains all the low-energy phonon modes.

• **Stabilizing patterns in active robotic swarms:**
In robotic swarms, the pattern obtained is stable and as a whole can be translated without interfering with the stabilization algorithm. The agents are not forced to sense, difficult to measure, environmental parameters such as local velocity of air or water in order to stabilize the swarm. A novel outcome of this study is that by maintaining the structure of robotic swarm, the statistics of underlying flow field can be determined solely from non-affine forces. As non-affine forces are a-priori known, no extra measurement on the turbulent field is required to obtain the statistics. Therefore, such techniques will be useful in studying the turbulent flow where the direct measurement of flow velocities is difficult.

• **Self consistent phonon theory:**
It aimed towards understanding the behaviour of non-affine displacements when anharmonicity of the inter-atomic potential is taken into account. Using Gibbs variational principle, self consistent equations for the free energy density (with adjustable parameters) was obtained. Solution to these self consistent equations then provides a renormalised Dynamical matrix or vibrational modes of the system.

• **Quasistatic yielding of crystals:**
When a crystalline solid is slowly deformed, it encounters an equilibrium first order transition that breaks lattice translation symmetry and releases stress by lattice slip. We show that this transition, which occurs at infinitesimal deformation, may be viewed as a condensation of a specific linear combination of elastic displacements known as a non-affine mode; this is the order parameter for the transition. Auxiliary tensor fields are necessary to render spatial gradients of the order parameter, and therefore the free energy density, lattice translation invariant. Interfaces necessarily contain contributions from both order parameter gradients and dislocations, which arise naturally from spatial derivatives of the auxiliary fields.

• **Sedimentation dynamics of an array of discs:**
As a part of graduate coursework, an experimental study to understand the sedimentation dynamics of a single and an array of discs at a very low Reynolds number was performed. This project was supervised by Prof. Narayanan Menon and Prof. Sriram Ramaswamy at TIFR Hyderabad.

• **Coherent Josephson tunneling in trapped cold Bosons:**
As a part of graduate coursework, a reading project was done under the supervision of Prof. Subodh R Shenoy at TIFR Hyderabad. This project was focused on (a) understanding tunneling of Bose-Einstein condensates (BEC) between the two wells of a double-well atomic potential trap by reproducing the results obtained in *Pramana Vol 58, No-2, p 385, 2002*. (b) With the further extension to develop a theoretical model for Josephson's junction and superconducting quantum interference devices (SQUID) for BECs.

Fellowships/Awards/Achievements

2021 **IoE Postdoctoral Fellowship**, *Department of Physics*, Indian Institute of Science, Bangalore, India.

2019 **SERB Fellowship**, TIFR-Hyderabad, India.

2013 **Research Scholar**, TIFR-Hyderabad, India.

2012 **JEST**, National level Joint Entrance Screening Test, India.

Conferences/Schools/Workshops

2019 **Workshop on emergent dynamics and self-assembly of out of equilibrium colloids**, *Ecole Polytechnique Fédérale de Lausanne*, Lausanne, Switzerland.

2018 **School on entropy, information and order in soft matter**, *International Center for Theoretical Sciences (ICTS)*, Bangalore, India.

2018 **5th Indian statistical physics community meeting**, *International Center for Theoretical Sciences (ICTS)*, Bangalore, India.

2015 **ICTS-RRI, 6th Bangalore school on statistical physics**, *Raman Research Institute (RRI)*, Bangalore, India.

2014 **Workshop on soft matter self assembly and dynamics**, *Department of Physics, University of Hyderabad*, India.

Talk/Poster presented

2019 **CompFlu**, *Indian Institute of Science Education and Research (IISER)*, Bhopal, India.
Poster

2019 **Translationally invariant colloidal crystal templates**, *Cecam workshop, Ecole Polytechnique Fédérale de Lausanne*, Lausanne, Switzerland.
Poster

2019 **Translationally invariant colloidal crystal templates**, *Glass Seminar Goettingen, Institut für Physik, University of Goettingen*, Goettingen, Germany.
Talk

2019 **Non-affine fluctuations and the stability of crystalline solids**, *Institut für Physik, University of Goettingen*, Goettingen, Germany.
Talk

Public outreach

2013-2014 **Volunteer**, *Sawaal-Jawaab (public outreach)*, TIFR Hyderabad.
With Prof. Shubha Tewari

Linguistic skills

Hindi Native

English Professional working proficiency

References

Prof. Surajit Sengupta (1962-2021)
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