The Fourth

BRICS Mathematics Conference

CMIT

Club of Mathematics IISER Thiruvananthapuram

Information Brochure

Indian Institute of Science Education and Research
Thiruvananthapuram. Kerala, India 695551

IISER THIRUVANANTHAPURAM

BML MUNJAL UNIVERSITY™
A Hero GROUP INITIATIVE

ABOUT BRICS

The BRICS, associated with the five major emerging economies: Brazil, Russia, India, China and South Africa, represents countries that are known for their significant influence on regional affairs, and thus the annual BRICS Mathematics Conference is an excellent platform for an international-level academic collaboration.

With an aim to strengthen cooperation and exchanges in the field of mathematics among these five countries, the BRICS Mathematics Conference was launched in 2016, with its first three editions in China (2017), Brazil (2018) and Russia (2019). The fourth edition of this conference in 2021 will be held at IISER Thiruvananthapuram in a hybrid (online + offline) mode during December 07th to 10th, featuring 15 plenary talks, three from each of the five BRICS nations, 21 invited talks, and several contributed talks in Pure & Applied Mathematics and Probability & Statistics.

The Fourth
BRICS
Mathematics
Conference

https://conference.iisertvm.ac.in/bricsmathconf/

ABOUT IISER TVM

Established in 2008 by the Ministry of Human Resource and Development (MHRD), the Indian Institute of Science Education and Research (IISER) Thiruvananthapuram is a premier autonomous institution dedicated to advancing science education and research of global standards. The institute is devoted to contemporary pure and interdisciplinary research and offers ample opportunities for the holistic development of young scientists imbued with the spirit of scientific enquiry. World-class infrastructure for cutting-edge scientific research makes it the best choice for arousing curiosity and fostering intricate questions in natural and mathematical sciences. With a sprawling 200 acre campus nestled amongst the forests and foothills of the serene Western Ghats, we are one of India's finest research institutes. The picturesque and luscious green campus provides an ideal environment for young minds to live, learn and grow.

IISER THIRUVANANTHAPURAM

https://www.iisertvm.ac.in/

BML MUNJAL UNIVERSITY™
A Hero GROUP INITIATIVE

https://www.bmu.edu.in/

GENERAL INSTRUCTIONS

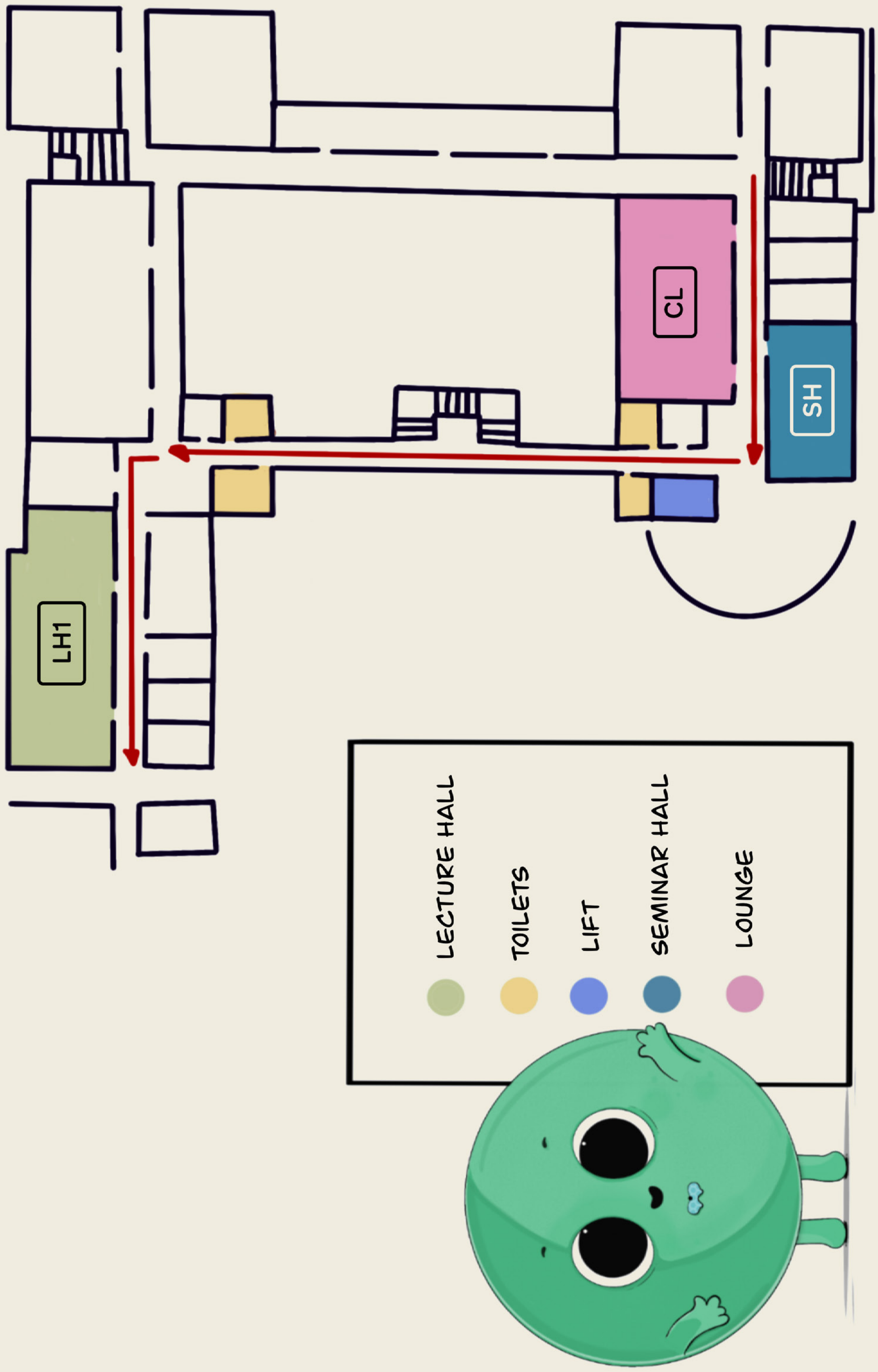
- All talks will be held in hybrid mode at the Seminar Hall (**SH**) and Lecture Halls (**LH1** and **LH2**) located at the Chemical Sciences Block.
- All the offline talks will be streamed on the corresponding zoom room of the hall, and all online talks will be projected at the halls for offline participants.
- Breakfast, lunch and dinner will be served for offline participants at the Visitors' Forest Retreat (**VFR**). Tea / coffee will be served at the Conference Lounge (**CL**) in the Chemical Sciences Block during tea breaks.
- Login credentials will be provided to each offline participant to connect to the campus WiFi during their stay during the conference days.
- Every offline participant will be provided with a conference badge. Kindly wear it at all times for convenience sake.

- Masks should be worn properly at all times.
- Sanitizer dispensers will be placed outside each hall. Kindly sanitize your hands before entering the halls.
- Maintain physical distancing at all places and at all times.
- Everyone is expected to strictly follow the COVID protocols.

CAMPUS MAP

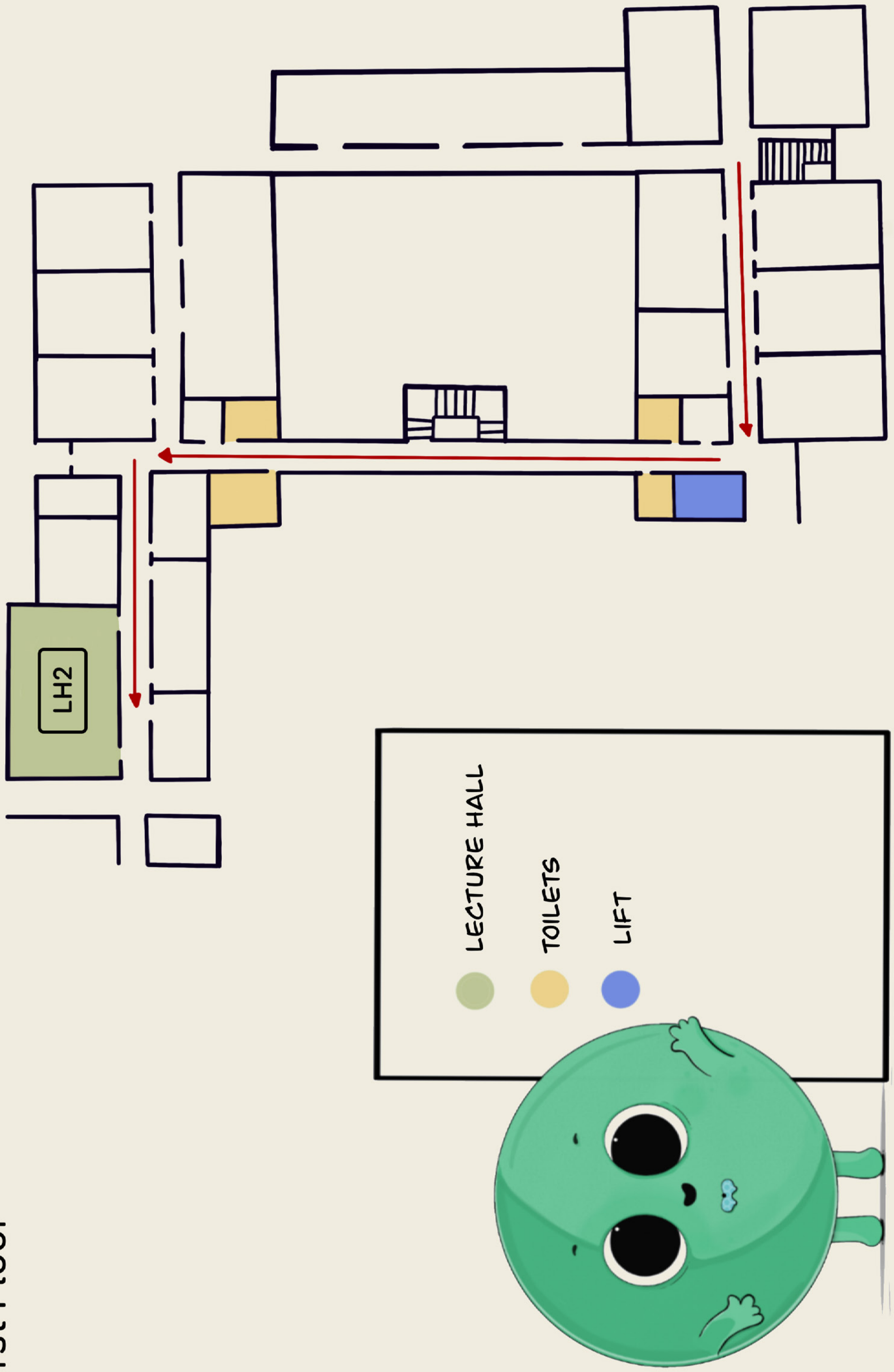
1. Campus Entrance
2. Visitors' Forest Retreat (VFR)
3. Students' Library
4. SBI ATM
5. Restaurant
6. Bus Stop
7. Central Dining Hall
8. Student Lounge and Cafe
9. Physical and Mathematical Sciences Block
10. Chemical Sciences Block (CSB) / Conference venue
11. Biological Sciences Block
12. Students' Hostel area
13. Medical Center
14. General Store

CONFERENCE VENUE



Chemical Sciences Block
Second Floor

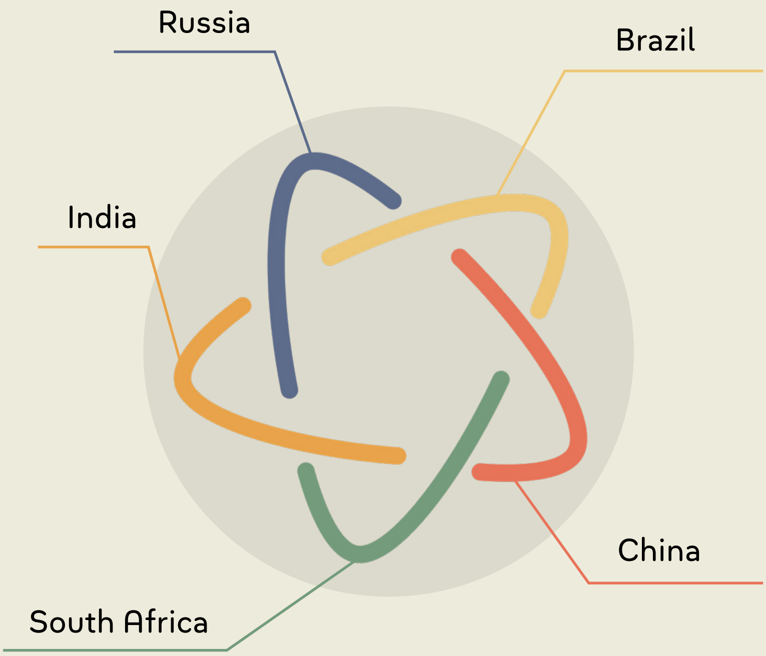
CONFERENCE VENUE



Chemical Sciences Block
First Floor

SCHEDULE GUIDE

Country colour codes for Plenary Talks:



Colour codes for other talks:

(green)	Pure Mathematics
(purple)	Applied Mathematics
(orange)	Probablity and statistics
(pink)	Public Lecture
●●●	Plenary Talk
●●	Invited Talk
●	Contributed Talk

LH1	Lecture Hall I
LH2	Lecture Hall II
SH	Seminar Hall
VFR	Visitors' Forest Retreat
CL	Conference Lounge

Each offline event will be streamed to a corresponding Zoom room for all days of the conference. Online participants can be part of the talks by joining us through Zoom.

The room addresses are as follows:

SH	Zoom Room	Meeting ID: 97813713398	Passcode: *euler*
LH1	Zoom Room	Meeting ID: 99035263967	Passcode: *euler*
LH2	Zoom Room	Meeting ID: 99643222868	Passcode: *euler*

DAY 01 / 07TH DECEMBER

TIME	Track I	Track II	Track III
IST 07:45am - 08:30am BRT 11:15am - 12:00am MSK 05:15am - 06:00am CST 10:15am - 11:00am SAST 04:15am - 05:00am	Breakfast VFR		
IST 08:30am - 09:00am BRT 12:00am - 12:30am MSK 6:00am - 6:30am CST 11:00am - 11:30am SAST 5:00am - 5:30am	Inaugural Function SH		
IST 09:00am - 09:45am BRT 12:30am - 01:15am MSK 06:30am - 07:15am CST 11:30am - 12:15pm SAST 05:30am - 06:15am	Meena Mahajan ●●● SH		
IST 09:55am - 10:25am BRT 01:25am - 01:55am MSK 07:25am - 07:55am CST 12:25pm - 12:55pm SAST 06:25am - 06:55am	Siva Athreya ●● LH2	Dipendra Prasad ●● SH	A. K. Pani ●● LH1
IST 10:35am - 10:55am BRT 02:05am - 02:25am MSK 08:05am - 08:25am CST 01:05pm - 01:25pm SAST 07:05am - 07:25am	Tea Time CL		
IST 11:00am - 11:20am BRT 02:30am - 02:50am MSK 08:30am - 08:50am CST 01:30pm - 01:50pm SAST 07:30am - 07:50am	Vineesh Kumar ● LH2	Rakhi Pratihar ● SH	Gopikrishnan C. Remesan ● LH1
IST 11:25am - 12:10pm BRT 02:55am - 03:40am MSK 08:55am - 09:40am CST 01:55pm - 02:40pm SAST 07:55am - 08:40am	Jun Li ●●● SH		
IST 12:20pm - 12:40pm BRT 03:50am - 04:10am MSK 09:50am - 10:10 am CST 02:50pm - 03:10pm SAST 08:50am - 09:10am	Yogesh Prajapaty ● SH	Aswin V. S. ● LH2	Imtiaz Hussain ● LH1
IST 12:45pm - 02:15pm BRT 04:15am - 05:45am MSK 10:15am - 11:45am CST 03:15pm - 04:45pm SAST 09:15am - 10:45am	Lunch VFR		
IST 02:20pm - 03:05pm BRT 05:50am - 06:35am MSK 11:50 am - 12:35pm CST 04:50pm - 05:35pm SAST 10:50am - 11:35am	A. I. Bufetov ●●● SH		
IST 03:15pm - 03:45pm BRT 06:45am - 07:15am MSK 12:45pm - 01:15pm CST 05:45pm - 06:15pm SAST 11:45am - 12:15pm	Manjunath Krishnapur ●● LH2	Apoorva Khare ●● SH	Venky Krishnan ●● LH1
IST 03:55pm - 04:55pm BRT 07:25am - 08:25am MSK 01:25pm - 02:25pm CST 06:25pm - 07:25pm SAST 12:25pm - 01:25pm	M. S. Raghunathan SH		

DAY 01 / 07TH DECEMBER

TIME	Track I	Track II	Track III
IST 05:05pm - 05:25pm BRT 08:35am - 08:55am MSK 02:35pm - 02:55pm CST 07:35pm - 07:55pm SAST 01:35pm - 01:55pm	Tea Time CL		
IST 05:25pm - 06:10pm BRT 08:55am - 09:40am MSK 02:55pm - 03:40pm CST 07:55pm - 08:40pm SAST 01:55pm - 02:40pm	●●● Luna Lomonaco SH		
IST 06:20pm - 06:50pm BRT 09:50am - 10:20am MSK 03:50pm - 04:20pm CST 08:50pm - 09:20pm SAST 02:50pm - 03:20pm	●● Bruce Watson SH		
IST 07:00pm - 07:45pm BRT 10:30am - 11:15am MSK 04:30pm - 05:15pm CST 09:30pm - 10:15pm SAST 03:30pm - 04:15pm	●●● Sudan Hansraj SH		
IST 08:00pm BRT 11:25am MSK 05:25pm CST 10:25am SAST 04:25pm	Dinner VFR		

DAY 02 / 08TH DECEMBER

TIME	Track I	Track II	Track III
IST 08:00am - 09:00am BRT 11:30pm - 12:30am MSK 05:30am - 06:30am CST 10:30am - 11:30am SAST 04:30am - 05:30am	Breakfast (VFR)		
IST 09:00am - 09:45am BRT 12:30am - 01:15am MSK 06:30am - 07:15am CST 11:30am - 12:15pm SAST 05:30am - 06:15am	●●● Ya-Xiang Yuan (SH)		
IST 09:55am - 10:25am BRT 01:25am - 01:55am MSK 07:25am - 07:55am CST 12:25pm - 12:55pm SAST 06:25am - 06:55am	●● Parthanil Roy (LH2)	●● Amalendu Krishna (SH)	●● K. Sreenadh (LH1)
IST 10:35am - 10:55am BRT 02:05am - 02:25am MSK 08:05am - 08:25am CST 01:05pm - 01:25pm SAST 07:05am - 07:25am	Tea Time (CL)		
IST 11:00am - 11:20am BRT 02:30am - 02:50am MSK 08:30am - 08:50am CST 01:30pm - 01:50pm SAST 07:30am - 07:50am	● Aditya Tiwari (SH)	● Asha Dond (LH2)	● Sneha Gupta (LH1)
IST 11:25am - 12:10pm BRT 02:55am - 03:40am MSK 08:55am - 09:40am CST 01:55pm - 02:40pm SAST 07:55am - 08:40am	●●● A. V. Arutyunov (SH)		
IST 12:20pm - 12:40pm BRT 03:50am - 04:10am MSK 09:50am - 10:10 am CST 02:50pm - 03:10pm SAST 08:50am - 09:10am	● Alok Kumar Sahoo (LH2)	● Sunil Joshi (SH)	● Bijaya Laxmi Panigrahi (LH1)
IST 12:45pm - 02:15pm BRT 04:15am - 05:45am MSK 10:15am - 11:45am CST 03:15pm - 04:45pm SAST 09:15am - 10:45am	Lunch (VFR)		
IST 02:20pm - 03:05pm BRT 05:50am - 06:35am MSK 11:50 am - 12:35pm CST 04:50pm - 05:35pm SAST 10:50am - 11:35am	●●● Rajendra Bhatia (SH)		
IST 03:15pm - 03:45pm BRT 06:45am - 07:15am MSK 12:45pm - 01:15pm CST 05:45pm - 06:15pm SAST 11:45am - 12:15pm	●● Srikanth Srinivasan (SH)	●● Amit Apte (LH1)	
IST 03:55pm - 04:55pm BRT 07:25am - 08:25am MSK 01:25pm - 02:25pm CST 06:25pm - 07:25pm SAST 12:25pm - 01:25pm	Rajeeva Karandikar (SH)		

DAY 02 / 08TH DECEMBER

TIME		Track I	Track II	Track III
IST BRT MSK CST SAST	05:05pm - 05:25pm 08:35am - 08:55am 02:35pm - 02:55pm 07:35pm - 07:55pm 01:35pm - 01:55pm	Tea Time CL		
IST BRT MSK CST SAST	05:25pm - 06:10pm 08:55am - 09:40am 02:55pm - 03:40pm 07:55pm - 08:40pm 01:55pm - 02:40pm	Inger Fabris-Rotelli ••• SH		
IST BRT MSK CST SAST	07:00pm - 07:45pm 10:30am - 11:15am 04:30pm - 05:15pm 09:30pm - 10:15pm 03:30pm - 04:15pm	Hedibert Lopes ••• SH		
IST BRT MSK CST SAST	08:00pm 11:25am 05:25pm 10:25am 04:25pm	Dinner VFR		

DAY 03 / 09TH DECEMBER

TIME	Track I	Track II	Track III
IST 08:00am - 09:00am BRT 11:30pm - 12:30am MSK 05:30am - 06:30am CST 10:30am - 11:30am SAST 04:30am - 05:30am	Breakfast VFR		
IST 09:00am - 09:45am BRT 12:30am - 01:15am MSK 06:30am - 07:15am CST 11:30am - 12:15pm SAST 05:30am - 06:15am	Arup Bose ●●● SH		
IST 09:55am - 10:25am BRT 01:25am - 01:55am MSK 07:25am - 07:55am CST 12:25pm - 12:55pm SAST 06:25am - 06:55am	Riddhipratim Basu ●● LH2	Neena Gupta ●● SH	
IST 10:35am - 10:55am BRT 02:05am - 02:25am MSK 08:05am - 08:25am CST 01:05pm - 01:25pm SAST 07:05am - 07:25am	Tea Time CL		
IST 11:00am - 11:20am BRT 02:30am - 02:50am MSK 08:30am - 08:50am CST 01:30pm - 01:50pm SAST 07:30am - 07:50am	Lokesh Singh ● LH1	Dharm Veer ● SH	Nick Hale ● LH2
IST 11:25am - 12:10pm BRT 02:55am - 03:40am MSK 08:55am - 09:40am CST 01:55pm - 02:40pm SAST 07:55am - 08:40am	Xiaoyun Wang ●●● SH		
IST 12:20pm - 12:40pm BRT 03:50am - 04:10am MSK 09:50am - 10:10 am CST 02:50pm - 03:10pm SAST 08:50am - 09:10am	Renu Joshi ● LH1	Anu Rani ● LH2	Sagnik Saha ● SH
IST 12:45pm - 02:15pm BRT 04:15am - 05:45am MSK 10:15am - 11:45am CST 03:15pm - 04:45pm SAST 09:15am - 10:45am	Lunch VFR		
IST 02:20pm - 03:05pm BRT 05:50am - 06:35am MSK 11:50 am - 12:35pm CST 04:50pm - 05:35pm SAST 10:50am - 11:35am	Andrey Mironov ●●● SH		
IST 03:15pm - 03:45pm BRT 06:45am - 07:15am MSK 12:45pm - 01:15pm CST 05:45pm - 06:15pm SAST 11:45am - 12:15pm	Parameswaran Sankaran ●● SH		
IST 03:55pm - 04:15pm BRT 07:25am - 07:45am MSK 01:25pm - 01:45pm CST 06:25pm - 06:45pm SAST 12:25pm - 12:45pm	Anirban Chakraborti ● SH	Akhlaq Husain ● LH1	

DAY 03 / 09TH DECEMBER

TIME		Track I	Track II	Track III
IST BRT MSK CST SAST	05:05pm - 05:25pm 08:35am - 08:55am 02:35pm - 02:55pm 07:35pm - 07:55pm 01:35pm - 01:55pm	Tea Time CL		
IST BRT MSK CST SAST	05:25pm - 06:10pm 08:55am - 09:40am 02:55pm - 03:40pm 07:55pm - 08:40pm 01:55pm - 02:40pm	●●● Paulo José da Silva e Silva SH		
IST BRT MSK CST SAST	06:20pm - 06:50pm 09:50am - 10:20am 03:50pm - 04:20pm 08:50pm - 09:20pm 02:50pm - 03:20pm	●● Sanoli Gun SH		
IST BRT MSK CST SAST	07:00pm - 07:45pm 10:30am - 11:15am 04:30pm - 05:15pm 09:30pm - 10:15pm 03:30pm - 04:15pm	●●● Zurab Janelidze, Amartya Goswami SH		
IST BRT MSK CST SAST	08:00pm 11:25am 05:25pm 10:25am 04:25pm	Dinner VFR		

DAY 04 / 10TH DECEMBER

TIME	Track I	Track II	Track III
IST 08:00am - 09:00am BRT 11:30pm - 12:30am MSK 05:30am - 06:30am CST 10:30am - 11:30am SAST 04:30am - 05:30am	Breakfast VFR		
IST 09:00am - 09:20am BRT 12:30am - 12:50am MSK 06:30am - 06:50am CST 11:30am - 11:50am SAST 05:30am - 05:50am	Swapnil Tripathi LH1	Komma Patali SH	Harshita Madduri LH2
IST 09:25am - 09:45am BRT 12:55am - 01:15am MSK 06:55am - 07:15am CST 11:55am - 12:15pm SAST 05:55am - 06:15am	Pasupulati Sunil Kumar LH1	Suhith K. N. LH2	Mitra Koley SH
IST 09:50am - 10:10am BRT 01:20am - 01:40am MSK 07:20am - 07:40am CST 12:20pm - 12:40pm SAST 06:20am - 06:40am	Adittya Chaudhuri SH	Wasim Akram LH2	Subham Bhakta LH1
IST 10:15am - 10:45am BRT 01:45am - 02:15am MSK 07:45am - 08:15am CST 12:45pm - 01:15pm SAST 06:45am - 07:15am	Tea Time CL		
IST 10:50am - 11:10am BRT 02:20am - 02:40am MSK 08:20am - 08:40am CST 01:20pm - 01:40pm SAST 07:20am - 07:40am	A. Akilandeeswari LH1	Haritha C. SH	Anumol Joseph LH2
IST 11:15am - 11:35am BRT 02:45am - 03:05am MSK 08:45am - 09:05am CST 01:45pm - 02:05pm SAST 07:45am - 08:05am	Pankaj Dey SH	Ruma Maity LH2	Saipriya Dubey LH1
IST 11:40am - 12:00pm BRT 03:10am - 03:30am MSK 09:10am - 09:30am CST 02:10pm - 02:30pm SAST 08:10am - 08:30am	Pankaj Kumar Manjhi SH	Sweta Sinha LH1	
IST 12:45pm - 02:15pm BRT 04:15am - 05:45am MSK 10:15am - 11:45am CST 03:15pm - 04:45pm SAST 09:15am - 10:45am	Lunch VFR		
IST 08:00pm BRT 11:25am MSK 05:25pm CST 10:25am SAST 04:25pm	Dinner VFR		

Artless Innocents and Ivory Tower Sophisticates: Some Personalities on the Indian Mathematical Scene

M. S. Raghunathan

Centre for Basic Sciences

Role of Statistics in the era of BigData, Analytics and Data Science

Rajeeva Laxman Karandikar

Chennai Mathematical Institute

Abstract

Statistics evolved as a science in an era where the amount of data available was small and efforts were on to extract maximum actionable intelligence out of the available data. Is it still relevant in the era of BigData?

We will illustrate via examples that while some techniques may no longer be relevant, several concepts developed during the past 150 years in statistics are as relevant in this era as they were then, and ignoring them can lead to serious errors.

The complexity of formal proofs

Meena Mahajan

The Institute of Mathematical Sciences, Chennai

Abstract

In a logical calculus, one starts with a few initial tautologies and axioms of some simple form, and uses specific inference rules to derive more complex tautologies. The derivation itself is thus a proof of the final statement. A good proof is not too long and is not too hard to verify. Proof complexity formalises such calculi and proof systems, and analyses the structure and the length of derivations. It is intimately connected to fundamental questions in computational complexity. This talk will describe some ideas that have proved useful in designing short proofs, and some techniques that have been used to show that in certain settings, short proofs do not exist.

Bit-based cryptanalysis on hash functions

Xiaoyun Wang

Tsinghua University

Abstract

Cryptographic hash function is one of the three basic cryptographic primitives (encryption, digital signature and hash function). It is not only the key technique of digital signatures, MACs (Message Authentication Codes) and many provably secure cryptosystems, but also a building block of enormous real-world cryptographic applications including SSL/TLS, IPsec, WPA2, X.509 certificate, blockchain etc. A cryptographic hash function takes the message with any length (usually less than 2128-bits) as input and produces a short hash value with 256, 384, or 512 bits etc. (also named digital digest or digital fingerprint). A sure hash function should satisfy three important requirements(collision-free, second preimage resistance, preimage resistance). The collision-free means that it is computationally hard to find two different messages corresponding to the same hash value which will cause the terrible occurrence of two different messages corresponding to the same signature. In this talk, I will present a series of powerful cryptanalysis methods for hash functions, especially bit-based modular differential cryptanalysis. These methods showed the fatal weaknesses of the widely deployed MD5 and SHA-1 before 2005. The work also promoted the replacement of SHA-1 with SHA-2, and the development of new-generation of cryptographic hash functions including SHA-3, SM3 etc.

Determinantal Point Processes: Quasi-symmetries and Interpolation

Alexander Igorevich Bufetov
The Steklov Institute of Mathematics

Abstract

The study of point processes, that is, random subsets of a Polish space, goes back at least to the 1662 work of John Graunt on mortality in London. Matrices whose entries are given by chance were studied by Ronald Fisher in 1915 and John Wishart in 1928 and used by Freeman Dyson who in 1962 observed that "the statistical theory (...) will describe the degree of irregularity (...) expected to occur in any nucleus".

The Weyl character formula implies that the correlation functions for the eigenvalues of a Haar-random unitary matrix have determinantal form — the Ginibre-Mehta theorem, — and in 1973 Odile Macchì started the systematic study of point processes whose correlation functions are given by determinants.

This level of abstraction has proved very fruitful: on the one hand, examples of determinantal point processes arise in diverse areas such as asymptotic combinatorics (Burton-Pemantle, Benjamini-Lyons-Peres-Schramm, Baik-Deift-Johansson, Borodin-Okounkov-Olshanski), representation theory of infinite-dimensional groups (Olshanski, Borodin-Olshanski), random series (Hough-Krishnapur-Peres-Virág) and, of course, random matrices; on the other hand, the general theory of determinantal point processes includes limit theorems (Soshnikov), a characterization of Palm measures (Shirai-Takahashi), the Kolmogorov as well as the Bernoulli property (Lyons, Lyons-Steif), and rigidity (Ghosh, Ghosh-Peres).

In this talk, the correlation kernels of our determinantal point processes will be assumed to induce orthogonal projections: for example, the sine-kernel of Dyson induces the projection onto the Paley-Wiener space of functions whose Fourier transform is supported on the unit interval, while the Bessel kernel of Tracy and Widom induces the orthogonal projection onto the subspace of square-integrable functions whose Hankel transform is supported on the unit interval.

What is the relation between the point process and the Hilbert space that governs it?

Extending the earlier work of Lyons and Ghosh, in joint work with Qiu and Shamov, it is proved that almost every realization of a determinantal point process is a uniqueness set for the underlying Hilbert space. For the sine-process, almost every realization with one particle removed is a complete and minimal set for the Paley-Wiener space, whereas if two particles are removed, then one obtains a zero set for the Paley-Wiener space. Quasi-invariance of the sine-process under compactly supported diffeomorphisms of the line plays a key role.

The 1933 Kotelnikov theorem samples a Paley-Wiener function from its restriction onto the integers. How to reconstruct a Paley-Wiener function from a realization of the sine-process?

In joint work with Borichev and Klimenko, it is proved that if a Paley-Wiener function decays at infinity as a sufficiently high negative power of the distance to the origin, then the Lagrange interpolation formula yields the desired reconstruction. Similar results are also obtained for the Airy kernel, the Bessel kernel, and the Ginibre kernel of orthogonal projection onto the Fock space.

In joint work with Qiu, the Patterson-Sullivan construction is used to interpolate Bergman functions from a realization of the determinantal point process with the Bergman kernel, in other words, by the Peres-Virág theorem, the zero set of a random series with independent complex Gaussian entries. The invariance of the zero set under the isometries of the Lobachevsky plane plays a key role.

Mating quadratic maps with the modular group

Luna Lomonaco

University of São Paulo

Abstract

Holomorphic correspondences are polynomial relations $P(z, w) = 0$, which can be regarded as multi-valued self-maps of the Riemann sphere, this is implicit maps sending z to w. The iteration of such a multi-valued map generates a dynamical system on the Riemann sphere: dynamical system which generalises rational maps and finitely generated Kleinian groups. We consider a specific 1-(complex)parameter family of $(2 : 2)$ correspondences F_a (introduced by S. Bullett and C. Penrose in 1994), which we describe dynamically. In particular, we show that for every parameter in a subset of the parameter plane called 'the connectedness locus' and denoted by M_Γ, this family behaves as rational maps on a subset of the Riemann sphere and as the modular group on the comple-

ment: in other words, these correspondences are mating between the modular group and rational maps (in the family Per_1(1)). Moreover, we develop for this family of correspondences a complete dynamical theory which parallels the Douady-Hubbard theory of quadratic polynomials, and we show that M_Γ is homeomorphic to the parabolic Mandelbrot set M_1.

This is joint work with S. Bullett (QMUL).

Mathematics of Gravity

Sudan Hansraj

University of KwaZulu-Natal

Abstract

We consider a brief history of developments over the past century in the area of gravitation. The seminal work of Einstein, namely his general theory of relativity propounded in 1915, opened new vistas of science that would exert a profound influence on the advance of humanity. What began as mathematical speculations in answering fundamental questions about the universe, the galaxies and stars has led to the development of novel technologies to verify a number of theoretical predictions experimentally in our time. The detection of gravitational waves and the photon sphere around black holes ushered in a new era of mathematical physics and for good reason earned Nobel recognition. But several questions remain unanswered. For example, what explains the observed accelerated expansion of the universe? The answers may lie in the area of experimental physics such as in finding support for the existence of dark matter and dark energy.

On the other hand, the answers may lie in, modifying the mathematical sector of Einstein's theory of relativity to incorporate higher curvature effects which can explain anomalous behaviour. These ideas will be contemplated in our talk. Additionally, we argue for the continued support to be given to fundamental investigations and groundbreaking mathematical discoveries at universities that can hold the key to unlocking an understanding of previously obscure scientific phenomena.

Least H^2-norm updating quadratic model for derivative-free trust region algorithms

Ya-Xiang Yuan

Academy of Mathematics and Systems Science,
Chinese Academy of Sciences)

Abstract

To be announced

Implicit Function Theorems and Abnormality

Aram Vladimirovich Arutyunov

Moscow State University

Abstract

We consider the equation $F(x, \sigma) = 0$, $x \in K$, with a parameter σ and unknown x which takes value in a given closed convex cone K in a Banach space X. This equation is studied in a neighbourhood of a given point (x_0, σ_0), for which the Robinson's regularity condition may not hold. We introduce a 2-regularity condition which is much weaker than the Robinson's condition and proves that the introduced regularity condition is sufficient for the existence of a continuous implicit function.

Matrix Analysis and Geometry

Rajendra Bhatia
Ashoka University

Abstract

In the past two decades, ideas from Riemannian geometry have been successfully employed in defining geometric means of positive definite matrices. These are of intrinsic interest in matrix analysis, and have several applications in diverse areas where the data points are positive definite matrices. The talk will be a gentle introduction to the problem and some of the results obtained.

An informal road detection neural network for societal impact in developing countries

Inger Fabris-Rotelli
The University of Pretoria

Abstract

Roads found in informal settlements arise out of convenience are often not recorded or maintained by authorities. This may cause issues with service delivery, sustainable development and crisis mitigation, including COVID-19. Therefore, the aim of extracting informal roads in remote sensing images is posed. Existing techniques aiming at the extraction of formal roads are not completely suitable for the problem due to the complex physical and spectral properties of informal roads pose. These complexities are due to their physical and spectral properties. The only existing approaches for informal roads, namely [2, 3], do not consider neural networks as a solution. Neural networks show promise in overcoming these complexities due to the way they learn through training. They require a large amount of data to learn, which is currently not available due to the expensive and time-consuming nature of collecting such data sets. We implement a neural network developed for formal roads to extract informal roads from a data set digitised by this research group. We consider a portion of the training data set and implement the GAN-UNet model that obtained the highest F1-score in a 2020 review paper [1] on the state-of-the-art deep learning models used to extract formal roads. The results obtained indicate that the model is able to extract informal roads successfully.

Decoupling shrinkage and selection in Gaussian linear factor analysis

Hedibert Freitas Lopes

Insper - Institute of Education and Research

Abstract

Factor analysis is a popular method for modelling dependence in multivariate data. However, determining the number of factors and obtaining a sparse orientation of the loadings are still major challenges. In this paper, we propose a decision-theoretic approach that brings to light the relation between a sparse representation of the loadings and factor dimension. This relation is done through a summary from information contained in the multivariate posterior. To construct such summary, we introduce a three-step approach. In the first step, the model is fitted with a conservative factor dimension. In the second step, a series of sparse point-estimates, with a decreasing number of factors, is obtained by minimizing an expected predictive loss function. In step three, the degradation in utility in relation to the sparse loadings and factor dimensions is displayed in the posterior summary. The findings are illustrated with applications in classical data from the Factor Analysis literature. We used different prior choices and factor dimensions to demonstrate the flexibility of the proposed method.

Spectral measures of empirical autocovariance matrices of high dimensional stationary processes

Arup Bose

Indian Statistical Institute, Kolkata

Abstract

Consider the empirical autocovariance matrix at a given non-zero time lag based on observations from a multivariate complex Gaussian stationary time series. We study the behaviour of their spectral measures in the asymptotic regime where the time series dimension and the observation window length both grow to infinity, and at the same rate. Following a general framework in the field of the spectral analysis of large random non-Hermitian matrices, at first the

probabilistic behaviour of the small singular values of the shifted versions of the autocovariance matrix are obtained. This is then used to infer about the large sample behaviour of the empirical spectral measure of the autocovariance matrices at any lag. Matrix orthogonal polynomials on the unit circle play a crucial role in our study.

To be announced

Jun Li
Shanghai Center for Mathematical Sciences

Abstract

To be announced

Commuting differential and difference operators

Andrey Evgenevich Mironov
Sobolev Institute of Mathematics

Abstract

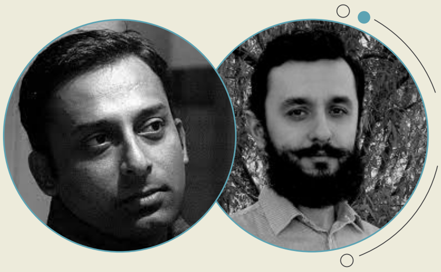
We will discuss the connection between commuting ordinary differential operators and commuting difference operators.

Robot dance: Using optimisation for intervention against Covid-19 in a complex network

Paulo José da Silva e Silva
University of Campinas

Abstract

Robot Dance is a computational platform developed in response to the coronavirus outbreak, to support the decision-making on public policies at a regional level. The tool is suitable for understanding and suggesting levels of intervention needed to contain the spread of diseases when the mobility of inhabitants through a regional network is a concern. Such is the case for Covid-19 that is highly contagious and, therefore, the circulation of people must be considered in the epidemiological compartmental models. Robot Dance anticipates the spread of epidemics in a complex regional network, identifying fragile links where applying differentiated measures of containment, testing, and vaccination are the most effective. Based on stochastic optimization, the model determines optimal strategies on the basis of the commuting of individuals and the situation of hospitals in each district. Uncertainty in the capacity of intensive care beds is handled by a chance-constraint approach. Some functionalities of Robot Dance are illustrated on the state of São Paulo in Brazil, using real data for a region with more than forty million inhabitants.



Duality for groups, revisited

Amartya Goswami and Zurab Janelidze

University of Johannesburg and Stellenbosch University

Abstract

"Duality for groups" is the title of the 1950 paper by Saunders Mac Lane, where he pioneered applications of categorical methods in the study of algebraic structures. Some of the most fundamental notions of category theory were introduced in this paper. The aim of the paper was to use the categorical language to describe a self-dual axiomatic setting (similar to how, e.g., the axiomatic setting of projective plane geometry is self-dual), for establishing theorems dealing with homomorphisms of groups (among such theorems would be the Noether isomorphism theorems, Zassenhaus lemma, diagram lemmas of homological algebra, etc.). After making first few steps in this direction, the paper restricts to consideration of only abelian groups, leaving the non-abelian version of the theory for a future development. His axioms were later refined to form the axioms of the modern-day notion of an abelian category, which has uses in a variety of fields of abstract mathematics, including commutative algebra, algebraic topology, algebraic geometry, and others. In 2002, a notion of a semi-abelian category was introduced as a generalization of the notion of an abelian category, which would include the categories of non-abelian groups and many other categories of group-like structures. Unlike the axiomatic setting of an abelian category, which is self-dual, the setting of a semi-abelian category is far being such. In fact, forcing it to be self-dual brings us back to the setting of an abelian category. This seemed to suggest that Mac Lane's original idea that there should be a self-dual axiomatic setting is not achievable. However, as explained in our paper published in 2019, this is not so. The "trick" is to use a "functorial context" rather than a "categorical one". The resulting self-dual theory of homomorphism theorems of non-abelian groups and other group-like structures can be described in an elementary language, without knowledge of either categories or functors (or any category theory, as a matter of fact). In this talk we will describe the self-dual axioms and give a sketch of how some homomorphisms theorems of group theory can be deducted from them.

Covid-19 snapshots and modelling from Karnataka – A probability perspective.

Siva Athreya
Indian Statistical Institute Bangalore

Abstract

We will review some of the work that has been done during the pandemic with the state of Karnataka. These include analysis of the snapshots of the pandemic via serological surveys and long/short term modelling via SEIR models incorporating vaccination and antibody waning.

Relations between cusp forms sharing Hecke eigenvalues

Dipendra Prasad
Indian Institute of Technology Bombay, Representation/Number Theory

Abstract

The lecture will discuss a variant of the multiplicity one theorem for modular forms, and consider the question of when the set of Hecke eigenvalues of a cusp form on $GL(n)$ is contained in the set of Hecke eigenvalues of a cusp form on $GL(m)$ for $n \leqslant m$.

Joint work with R. Raghunathan.

On fractional in time evolution problems: Some theoretical and computational studies

Amiya Kumar Pani
Indian Institute of Technology Bombay, Numerical Analysis

Abstract

This talk starts with some basic notions on fractional order integral operators which help to define fractional order derivatives with properties. After discussing linear time fractional ODEs, I shall move to time-fractional evolution problems and try to bring out some salient features of time fractional diffusion versus heat equation. Then, spend some time on solution representation and limited smoothing property. As computational PDE is close to my heart, I finally settle with the conforming piecewise-linear finite element method (FEM) applied to approximate the solution of time-fractional diffusion equations with variable diffusivity on bounded convex domains. Standard energy arguments do not provide satisfactory results for such a problem due to the low regularity of its exact solution, therefore, using a delicate energy analysis, *a priori* optimal error bounds in L^2, H^1, and quasi-optimal in L^∞-norms are derived for the semi-discrete method for cases with smooth and nonsmooth initial data. The main tool of our analysis is based on a repeated use of an integral operator and use of a t^m type of weights to take care of the singular behavior of the continuous solution at $t = 0$. The generalized Leibniz formula for fractional derivatives is found to play a key role in our analysis. The present analysis can be extended to other types of fractional in time evolution problems.

On the KMT theorem for simple symmetric random walks

Manjunath Krishnapur

Indian Institute of Science Bangalore

Abstract

A fundamental result in probability due to Komlos-Major-Tusnady says that a simple symmetric random walk on integers can be coupled with a Brownian motion in such a way that up to time n, they are within $\log(n)$ distance of each other. This has been generalized and extended to other settings, but the basic result is still of much interest and new simplified proofs appear periodically. A new kind of proof, using methods akin to Stein's method was found by Sourav Chatterjee about ten years ago. We present a simplified version of this proof that involves coupling two nearest neighbour Markov chains on integers.

Schur polynomials on the positive orthant: analysis meets algebra

Apoorva Khare

Indian Institute of Science - Analysis

Abstract

Schur polynomials are homogeneous, symmetric polynomials in several variables that are sums of monomials, hence non-decreasing when evaluated on the positive orthant. We present a Schur Monotonicity Lemma, which shows that their ratios have the same property if the powers in the numerator dominate those in the denominator. As an application, we obtain a novel characterization of weak majorization using Schur polynomials, and strengthen a similar characterization of majorization by Cuttler-Greene-Skandera and Sra, from integer tuples to all real tuples. We then present our original motivation: proving the existence of entrywise polynomials that preserve positivity in a fixed dimension. We conclude with a question on optimizing the ratio of Schur polynomials over the cube $[-1, 1]^N$.

(Joint with Terence Tao.)

Higher order Reshetnyak formulas for the ray transform of symmetric tensor fields in Sobolev spaces

Venky Krishnan

TIFR Centre for Applicable Mathematics - Inverse Problems

Abstract

The ray transform of a symmetric m-tensor field is defined as integrals along lines in Euclidean space. In this talk, we derive higher order Reshetnyak formulas for the ray transform of symmetric fields in Sobolev spaces. These are Plancherel-type isometry relations involving certain weighted Sobolev norms of a tensor field and that of its ray transform.

This is joint work with Vladimir Sharafutdinov.

Stable Random Fields, Patterson-Sullivan measures and Extremal Cocycle Growth

Parthanil Roy
Indian Statistical Institute Bangalore

Abstract

We study extreme values of group-indexed stable random fields for discrete groups G acting geometrically on a suitable space X. The connection between extreme values and the indexing group G is mediated by the action of G on the limit set equipped with the Patterson-Sullivan measure. Based on motivation from extreme value theory, we introduce an invariant of the action called extremal cocycle growth, which quantifies the distortion of measures on the boundary in comparison to the movement of points in the space X. We show that its non-vanishing is equivalent to finiteness of the Bowen-Margulis measure for the associated unit tangent bundle $U(X/G)$ provided X/G has non-arithmetic length spectrum. As a consequence, we establish a dichotomy for the growth-rate of a partial maxima sequence of stationary symmetric α-stable $(0 < \alpha < 2)$ random fields indexed by groups acting on such spaces. We also establish analogous results for normal subgroups of free groups.

(Joint work with Jayadev Athreya and Mahan Mj, under review in Probability Theory and Related Fields.)

Algebraic K-theory, cycles and class field theory

Amalendu Krishna
IISc Bangalore

Abstract

In this talk, I shall present some results on the applications of algebraic K-theory and algebraic cycles to the class field theory of varieties over finite fields.

The talk will be based on my separate joint works with Binda-Saito and Gupta

---

Elliptic problems with Hardy-Littlewood-Sobolev critical exponents

Konijeti Sreenadh
Indian Institute of Technology Delhi, PDE

Abstract

In this talk, we will discuss the recent developments on elliptic critical exponent problems motivated by Hardy-Littlewood-Sobolev inequality. The main focus will be on some recent results on the existence, regularity, the effect of the topology, and critical dimensions.

Polynomial representations and computation

Srikanth Srinivasan
Indian Institute of Technology Bombay, TCS

Abstract

Every multivariate polynomial $P(x_1, ..., x_N)$ can be written as a sum of monomials, i.e. a sum of products of variables and field constants. In general, the size of such an expression is the number of monomials in P.

What happens if we add another layer of complexity, and consider sums of products of sums (of variables and field constants) expressions? Now, it becomes unclear how to prove that a given polynomial $P(x_1, ..., x_N)$ does not have small expressions. In a recent result, we solved exactly this problem.

In this talk, I will state this result and give some context behind this question, linking it to some well known open questions in Computational Complexity theory.

Stability of filters for chaotic dynamics

Amit Apte

Indian Institute of Science Education and Reseach, Pune

Abstract

The Bayesian formulation of the data assimilation problem leads to the problem of non-linear filtering. In many applications, the dynamical models are deterministic and chaotic, in which case most of the classical stability results for nonlinear filtering are not applicable because such systems do not satisfy the assumption of controllability. In this talk, I discuss our recent results (arxiv 1901.00307 and 1910.14348) proving asymptotic filter stability for deterministic, chaotic dynamics. I will discuss the relation between the dynamical characteristics of such systems and the asymptotic filtering distribution, as well as the implications for data assimilation problem in earth sciences.

Large-scale geometry of randomly growing interfaces

Riddhipratim Basu

International Centre for Theoretical Sciences Bangalore

Abstract

A variety of models for randomly growing interfaces, believed to be in the so-called Kardar-Parisi-Zhang (KPZ) universality class, is expected to exhibit the same universal asymptotics that are empirically observed in the large scale geometry of many naturally occurring growing interfaces. The rigorous analysis of a class of these models are fueled by underlying exactly solvable structures and remarkable connections to many different areas of mathematics. In this talk, I shall discuss some recent progress in studying the large scale geometry of exactly solvable models of planar last passage percolation.

On finite generation of subalgebras of polynomial algebras

Neena Gupta

Indian Statistical Institute Kolkata, Comm algebra

Abstract

Let R be a complete domain and A be a Noetherian subring of the polynomial ring $R[X]$. An analogue of Hilbert's fourteenth problem for complete rings asks when is A a finitely generated R-algebra. An affirmative answer was given by A.K. Dutta and N. Onoda over rings like $C[[X]]$. In this talk, we will discuss some recent developments on this problem over rings like $C[[X, Y]]$.

This is a joint work with A. K. Dutta and N. Onoda.

Large prime factors of specialisations of $x^n - 1$

Sanoli Gun

Institute of Mathematical Sciences, Number Theory

Abstract

We discuss a celebrated theorem of Stewart regarding existence of large prime factors of $\gamma^n - 1$, where $[\mathbb{Q}(\gamma) : \mathbb{Q}] \leq 2$ and γ is not a root of unity. This theme has several ramifications in number theory (also in finite group theory). Finally we report on a recent work where an explicit version of Stewart's theorem is investigated.

This is a joint work with Yuri Bilu and Haojie Hong.

K-theory of Springer variety

Parameswaran Sankaran

Institute of Mathematical Sciences, Geometry/Topology

Abstract

Let $A \in M_n(C)$ be an nilpotent matrix (over the field C of complex numbers) in Jordan canonical form with Jordan block sizes $\lambda = \lambda_1 \geq \cdots \geq \lambda_r$. (Thus λ is a partition of n.)

Let $F = Flag(C^n)$ denote the complete flag variety over C. An element of F is a flag $V : 0 = V_0 \subset V_1 \subset \cdots \subset V_n = C^n$ The Springer variety of type λ, denoted F_λ is the subspace of all flags V such that $A(V_j) \subset V_{j-1}$ for all $j \leq n$. It has the structure of a complex projective variety and is known to be not irreducible. The integral cohomology of these spaces have been well understood.

I will talk on recent results on the K-theory of the Springer variety. This is based on recent joint work with V. Uma.

Discrete time martingales, mixingales and mixing processes in Riesz spaces

Bruce Watson

University of the Witwatersrand

Abstract

Mixingales are stochastic processes which combine the concepts of martingales and mixing sequences. McLeish introduced the term mixingale in 1974. We generalize the concept of a mixingale to the measure-free Riesz space setting. This generalizes all of the $L_p; 1 \leqslant p \leqslant \infty$ variants. We also generalize the concept of uniform integrability to the Riesz space setting and prove that a weak law of large numbers holds for Riesz space mixingales. Connections are also made with discrete time martingales and mixing processes in both the L_p space and the Riesz space settings will be discussed.

This talk is based on joint work with Wen-Chi Kuo and various other co-authors.

Construction of the soliton solutions and modulation instability analysis for the Mel'nikov system

Vineesh Kumar

Abstract

In this talk, we discuss the soliton solutions of the Mel'nikov system by the complex amplitude ansatz method and the He's variational principle. The bright, anti-bright, dark, anti-dark, kink, anti-kink, bell-shaped, general breather and homoclinic orbits are obtained in different possible solutions of the Mel'nikov system by the two methods. The modulation instability analysis of the steady-state solutions of the Mel'nikov system is investigated. This investigation has revealed that the Mel'nikov system is stable against small perturbation for a certain range of perturbation wave numbers. Apart from this, these solutions also help in validating the amount of accuracy in the numerical solutions and to perform the stability analysis further.

Homology of shellable q-complexes and q-matroids

Rakhi Pratihar

Abstract

Shellability is a useful notion in algebraic combinatorics and combinatorial topology. For an (abstract) simplicial complex, shellability is a way of constructing the complex by gluing its facets (i.e., maximal faces) in a well-behaved way. Motivated by the application of shellability and homology of matroid complexes to Hamming metric codes, we consider q-matroids and q-complexes, the q-analogues of the notions of simplicial complexes and matroids, respectively. These notions arise naturally in the context of rank-metric codes and this led us to study the shellability and homology of q-complexes, especially those induced from q-matroids.

Strong bounded variation estimates for the multi–dimensional finite volume approximation of scalar conservation laws and application to a tumour growth model

Gopikrishnan Chirappurathu Remesan

Abstract

A uniform bounded variation estimate for finite volume approximations of the nonlinear scalar conservation law $\partial_t \alpha + div(\boldsymbol{u} f(\alpha)) = 0$ in two and three spatial dimensions with an initial data of bounded variation is established. We assume that the divergence of the velocity $div(\boldsymbol{u})$ is of bounded variation instead of the classical assumption that $div(\boldsymbol{u})$ is zero. The finite volume schemes analysed in this article are set on nonuniform Cartesian grids. A uniform bounded variation estimate for finite volume solutions of the conservation law $\partial_t \alpha + div(F(t, \boldsymbol{x}, \alpha)) = 0$, where $div_{\boldsymbol{x}} \boldsymbol{F} \neq 0$ on non-uniform Cartesian grids is also proved. Such an estimate provides compactness for finite volume approximations in L^p spaces, which is essential to prove the existence of a solution for a partial differential equation with nonlinear terms in α, when the uniqueness of the solution is not available. This application is demonstrated by establishing the existence of a weak solution for a model that describes the evolution of initial stages of breast cancer proposed by S. J. Franks et al. [J. Math. Bio., 47(5):424–452, 2003]. The model consists of four coupled variables: tumour cell concentration, tumour cell velocity–pressure, and nutrient concentration, which are governed by a hyperbolic conservation law, viscous Stokes system, and Poisson equation, respectively. Results from numerical tests are provided and they complement theoretical findings.

Dynamic of non-negative matrices

Yogesh Prajapaty

Abstract

This talk aims to understand the dynamics of products of non-negative matrices in max algebra. We will generalize a well-known consequence of Peron Fröbenius theorem on periodic points of a non-negative matrix in a max algebra setting. We extend the result for a finite product associated with a p-lettered word on N letters from a finite collection of non-negative matrices, each having its maximum circuit geometric mean at most 1.

Monolithic and partitioning approaches for the numerical solution of electromechanical interactions in cardiac electrophysiology

Aswin V. S.

Abstract

Electro-mechanical models of the human heart have been used successfully to study fundamental mechanisms underlying a heartbeat in health and disease. An anisotropic and incompressible hyperelastic material model with active strain formulation is taken into consideration.

The active part of the deformation tensor carries the information of the electric-potential waves based on the Mitchell–Schaeffer Regularized (MSR) ionic model in Lagrangian configuration. The fully coupled electromechanical model is highly nonlinear and needs more computational effort to solve. In this work, a novel monolithic approach was developed and compared with the partitioned algorithms for a system of equations that describes the electromechanical dynamics of an electrically excitable elastic medium. In the partitioned method, the mechanical and MSR models are solved separately in each time step. Such kinds of coupling have been used in many studies to understand the excitation-contraction mechanisms in the heart. However, the weak coupling may result in the loss of vital data. The global system is solved as a whole at each time step in the monolithic approach. The algorithms are realized based on the finite element method for spatial discretization, and efficient time-stepping schemes were used in both approaches. Finally, we demonstrate the numerical results of both methods.

On an operator preserving inequalities between polynomials

Imtiaz Hussain

Abstract

Let $P(z)$ be a polynomial of degree at most n. We consider an operator N, which carries a polynomial $P(z)$ into

$$N[P](z) := \sum_{j=0}^{m} \lambda_j \left(\frac{nz}{2}\right)^j \frac{P^{(j)}(z)}{j!}$$

where $\lambda_0, \lambda_1, \ldots, \lambda_m$ are such that all the zeros of

$$u(z) = \sum_{j=0}^{m} \binom{n}{j} \lambda_j z^j$$

lie in the half plane

$$|z| \leq \left|z - \frac{n}{2}\right|$$

In this paper, we estimate the minimum and maximum modulii of $N[P(z)]$ on $|z| = 1$ with restrictions on the zeros of $P(z)$ and thereby obtain compact generalizations of some well known polynomial inequalities.

On the eigenvalues of the Laplacian on ellipsoids with curvature condition

Aditya Tiwari

Abstract

We study the eigenvalues of the Laplacian on ellipsoids that are obtained as perturbations of the standard Euclidean unit sphere in dimension two. A comparison of these eigenvalues with those of the standard Euclidean unit sphere is obtained under a Gaussian curvature condition, in line with the Lichnerowicz theorem on the first positive eigenvalue on a compact Riemannian manifold.

A posteriori error analysis for a distributed optimal control problem governed by the von Kármán equation

Dond Asha Kisan

Abstract

The adaptive finite element method (AFEM) is an elegant and powerful technique used to compute the numerical solution to differential equations with a minimal computational cost. In the talk, the adaptive estimator will be discussed for the distributed optimal control problem governed by the von Kármán equation defined on a polygonal domain in $\mathbb{R}^2$. The state and adjoint variables are discretised using the nonconforming Morley finite element method and the control is discretised using piecewise constant functions. The *a posteriori* error estimates are shown to be efficient and justified through numerical results.

This is joint work with Sudipto Chowdhury, Devika Shylaja, Neela Nataraj.

Geometry described by the Möbius action of $SL(2; R)$ on dual numbers using Erlangen program

Sneha Gupta

Abstract

Following Klein's Erlangen program, we have studied the geometry described by the Möbius action of the matrix Lie group $SL(2; R)$ on the space of dual numbers. We have described various properties of dual numbers and used the Iwasawa decomposition of $SL(2; R)$ to classify it into three one-parameter continuous subgroups A, N and K that defined three distinct actions on the space of dual numbers. It is the K-action that gave the most significant geometry and provided a basis for our further study of the geometry. As the main concept of Erlangen program revolves around invariance, so we have found various invariant properties of this geometry that includes the isotropy subgroup of the dual unit ϵ, its conjugate and related properties and orbit of the isotropy subgroup. We have also defined cycles and Fillmore-Springer-Cnops construction that connects cycles to a 2×2 matrix and used these two to show invariance of the isotropy subgroup.

S^1-concentrating solutions for a superlinear elliptic equation in $\mathbb{R}^3$

Alok Kumar Sahoo

Abstract

We consider singularly perturbed equations of the form

$$\begin{cases} \varepsilon^2 \Delta u - u + u^p = 0 \text{ in } A \subset \mathbb{R}^N \\ u > 0 \text{ in } A, u = 0 \text{ on } \partial A \end{cases}$$

where A is a annulus and $p > 1$. It has been conjectured for a long time that such problems posses solutions having m-dimensional concentration sets for every $0 \leq m \leq N-1$. For $N = 3$ solutions with 2-dimensional and 0-dimensional concentration sets are known, while no result was available for 1-dimensional concentration sets. With answer positively this conjecture, proving the existence of solutions that concentrate on circles S^1. The proof relies on a result by Santra-Wei which yields the existence of solutions concentrating on a Clifford torus $S^1 \times S^1$ for an annulus in $\mathbb{R}^4$.

Some unified integral formulae associated with Hurwitz-Lerch Zeta function

Sunil Joshi

Abstract

In this present work we investigate five new generalized integral formulae involving extension form of Hurwitz-Lerch zeta function, further we also address their special cases by making suitable substitutions. The results obtained here are of a general nature and far more auspicious in the study of applied science, engineering, and technology problems.

Hybrid collocation methods for Hammerstein integral equations with logarithmic kernel

Bijaya Laxmi Panigrahi

Abstract

In this paper, Hybrid collocation methods have been developed to solve the Hammerstein integral equations with the logarithmic kernel. The hybrid collocation methods combine the idea of singularity preserving collocation methods with graded collocation methods. In this method, the singular functions are approximated only on first and last subintervals, depending on the singularity arises on the endpoints and in other subintervals, functions are approximated by spline functions. By using the proposed methods, the global convergence rates have been obtained instead of local convergence rates. The numerical examples have been obtained by using this method.

A shadowing type result for difference equations.

Lokesh Singh

Abstract

A difference equation is said to have the shadowing property if in a vicinity of every approximate solution there exists an exact solution of the difference equation.

In this talk, we will discuss the shadowing property for a class of semilinear difference equations of the form

$$x_{n+1} = A_n x_n + f_n(x_n) \quad n \in \mathbb{Z}$$

where $A_n, n \in \mathbb{Z}$ are bounded, linear and invertible operators on a Banach space X and $f_n : X \to X, n \in \mathbb{Z}$ is a sequence of Lipschitz maps. In particular, we will formulate conditions under which exhibits the shadowing property, which unlike some previous works don't require any information related to the asymptotic behaviour of the linear part.

On Green-Lazarsfeld property N_p for Hibi rings

Dharm Veer

Abstract

Let L be a finite distributive lattice. By Birkhoff's fundamental structure theorem, L is the ideal lattice of its subposet P of join-irreducible elements. Write $P = p_1, \ldots, p_n$ and let $K[t, z_1, \ldots, z_n]$ be a polynomial ring in $n+1$ variables over a field K. The Hibi ring associated with L is the subring of $K[t, z_1, \ldots, z_n]$ generated by the monomials, where $\alpha \in L$. In this talk, we show that a Hibi ring satisfies property N_4 if and only if it is a polynomial ring or it has a linear resolution. We also discuss few results about property N_p for Segre product of Hibi rings for $p = 2$ and 3. For example, we show that if a Hibi ring satisfies property N_2, then its Segre product with a polynomial ring in finitely many variables also satisfies property $N + 2$.

The ultraspherical spectral element method

Nick Hale

Abstract

The ultraspectral element method is a spectral element method based on the ultraspherical spectral method and the hierarchical Poincaré-Steklov scheme. It is geared towards the high accuracy solution of second-order linear partial differential equations on polygonal domains using unstructured quadrilateral or triangular meshes. Properties of the ultraspherical spectral method lead to almost banded linear systems which are solved with a fast-direct method, allowing the ultraspectral element method to be competitive in the "high-p" regime ($p > 5$). In this talk, we give a short overview of the method and a brief demonstration of an open-source software implementation, ultraSEM, for flexible, user-friendly spectral element computations in MATLAB.

Non-inner automorphism conjecture

Renu Joshi

Abstract

In 1973, Berkowich proposed the following problem: Every non-abelian finite p-group has non-inner automorphism of order p. This problem has been proved for many classes of finite p-groups including verification of the conjecture for finite p-groups of nilpotency class 2 given by Liebeck, where p is an odd prime. While proving the result, Liebeck chose $d(G)$-generators of a group ($d(G)$:=the minimal number of generators of the group G) which satisfy certain properties. Using the methods of Abdollahi, we give a short proof of Liebeck's result on non-inner automorphism conjecture for finite p-groups of nilpotency class 2 by reducing to the $d(G) = 2$ case.

Multiple solutions for Biharmonic Critical Choquard equation involving sign-changing weight functions

Anu Rani

Abstract

The purpose of this article is to deal with the following biharmonic critical Choquard equation

$$\left\{\Delta^2 u = \lambda f(x)|u|^{q-2}u + g(x)\left(\int_\Omega \frac{g(y)|u(y)|^{2^*_\alpha}}{|x-y|^\alpha}dy\right)|u|^{2^*_\alpha-2}u \text{ in } \Omega,\ u,\ \nabla u = 0 \text{ on } \partial\Omega,\right.$$

where Ω is a bounded domain in $\mathbb{R}^N$ with smooth boundary $\partial\Omega$, $N \geqslant 5$, $1 < q < 2$, $0 < \alpha < N$, $2^*_\alpha = \frac{2N-\alpha}{N-4}$ is the critical exponent in the sense of Hardy-Littlewood-Sobolev inequality and $\lambda > 0$ is a parameter. The functions $f, g : \bar{\Omega} \to \mathbb{R}$ are continuous sign-changing weight functions. Using the Nehari manifold and fibering map analysis, we prove the existence of two non-trivial solutions of the problem with respect to parameter λ.

The generalised Fermat's polygonal number theorem

Sagnik Saha

Abstract

Fermat's famous conjecture of 1638 states that *every positive integer may be written as the sum of at most m m-gonal numbers.* Certain sums of polygonal numbers have been shown to be universal if they attain a minimal condition. We consider weighted sums of generalized polygonal numbers, thus generalizing the polygonal number theorem. In particular, we exactly obtain the minimal number of generalized m-gonal numbers required to represent every positive integer and further generalize this result to obtain optimal bounds when many of the generalized m-gonal numbers are repeated r times, for fixed $r \in \mathbb{N}$. In another variant of the problem, we relax some conditions to obtain a coherent set of results.

This is a joint work with Benjamin Kane and a summer research group.

An improved scheme for the solution of fractional differential equations

Harshita Madduri

Abstract

A numerical scheme based on Diethelm's scheme is constructed to solve nonlinear time fractional reaction diffusion equations based on a non-uniform mesh approximation to Caputo fractional derivative and a second order finite difference method in space direction. The standard Diethelm's scheme requires C^2 continuity to be of order $(2 - \alpha)$, whereas in the proposed scheme it is not required. The stability analysis of the proposed scheme is discussed and error estimates are presented when the non-uniform mesh is considered to be of the Chebyshev form. Various examples having applications in diverse fields are solved using the proposed scheme. The results obtained are of better accuracy and computationally efficient in comparison with uniform mesh scheme. Further, the proposed scheme gives a better approximation than graded mesh in certain cases.

Stabilising bimodal planar linear switched systems with both stable and unstable subsystems

Swapnil Tripathi

Abstract

A time-dependent switched system comprises an interaction between continuous and discrete dynamics, where switching between subsystems is governed by a function known as a switching signal. It is well-known that unconstrained switching may destabilize the system even when all its subsystems are stable, hence the problem of finding classes of signals under which a switched system is stable is extensively studied. For a time-dependent switched linear system with both stable and unstable subsystems, it is expected that if the signal spends sufficiently large time in the stable subsystem (dwell time constraint) and spends sufficiently small time in the unstable subsystem (flee time constraint), then the switched system is stable.

In this talk, we will present a literature review, specifically discussing results where the relation between dwell time and flee time for stability is obtained in terms of the eigenvalues and eigenvectors of subsystem matrices. We will then focus on bimodal planar linear switched systems. For this class of systems, we will present our results, where we analyse how dwell-flee relations change as we vary over all the possible eigenvectors of the subsystem matrices. We will discuss optimal choice of eigenvectors which give the least possible dwell time for a given flee time.

On Schur's exponent conjecture

Komma Patali

Abstract

Let G be a finite group. The validity of $exp(H_2(G, Z)) \,|\, exp(G)$ has been studied for several decades. In this talk, we will talk about Schur's exponent conjecture and outline our contributions to this conjecture. This is joint work with A. E. Antony and V. Z. Thomas.

A. E. Antony, P. Komma, V. Z. Thomas, On a property of p-groups of nilpotency class $p+1$ related to a theorem of Schur, Israel J. Math. (accepted).

Gröbner deformations and F-singularities

Mitra Koley

Abstract

For a commutative ring R of prime characteristic p, the map $F : R \to R$ sending $r \mapsto r^p$ is a ring endomorphism, called the Frobenius morphism. Frobenius morphism plays an important role in studying singularities of such rings. The singularities that have been defined in terms of the Frobenius map are called F singularities. In this talk we will look at the question how F-singularities behave along Gröbner deformation. This question is also related to the so-called deformation problem of F-singularities. This approach gives us a way to study F-singularities of various combinatorial algebras. For example, we will see that the algebras with straightening laws and the algebras defined by binomial edge ideals are always F-injective (one class of F-singularity).

This is a joint work with Matteo Varbaro.

On the existence of Euclidean ideal class in quadratic, cubic and quartic extensions

Pasupulati Sunil Kumar

Abstract

In 1979, Lenstra introduced the definition of the Euclidean ideal which is a generalization of Euclidean domain.

Definition 1. Let R be a Dedekind domain and $\mathbb{I}$ be the set of non zero integral ideals of R. If C is an ideal of R, then it is called Euclidean if there exists a function $\Psi : \mathbb{I} \to \mathbb{N}$, such that for every $I \in \mathbb{I}$ and $x \in I^{-1}C \backslash C$ there exist a $y \in C$ such that

$$\Psi\left((x-y)IC^{-1}\right) < \Psi(I)$$

Lenstra established that for a number field K with rank $\left(\mathcal{O}_K^{\times}\right) \geq 1$, the number ring $\mathcal{O}_K$ contains a Euclidean ideal if and only if the class group Cl_K is cyclic, provided GRH holds. Several authors worked towards removing the assumption of GRH. In this talk, I prove the existence of the Euclidean ideal class in abelian quartic fields. As a corollary, I will prove that a certain class biquadratic field with class number two has a Euclidean ideal class. I also discuss the existence of a Euclidean ideal class in certain cubic and quadratic extensions.

This is joint work with Srilakshmi Krishnamoorthy.

Neural codes and Neural ring endomorphisms

Suhith K. N.

Abstract

The brain works by sending and receiving signals, and these signals carry information on whether a particular neuron is on or off. This binary information put together forms *neural codes.* So, to understand how the brain works, we ultimately need to understand the information captured in these codes. We have investigated some combinatorial, topological and, algebraic properties of certain classes of neural codes. We look into a conjecture that states if the minimal *open convex* embedding dimension of a neural code is two then its minimal *convex* embedding dimension is also two. We prove the conjecture for two interesting classes of examples and provide a counterexample for the converse of the conjecture. We introduce a new class of neural codes, *Doublet maximal.* We show that a Doublet maximal code is open convex if and only if it is max-intersection complete. We prove that surjective neural ring homomorphisms preserve max-intersection complete property. We introduce another class of neural codes, *Circulant codes.* We give the count of neural ring endomorphisms for several sub-classes of this class.

Atiyah sequence and gauge transformations of a principal 2-bundle over a Lie groupoid

Adittya Chaudhuri

Abstract

A notion of a principal 2-bundle over a Lie groupoid has been introduced. For such principal 2-bundles, we produced a short exact sequence of VB-groupoids, namely, the Atiyah sequence. Two notions of connection structures viz. strict connections and semi-strict connections on a principal 2-bundle arising respectively, from a retraction of the Atiyah sequence and a retraction up to a natural isomorphism have been introduced. We constructed a class of principal $\mathbb{G} = [G_1 \rightrightarrows G_0]$-bundles and connections from a given principal G_0-bundle $E_0 \to X_0$ over $[X_1 \rightrightarrows X_0]$ with connection. An existence criterion for the connections on a principal 2-bundle over a proper, étale Lie groupoid is proposed. The action of the 2-group of gauge transformations on the category of strict and semi-strict connections has been studied. Finally, we noted an extended symmetry of the category of semi-strict connections.

This is a joint work with Saikat Chatterjee and Praphula Koushik. The preprint of our work is available at [1] https://arxiv.org/pdf/2107.13747.pdf

Feedback stabilisation of heat equation with memory and its numerical study

Wasim Akram

Abstract

In the first part of the talk, we study feedback stabilization of heat equation with memory by using localized interior controls. The equation can be rewritten as system coupled between a parabolic equation and an ODE. The system is feedback stabilizable with exponential decay $-\omega$, where $\omega \in (0, \omega_0)$ and ω_0 is determined by the spectrum of corresponding linear operator. The stabilizing control can be found in feedback form by solving a suitable algebraic Riccati equation. In the second part, finite element method is used to find a family of finite dimensional discrete system approximating the original system. The approximated system is also feedback stabilizable with exponential decay $-\omega + \epsilon$, for any $\epsilon > 0$ and the feedback control can be obtained by solving a discrete algebraic Riccati equation. Then the convergence of stabilized solutions as well as stabilizing feedback controls is obtained. We validate the theoretical result by showing some numerical implementation.

On conic fibrations over elliptic curves

Subham Bhakta

Abstract

A theorem of Serre states that almost all plane conics over $\mathbb{Q}$ have no rational point. We prove an analog of this for families of conics parametrized by an elliptic curve using elliptic divisibility sequences and a version of the Selberg sieve for elliptic curves. Consequently, we get an elliptic analogue of Landau's theorem on the sum of two squares.

Deciphering complexity of financial markets

Anirban Chakraborti

Abstract

The complexity of financial markets arises from the strategic interactions among agents trading stocks, which manifest in the form of vibrant correlation patterns among stock prices. Over the past few decades, complex financial markets have often been represented as networks whose interacting pairs of nodes are stocks, connected by edges that signify the correlation strengths. In this talk, I will try to present some of our studies on complex financial networks, which can significantly enhance our ability to understand market instability as well as measure the fragility of global financial systems.

CONTRIBUTED TALKS

Non-negative solution to fractional Keller-Segel system

A. Akilandeeswari

Abstract

The goal of this work is to establish the existence of non-negative weak solution to time fractional Keller-Segel system with Neumann boundary condition in a bounded domain in $\mathbb{R}^n$ with smooth boundary, $n > 1$. We first regularize the system and then under suitable assumptions on the initial conditions, we establish the existence of solution to the system by using Galerkin approximation method. The convergence of solutions is proved by means of compactness criteria for fractional partial differential equations, which is recently obtained by Li and Liu. Furthermore, the non-negativity of solution is proved by the standard arguments.

Positive solutions to superlinear semipositone problems on the exterior of a ball

Anumol Joseph

Abstract

We prove the compactness of the solution operator for a class of singular semilinear elliptic problems on the exterior of a ball in $\mathbb{R}^n, n \geqslant 3$. Compactness of solution operators for similar problems in $\mathbb{R}^n$, $n \geqslant 2$ are also established. Further, using these compactness results and employing Schauder fixed point theorem, we prove the existence of a positive solution to classes of semipositone problems with asymptotically linear reaction terms.

(Co-authored with Lakshmi Sankar, Indian Institute of Technology Palakkad.)

Parameter dependent finite element analysis for ferronematics solutions.

Ruma Rani Maity

Abstract

In this talk, we focus on the analysis of a free energy functional, that models a dilute suspension of magnetic nanoparticles in a two-dimensional nematic well, referred as ferronematics. We discuss the asymptotic analysis of global energy minimizers in the limit of vanishing elastic constant, where the re-scaled elastic constant l is inversely proportional to the domain area. Conforming finite element method is used to approximate the regular solutions of the corresponding nonlinear system of partial differential equations with cubic non-linearity and non-homogeneous Dirichlet boundary conditions. We establish the existence and local uniqueness of the discrete solutions, error estimates in the energy and L^2 norms with l-discretization parameter dependency. The theoretical results are complemented by the numerical experiments on the discrete solution profiles, and the numerical convergence rates that corroborates the theoretical estimates.

This talk is based on joint works with Apala Majumdar (Department of Mathematics and Statistics, University of Strathclyde, UK) and Neela Nataraj (Department of Mathematics, Indian Institute of Technology Bombay, India).

Higher rank numerical ranges of normal operators and unitary dilations

Pankaj Dey

Abstract

Let T be a bounded linear operator acting on a Hilbert space and $1 \leq k \leq \infty$. The k-rank numerical range of T, denoted by $\Lambda_k(T)$, is defined as

$$\Lambda_k(T) := \{\lambda \in \mathbb{C} : PTP = \lambda P, \text{ for some projection } P \text{ of rank } k\}$$

It appeared in the context of "quantum error correction". We describe the k-rank numerical range of a normal operator acting on an infinite dimensional Hilbert space in terms of its spectral measure. It is used to show that there exists a normal contraction T for which the intersection of the k-rank numerical ranges of all unitary dilations of T contains the k-rank numerical range of T as a proper subset. Finally, we strengthen and generalize a result of Wu by providing a necessary and sufficient condition for the k-rank numerical range of a normal contraction being equal to the intersection of the k-rank numerical ranges of all possible unitary dilations of it.

This is a joint work with Mithun Mukherjee.

Tight Hilbert Polynomial and F-rational local rings

Saipriya Dubey

Abstract

Let $(R, \mathfrak{m})$ be a Noetherian local ring of prime characteristic p and Q be an $\mathfrak{m}$-primary parameter ideal. The goal of the talk is to give criteria for F-rationality of R using the tight Hilbert function $H_Q^*(n) = \ell\left(R/\left(Q^n\right)^*\right)$ and the coefficient $e_1^*(Q)$ of the tight Hilbert polynomial $P_Q^*(n) = \sum_{i=0}^{d}(-1)^i e_i^*(Q)\binom{n+d-1-i}{d-i}$. We obtain a lower bound for the tight Hilbert function of Q for equidimensional excellent local rings that generalises a result of Goto and Nakamura. Craig Huneke asked if the F-rationality of unmixed local rings may be characterised by the vanishing of $e_1^*(Q)$. We construct examples to show that without additional conditions, this is not possible. Let R be an excellent, reduced, equidimensional Noetherian local ring and Q be generated by parameter test elements. Using the formulas for $e_1^*(Q), e_2^*(Q), \ldots, e_d^*(Q)$ in terms of Hilbert coefficients of Q, lengths of local cohomology modules of R, and the length of the tight closure of the zero submodule of $H_{\mathrm{m}}^d(R)$; we prove: R is F-rational $\Longleftrightarrow e_1^*(Q) = e_1(Q) \Longleftrightarrow \operatorname{depth} R \geq 2$ and $e_1^*(Q) = 0$

This is a joint work with Jugal K. Verma and Pham Hung Quy.

Perron-Frobenius theorem for a subshift of finite type

Haritha C.

Abstract

The Perron-Frobenius theorem is one of the most celebrated results in matrix theory. It guarantees the existence of the largest real eigenvalue (known as the Perron root) and associated positive left and right eigenvectors of an irreducible matrix. In this talk, we present a combinatorial method to compute the Perron root and eigenvectors associated with an irreducible subshift of finite type. As an application, we obtain an expression for the Perron root and eigenvectors of an irreducible 0–1 matrix. We use techniques from combinatorics and ergodic theory to compute the normalization factor of these eigenvectors. This in turn gives us an alternate definition for the Parry measure on a subshift of finite type that is invariant under the left shift map.

Mathematical modelling and simulation of mechano-chemical effect on two-phasevascular tumour

Sweta Sinha

Abstract

In this article, we derive the mathematical model that allows chemotaxis in avascular tumour growth in a two-phase medium. The two phases are the viscous cell phase and the inviscid fluid phase. The conservation of mass–momentum is incorporated in each phase, and appropriate constitutive laws are applied to formulate the governing equations. Further, these equations are simplified into three main variables: cell volume fraction, cell velocity, and nutrient concentration. These variables generate a coupled system of non-linear partial differential equations. A numerical scheme based on the finite volume method is applied to approximate the solution of cell volume fraction. The finite element method is applied to approximate the solutions of cell velocity and nutrient concentration. In this research, we investigate tumour growth when cells move along a fluid containing a diffusible nutrient to which the cells are drawn. We perform some numerical simulations to show the effect of the parameters. The findings of this literature are compatible with the existing literature.

On Hadamard matrices and Partial Hadamard matrices

Pankaj Kumar Manjhi

Abstract

Some well known methods of construction of Hadamard matrices has been discussed with recent stutus of hadamard conjecture. A generalized hadamard matrix known as Partial Hadamard matrix is discussed in brief and some properties of Ciculant Partial hadamard with some conjectures have been discussed.

Fractal (Hausdorff) dimension of coastlines & land frontiers

Akhlaq Husain

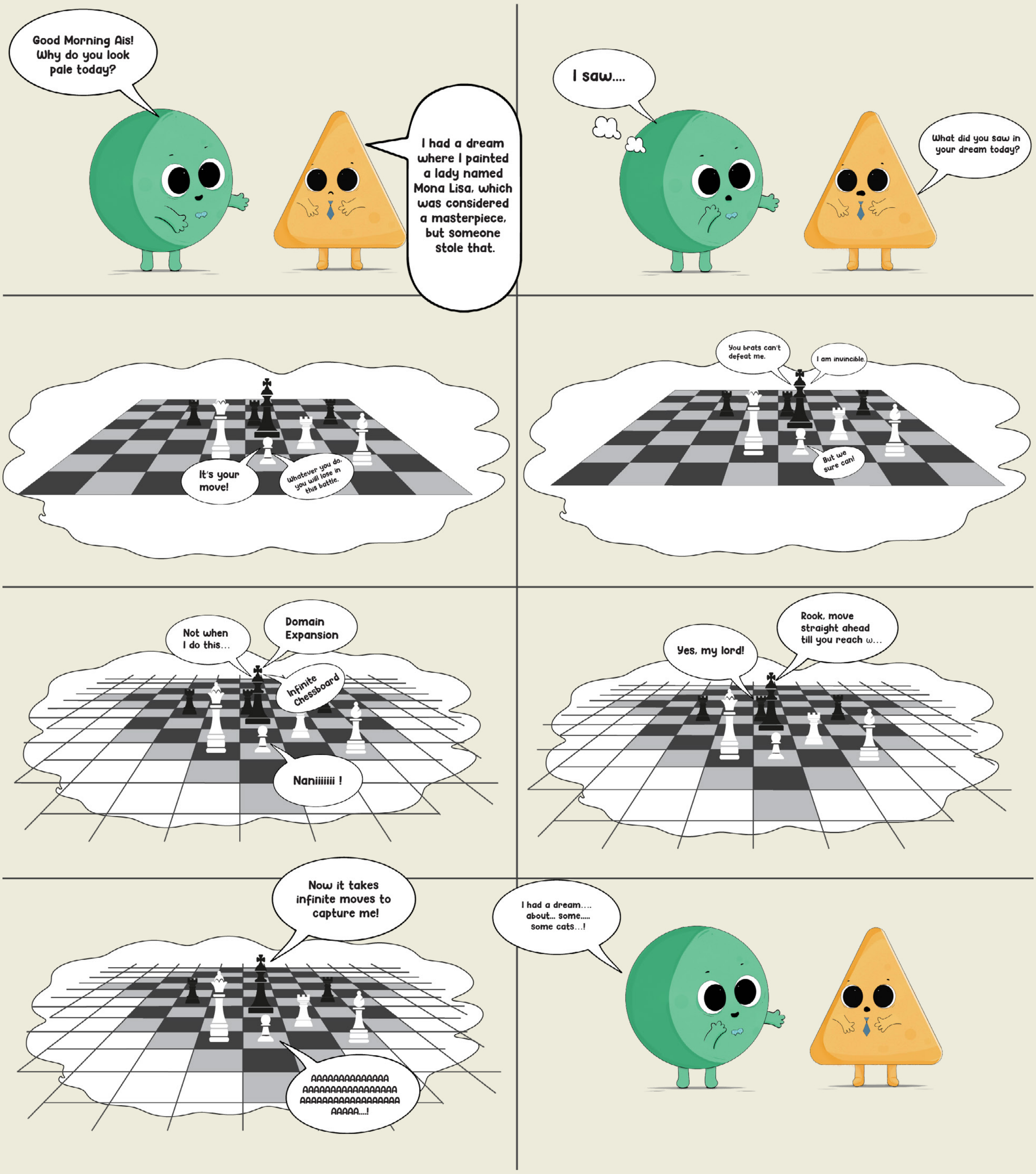
Abstract

Fractal dimension is a measure of geometric irregularity or complexity of an object. Coastlines and borders have random geometries, and the accurate calculation of the length of coastlines and borders are very important for geological, geographical, political, & diplomatic purposes.

In this talk, we shall discuss the so called Hausdorff dimension (based on measures) and its importance in computing the fractal dimension of deterministic and random fractals (e.g., coastlines etc.). We will present a robust, multicore, parallel processing algorithm to calculate the fractal dimension of natural objects along with simulation results for the coastline of Australia and India.

The algorithm is scalable, and it can measure the geometric complexity of objects at multiple scales ranging from cauliflower, surface of human brain, surface of broccoli, lungs, human retina, rivers, mountains, forests, clouds, and even other planets which exhibit fractal characteristics and cannot be well characterised by the Euclidean geometry.

MATHOMIC



Comic Explained: In the morning, Lin askes Ais why he looked upset, to which Ais responds by explaining the dream he saw last night. Then Ais casually asks Lin what he dreamt about. Ais tries to remember his dream where he saw a unique chess scenario where the defeat of the black King was assured. But in his dream, the black King uses a special technique called DOMAIN EXPANSION (Jujutsu Kaisen reference) which allowed the black King to convert the regular 8x8 chessboard to an infinite chessboard. Moving the central rook to the first infinite ordinal straight ahead in an infinite chessboard would take infinite moves to capture the King. So the black King played a big brain move in Lin's dream, but Lin thought Ais wouldn't get his obscure humour in the dream and lied that he dreamt about cats.

The Fourth BRICS Mathematics Conference

With an aim to strengthen cooperation and exchanges in the field of mathematics among five countries, the BRICS Mathematics Conference was launched in 2016, with its first three editions happening in China (2017), Brazil (2018), and Russia (2019). The BRICS represent countries that are known for their significant influence on regional affairs, and thus the annual BRICS Mathematics Conference is an excellent platform for an international-level academic collaboration.