THE INSTITUTE OF MATHEMATICAL SCIENCES
TARAMANI, CHENNAI 600 113.

Quarterly Report
October 2017 - December 2017

Research Highlights:-

Representation Theory:-

In a classic paper of 1950, Gelfand and Tsetlin, constructed certain distinguished bases for representations of the Lie algebras of traceless matrices. These Lie algebras and their representations are of great importance in particle physics and in many other areas of science and engineering. This work spawned a vast body of research over the last 60 years.

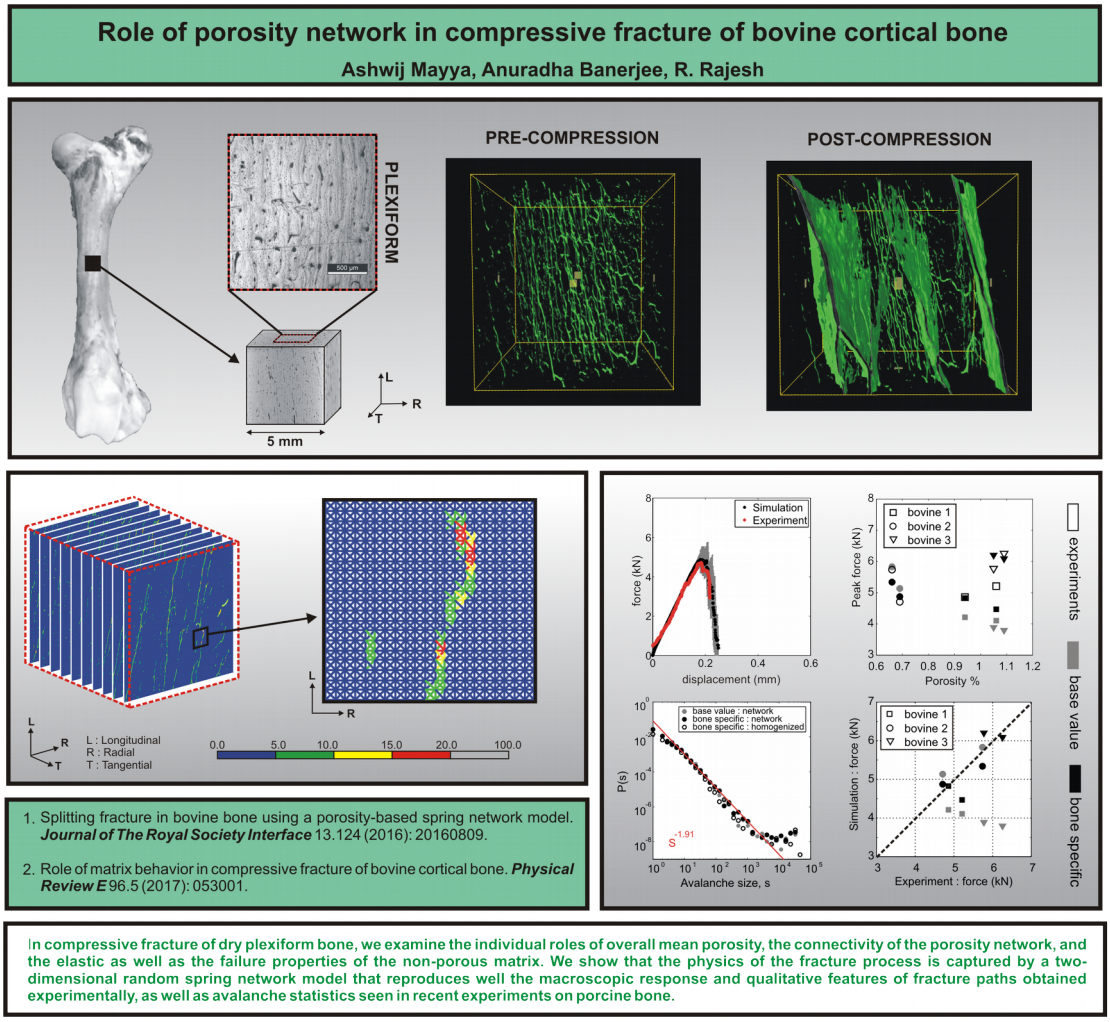
The combinatorial objects parametrizing these bases are well known as "GT partterns" or just "patterns" (GT stands for Gelfand-Tsetlin). In the early 2000s, Chari, Pressley and Loktev obtained bases for representations of current algebras (associated to Lie algebras of traceless matrices), by extending the Gelfand-Tsetlin construction. Recent work done in the mathematics group at IMSc (K N Raghavan, B. Ravinder and S. Viswanath, Journal of Combinatorial Theory A, 2018 (to appear)) provides a fresh perspective on these new bases, realizing them in a manner that is closer in spirit to the original Gelfand-Tsetlin point of view.

Specifically, a new combinatorial idea, namely that of a "partition overlay" on a GT pattern is introduced. Partition overlaid patterns parametrize the new bases just as patterns parametrized the old bases.

The clarity thus brought to the topic allowed the formulation of some interesting conjectures about the asymptotic stability properties of the new bases. The conjectures have since been proved by B. Ravinder (preprint, 2017) a former doctoral student at IMSc and now an INSPIRE Faculty Fellow at CMI.

Biological Physics:-

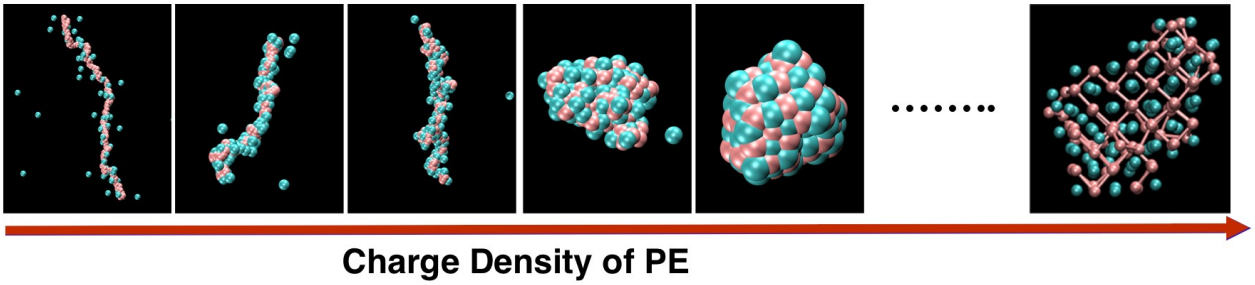
Cortical or compact bone, found in the midshaft of load-bearing bones such as femurs and tibiae, is a brittle, porous biomaterial. Being a living tissue, the local microstructure and porosity network of the cortical bone evolves in response to the mechanical stresses to which the bone is subjected, and this in turn modifies the local mechanical properties. Under-standing the relationship between microstructure and mechanical properties is crucial for applications such as the extraction of bone grafts, in designing mechanically compatible im-plants and porous scaffolds for bone tissue engineering, in order to interpret loading history, evaluate the effectiveness of chemical and physical therapeutical measures for bone healing etc. An important aspect of this understanding is the development and testing of mod-els that incorporate microstructural features and predict material properties such as failure strength, elastic modulus, fracture paths, etc. Such models, if general enough, would also be of use in understanding failure behavior of a wider class of brittle materials with a well-defined porosity network, such as wood, rock, etc. We develop and test a discrete porosity based model that captures the physics of the fracture process of the bone and reproduces well the macroscopic response and qualitative features of experimentally obtained fracture paths, as well as avalanche statistics seen in experiments on porcine bone.



Results on Charged Polymers:-

In chemical, pharmaceutical, food and bio- industries, applications such as gene therapy, drug coating, water purification, colour removal, paper making etc., involve charged polymers in solution. The mechanical and chemical properties of these polymers depend on their conformational state which could be linear and extended, compact and collapsed or in the form of complex aggregates. The precise role of electric charge in determining the conformational properties is clarified through a combinational of large scale simulations and theoretical modelling.

1. Aggregation of flexible polyelectrolytes: Phase diagram and dynamics, A. M. Tom, R.Rajesh and S. Vemparala, The Journal of Chemical Physics, 147, 144903, 2017.
2. Regimes of strong electrostatic collapse of a highly charged polyelectrolyte in a poor solvent, A. M. Tom, S. Vemparala, R. Rajesh and N. V. Brilliantov, Soft Matter, 13,1862, 2017.
3. Mechanism of chain collapse of strongly charged polyelectrolytes, A. M. Tom, S. Vemparala, R. Rajesh and N. V. Brilliantov, Physical Review Letters, 117,147801, 2016.
4. Aggregation Dynamics of Rigid Polyelectrolytes, A. M. Tom, R. Rajesh and S. Vemparala, The Journal of Chemical Physics, 144, 034904, 2016.



Outreach Highlights:-

"Ganita Kaanagam" for school children : 23rd October 2017

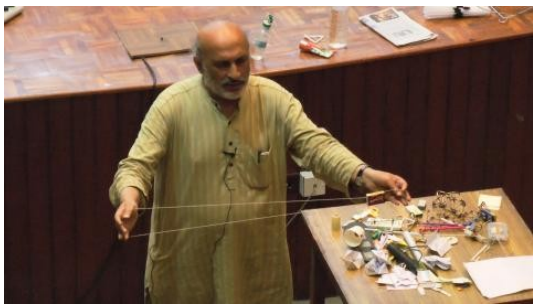
For the first time, the outreach program by IMSc for school children was conducted entirely in Tamil. The workshop was for students of classes VIII-XII from local government and corporation schools. To help students engage with the topics interactively, the program included mathematical activities conducted by IMSc members. About 125 students attended the program.

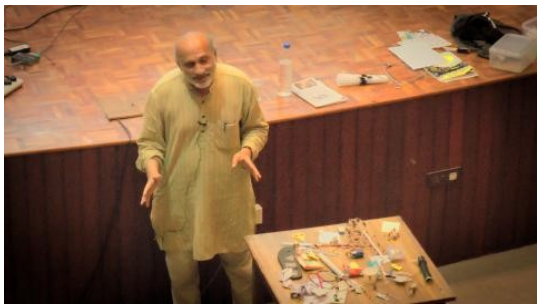
Organizer: Amritanshu Prasad

Activities handled: Sushmita V, Ramanathan Thinniyam, Janaki Raghavan, Anand Pathak, GArun Kumar, Madhusudhan Raman, Karthick Babu

Speakers: Athmaraman Rajaratnam (Retired Headmaster), G. Youvaraj (Ramanujan Institute for Advanced Study in Mathematics, University of Madras), S.P. Suresh (Chennai Mathematical Institute)

Science Fun, Science Toys: 2nd November 2017





Arvind Gupta (http://www.arvindguptatoys.com/)

Arvind Gupta is a toy inventor and popularizer of science for kids. An IIT-Kanpur graduate, he has been working since 1975 on innovative ways to teach and learn science. The talk was accompanied by demonstration of simple toys that he moulds out of trash and everyday goods to simplify the complex concepts of gravity, magnetic eld, friction, electricity, Newtonian laws among several other things. The talk was well attended, with students from CMI and IITM as well. The talk was followed by a discussion about how these toys could be used as educational aids with active participation from the audience.

Scientists and school education: A discussion: 24th November 2017

Krishna Kumar Visiting Fellow, MIDS, Chennai; Formerly Professor, Delhi University and Director, NCERT.

A discussion with Professor Krishna Kumar, an eminent educationist and scholar, will centred around: Can disciplinary researchers contribute meaningfully to school education? Should they? Over the course of the discussion, Prof. Krishna Kumar drew from his experience as the Director of NCERT to elucidate the what scientists can do to contribute to school curriculum and education.

Teachers' Enrichment Program: 27th November – 2nd December 2017

This week-long workshop was aimed at mathematics teachers in Enginneering colleges, to enable them to revisit and update content knowledge. Discussion hours offered opportunities to get doubts cleared and work out exercises (both routine and advanced). About 65 teachers were selected from about 200 applicants. This program was part of IMSc's Enriching Collegiate Education (ECE) series of workshops as an effort to facilitate interactions between research mathematicians and college teachers. Teachers routinely report that they find the program very helpful and are eager to participate in more such events. The workshop was held as a Teacher's Enrichment Workshop, a series co-sponsored by the National Centre for Mathematics (NCM).

Organizers: Anirban Mukhopadhyay, K. Srinivas

Speakers: S. Kesavan (IITM), K. N. Raghavan, P. Sankaran, K. Srinivas

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