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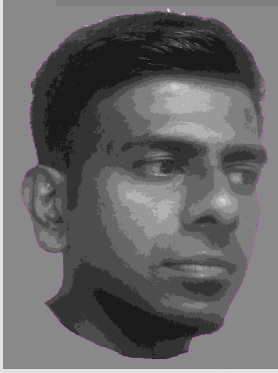
Personal

Date of birth : *20th July, 1981* (Kanyakumari, India)

Age : *38*

Citizenship : *Indian*

Marital Status : *Single*



Education

B.E. (2003)
National Institute of Technology, Karnataka (NITK).
Electrical and Electronics Engineering
Dissertation: *Wireless power transmission using microwaves.*
Advisor: Dr. G.S. Punekar

M.Sc.(Engg) (2005)
Indian Institute of Science (IISc), Bangalore.
Electrical Engineering
Thesis: *Novel application of supervised and self organized neural network for stereo disparity estimation.*
Advisor: Prof. Y.V. Venkatesh

Ph.D. (2015)
Raman Research Institute (RRI), Bangalore.
Soft Condensed Matter Physics
Thesis: *Interplay between shape, order and topological defects: Elasticity of some soft condensed matter systems.*
Advisor: Prof. Yashodhan Hatwalne

Professional experience

- Trainee at **Mangalore Refinery and Petroleum Ltd (MRPL)**, Mangalore: Jun 2001
- Trainee at **Larsen and Turbo (L&T)**, Medical Equipment and Systems, Mysore: Jun 2002
- Consultant, **Qualitas Technologies**, Bangalore: Nov 2013 - Feb 2014.
- Research Associate
  RRI: Oct 2014 – Jan 2015.
  IISc: Feb 2015 – Aug 2015.

Post Doc. (2015-present)
Indian Institute of Science (IISc), Bangalore.
Department of Physics
Advisor: Prof. Rahul Pandit

Conferences/Workshops attended

1) SERC preparatory school in theoretical high energy physics, Centre for High Energy Physics, Indian Institute of Science, Bangalore, INDIA Oct 30 - Nov 18, 2006.
2) A short course on differential geometry by Prof. Juergen Ehlers, Inter- University Center for Astronomy and Astrophysics, Pune, INDIA Jan 2-22, 2007.
3) Workshop on Assembly, Organization and Propulsion in Complex systems, (AOPCS07), Indian Institute of Technology Madras, Chennai, INDIA Feb 22-24, 2007.
4) Workshop on Dynamical Systems, IISc Mathematics Initiative (IMI), Indian Institute of Science, Bangalore, INDIA Oct 22-Nov 03, 2007.
5) The Interface of Life (IOL), An International School on Biomembrane Physics, Indian Institute of Technology Madras, Chennai, INDIA Jan 07-18, 2008.
6) Bangalore Area Statistical Mechanics Meeting, Bangalore, INDIA Apr 12-1, 2008.
7) RRI school on Statistical Physics, Raman Research Institute, Bangalore, Mar 22 – Apr 03, 2010, Mar 07 - Mar 19, 2011, Mar 26 - Apr 07, 2012.
8) Conference and School on Nucleation, Aggregation and Growth, Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bangalore, INDIA: (i) Conference: Jul 26 – 30 and (ii) School: Aug 1 - 6, 2010.
9) Unifying concepts in materials: J A Krumhansl school & symposium 2012, JNCASR, Bangalore, INDIA Jan 30 – Feb 08, 2012.
10) US-India Advanced Studies Institute on Thermalization: From Glasses to Black Holes, Indian Institute of Science, Bangalore, INDIA Jun 10-21, 2013.
11) Complex-Fluids (COMPFLU16), Indian Institute of Science Education and Research, Pune, INDIA Jan 2-4, 2016.
12) International workshop on the Economy as a complex system, The Institute of Mathematical Sciences, INDIA, Nov 13-14, 2017.
13) ICTS Distinguished Lectures on Machine Learning, International Center for Theoretical Science, INDIA, Feb 12-13, 2019.
14) Indian Statistical Physics Community Meeting, International Center for Theoretical Science, INDIA, Feb 14-16, 2019.

Talks/Posters

1) Invited talk on "***Artificial Neural Networks***", Jagadguru Sri Shivarathreeshwara Science and Technology University, Mysore, INDIA, Apr 30, 2006.
2) Poster on "***Tent morphology of polymer crystallites***", **Complex-Fluids (COMPFLU16),** Indian Institute of Science Education and Research, Pune, INDIA Jan 2-4, 2016.
3) Talk on "***Phases, morphologies, and transitions in a mathematical model for the endoplasmic reticulum***", **Indian Statistical Physics Community Meeting,** International Center for Theoretical Science, INDIA, Feb 14-16, 2019.

Academic visits

1) Observatoire de la Cote d'Azur, Nice, France, May 21 – Jun 8, 2018.

Publications

1) Y.V. Venkatesh, B.S. Venkatesh, A. Jaya Kumar, "**Stereodisparity estimation using a supervised neural network**", Machine Learning for Signal Processing, *Proceedings of the 2004 14th IEEE Signal Processing Society Workshop*, Brazil 2004, Sept. 29 - Oct. 1 Page(s): 785 – 793.

2) Y. V. Venkatesh, S. Kumar Raja, A. Jaya Kumar, "**On the application of a modified self-organizing neural network to estimate stereo disparity**", *IEEE Transactions on Image Processing* 16(11): 2822-2829 (2007).

3) A. Anitha, A. Jaya Kumar, R. Mascarenhas, A. Husain, "**Laser Guided Automated Calibrating System for Accurate Bracket Placement**", *Annals of Medical and Health Sciences Research*, 2015 Jan-Feb; 5(1): 42–44.

4) A. Jaya Kumar, Y. Hatwalne, M. Muthukumar, "**Stability of the sectored morphology of polymer crystallites**", *Phys. Rev. E 94*, 032506, Sept 2016.

5) A. Jaya Kumar, B. Chakrabarti, Y. Hatwalne, "**Elasticity of smectic liquid crystals with in-plane orientational order and dispiration asymmetry**", *Phys. Rev. E 95,* 022701, Feb 2017.

6) A. Jaya Kumar, B. Chakrabarti, Y. Hatwalne, "**Equilibrium of fluid membranes endowed with orientational order**", *Phys. Rev. E 95,* 042806, Apr 2017.

7) A. Jaya Kumar, Rahul Pandit, "**Science and Engineering Research in India (1985-2016): insights from two scientometric databases**", *Current Science 115(3),* Aug 2018.

In preparation:

8) A. Jaya Kumar, Y. Hatwalne, "**Classification of crystal structures and topological defects in graphene nanotori and fullerenes with high genus**".

9) M. Mahesh Kumar, A. Jaya Kumar, Rahul Pandit, "**Deep-learning assisted detection and termination of spiral and broken spiral waves in mathematical models for cardiac tissue**".

10) A. Jaya Kumar, Akhilesh Verma, Jeremie Bec, Rahul Pandit "**Path-planning smart swimmers in turbulent flows**".

11) A. Jaya Kumar, Akhilesh Verma, Jeremie Bec, Rahul Pandit "**Adversarial reinforcement learning for gravitaxis in turbulent flows**".

12) A. Jaya Kumar, Y. Hatwalne, Rahul Pandit "**Phases, morphologies, and transitions in a mathematical Model for the endoplasmic reticulum**".

13) Sai Chand, A. Jaya Kumar, Y. Hatwalne "**On the stability of line-defects in nematic order on fixed Topographies**".

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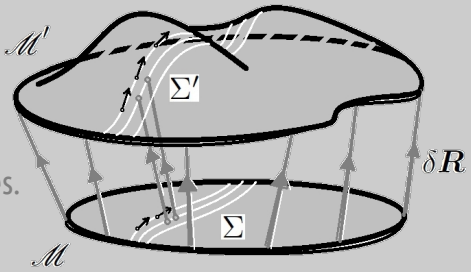
List of research projects

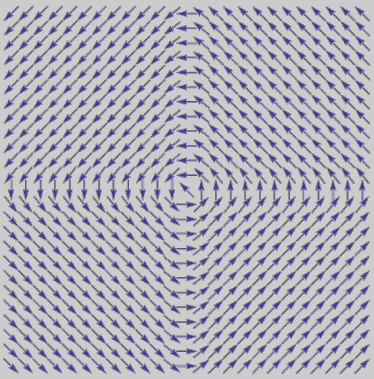
My principal research work involves ideas from the physics of liquid crystals, polymers, and membranes to study the interplay between geometry and topology of order and embedding shapes of surfaces. My neoteric foray into statistics has led to a resurgence in work related to machine learning and statistical mechanics.

• Equilibrium of fluid membranes with tangent-plane order (TPO), elasticity of smectic liquid crystals with TPO, and dispiration asymmetry in smectics-C* : *with Buddhapriya Chakrabarti (University of Durham), Yashodhan Hatwalne (RRI) (arXiv:1506.05616 [cond-mat.soft])*



Fluid membranes endowed with TPO (such as tilt- and hexatic order) afford unique soft matter systems for investigating the interplay between elasticity, shape, topology and thermal fluctuations. Using the spin-connection formulation for membrane- free energy we obtain equations of equilibrium together with free boundary conditions for the ground states of such membranes. We extend the spin-connection formulation to smectic liquid crystals with TPO and and show that for chiral smectics-C* this generalization leads to experimentally verifiable consequences for dispirations having topological indices of the same magnitude but opposite signs.

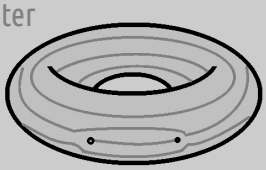
• Tent-morphologies of polymer crystallites: *with Yashodhan Hatwalne (RRI) and M. Muthukumar (UMASS)* (parts published in *Phys. Rev. E 94*, 032506, Sept 2016)

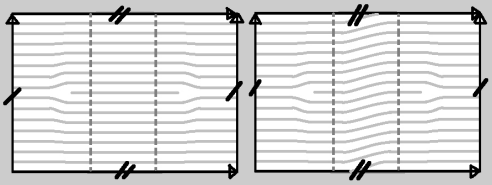


There is a significant difference between the growth of atomic crystals and polymeric crystals. Polymers are connected, whereas atoms and molecules are not. This leads to interesting consequences for the shape and morphology of polymer crystals. All the observed morphologies of polymer crystallites are lamellar in nature. These either show spherulitic structures composed of helicoids, or tent-like structures, or scroll structures.

We modify the Föppl–von Kármán theory of thin plates to account for (i) the fold-order, i.e. orientational order of polymer folds on the surface of lamellar polymer crystallites, (ii) anisotropy of line tension at crystallite edge. We obtain an exact intersecting kink (soliton) solution for the equations of equilibrium (corresponding to the modified plate theory) for a flat crystallite, and show that the flat crystallite buckles to form a tent that has a +1 disclination at its apex. Our results match the experimenatlly mapped fold-fields in tent-shaped crystallites.

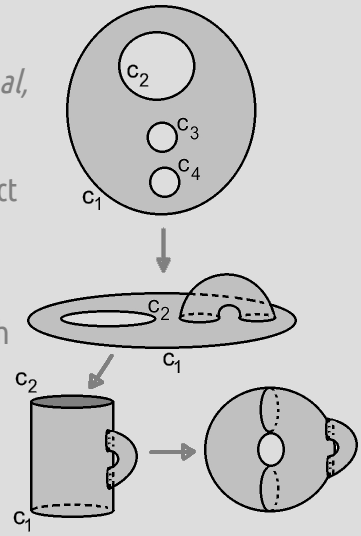
• Classification of crystal structures and topological defects in graphene nanotori and fullerenes with high genus: *with Yashodhan Hatwalne (RRI)* Manuscript in preparation.





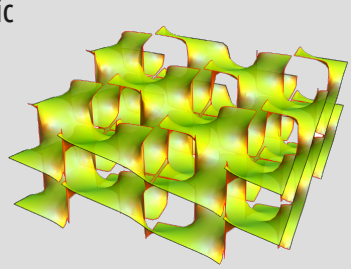
A carbon nanotube can be made by rolling graphene sheets into cylinders of ~1 nanometer diameter. Due to hexagonal symmetry of graphene, one can choose a range of rolling directions with respect to basis vectors of its lattice. This gives rise to different ground states. Experimental and theoretical analysis show that the mechanical and electronic properties of the nanotubes change drastically with the rolling direction. In addition to tubular structures, carbon nanotori have been observed experimentally and show high paramagnetic moments *(Lei Liu. et al, Phys. Rev. Lett. 88, 217206 (2002))*. This paramagnetic moment has been shown to depend critically on the crystalline structure. Thus, there is a

need to characterize and classify the different ground states of 2D crystals. In addition to nanotori it is possible that fullerenes with high genus can be synthesized *(Terrones et al, New J. Phys. 5 (2003) 126).*

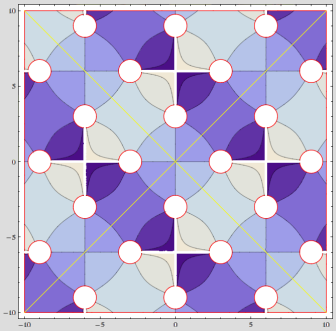


In this work, we classify the different ground states of crystalline order on closed, compact surfaces (without boundaries) of any genus. Our classification scheme is not based upon homotopy theory. We adopt foliation theory (ribbon graphs) *(Anton Zorich, eprint arXiv:math/0609392)* from dynamical systems, and extend the idea of Dehn twist to tori and higher genus surfaces with crystalline order. To classify such crystalline surfaces (with and without topological defects) a unique ribbon graph represents a given crystalline configuration of fullerenes with arbitrary genus. The ribbon graph also provides a mechanism by which one can generate a class of distinct ground states.

- Phases, morphologies, and transitions in a mathematical model for the endoplasmic reticulum: *with Rahul Pandit (IISc), Yashodhan Hatwalne (RRI)*
  Manuscript in preparation.



Recent experimental studies on the rough endoplasmic reticulum in cells indicate the presence of screw dislocations. We propose that the pressure is reponsible for inducing screw dislocations in endoplasmic reticulum. Critical pressure to induce nucleation of single dislocation and a centered square lattice of oppositely charged screw dislocations are estimated in linear theory. Further we investigate the effect of non-linearity on the phase diagram, numericaly, using Surface Evolver code. A detailed phase diagram with tubules, fenestrations, lattice of holes and the screw dislocation lattice are being explored.

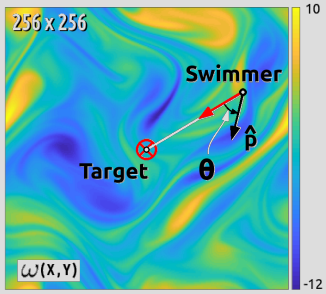


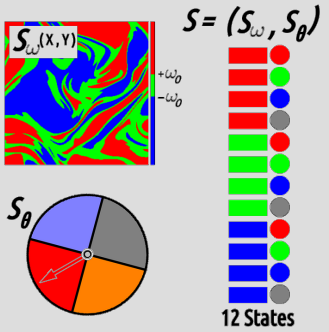
- Economy of academic research: *with Rahul Pandit (IISc)*
  Work in progress (Funded by DST).

We investigate the economy of academic research by studying different models of funding agencies across countries. We use Scientometric and econometric measures to compare and rank the performance of research organizations of the different countries. Our goal is to detect economic factors that affect the academic output efficiency.

- Machine learning in turbulent flows: *with Rahul Pandit (IISc) and Jeremie Bec (Observatoire de la Côte d'Azur)* Manuscript in preparation.

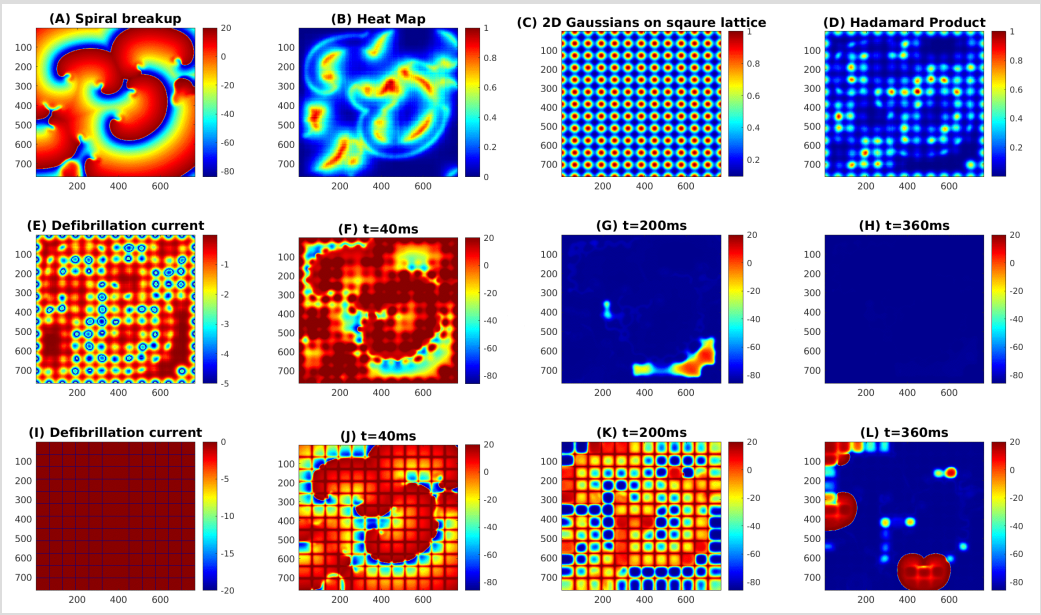
We explore the prospect of using machine-learning methods to optimize the transport properties of passive self-propelled Lagrangian particles in homogeneous isotropic turbulent flows. In particular, we use Q-learning, a form of reinforced machine-learning technique, to develop optimal schemes of propulsion to maximize the number of particles that arrive at a target in a fixed time. Preliminary results on arrival time statistics show that the performance of Q-learning depends on the period in which the learning is operational. If the Q-learning and particle evolution are initiated simultaneously, for short time scales the rate of particle arrival at the target is higher than the naive strategy; but this scheme performs poorly in comparison to the naive strategy over long time scales. On the other hand, we observe for a few numerical trials, that the particle arrival rate can be enhanced by delayed learning or re-initializing the Q-matrix at later times.





- Machine learning to control spatio-temporal chaos in cardiac arrhythmia: *with Rahul Pandit (IISc)*
  Manuscript in preparation.

The aim of developing a low amplitude defibrillation scheme to eliminate pathological waves, in the heart, is of central interest in the clinical field. In this article, we report that, we make use of the deep learning technique such as the convolution neural network (CNN) to train all possible wave solutions in an excitable media to accurately detect spiral and non-spiral waves. Furthermore, we utilise the trained CNN model to generate a heat map of positions of spiral core/cores in spiral waves/broken spiral waves which is central to our new defibrillation scheme. Using the positions of spiral core we can eliminate the local spiral waves by applying a local defibrillation current of 2D Gaussian profile in a squarre lattice. With our new scheme, we report that, we have successfully eliminated broken spiral waves in silico.



Research Interests

- Geometry and Topology in Physics.
- Machine Learning.
- Statistics.
- Soft-condensed matter.
- Statistical mechanics.
- Geometry in Computer Vision.

Courses graded

- **Computer vision** (E1 216) in 2004.
- **Advanced statistical mechanics** (PH 325) in 2016, 2017.
- **Modern topics in condensed matter** (PH 335) in 2017.

Computer Skills

Programming Languages: C, C++, Matlab, Mathematica, Surface Evolver, Blender, Python, QT, html, Latex.

Program developments: Android, Raspberry-Pi, artificial intelligence and image processing, robotics, 3D graphics, 2D and 3D game development, serial and parallel port interface, camera interface, Flash based webdesign and animation, data visualization.

Spoken languages

Tamil	Native	Spoken
English	12^{th} grade	Read, Write, Spoken
Kannada	12^{th} grade	Read, Write, Spoken
Hindi	12^{th} grade	Read, Write, Spoken
Tulu		Spoken

References:

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Prof. Samuel Joseph
Theoretical Physics Group
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