BML MUNJAL UNIVERSITY™
A Hero GROUP INITIATIVE

ICCPDEA 2022

International Conference on Computational Partial Differential Equations and Applications

ICCPDEA-2022

Organized by
School of Engineering and Technology
BML MUNJAL UNIVERSITY

September 6 - 8, 2022

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Message from the President

Ms. Swati Munjal
President
BML Munjal University

It is a matter of great honor and pleasure that the School of Engineering & Technology, BML Munjal University is organizing the *International Conference on Computational Partial Differential Equations and Applications (ICCPDEA-2022)*. On behalf of organizing committee of the conference, I feel privileged and delighted to welcome all the delegates, eminent mathematicians, invited speakers and young researchers in this distinguished seat of learning. Changing trends in the society demand the value orientation of its youth, hence knowledge acquisition followed by appropriate implementation should be focused upon. The present conference aims to provide a common platform for interaction, exchange of ideas and latest developments in the field of partial differential equations and its applications.

I would like to express my gratitude to all the participants for their interest in the conference and hope that each of them will get the maximum benefit in terms of networking, knowledge, understanding and fruitful interactions from this conference. I wish an enjoyable and productive conference and hope that you will leave from this conference with the satisfaction of having a very fulfilling, pleasant, and rewarding experience.

(Ms. Swati Munjal)

Message from the Executive Vice-President

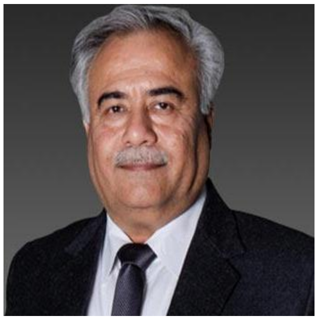
Prof. Shyam Menon
Executive Vice-President,
BML Munjal University

It is our pleasure to host the *International Conference on Computational Partial Differential Equations and Applications (ICCPDEA-2022)* during September 06-08, 2022. Partial Differential Equations are fundamental in nature and in mathematics which play a key role in the mathematical modelling of natural, scientific, engineering and industry-related problems. The conference aims to bring together experts and practitioners working in the field of partial differential equations and computational algorithms for sharing and exchange of knowledge, experiences, and evolving ideas on innovations and technological application of partial differential equations in various fields.

I welcome all the delegates, plenary speakers, invited speakers, senior scientists, young researchers and participants from the industry and academia who have travelled long distances from various parts of India and abroad and gathered at BMU to participate in the conference. I am confident that the conference will be a major success. I also take this opportunity to congratulate the organizing team for hosting this significant conference at BMU which will benefit both the participants and the University. I believe it will open up wider horizons for future mathematicians.

(Prof. Shyam Menon)

Message from the Vice-Chancellor



Prof. Manoj K Arora
Vice-Chancellor,
BML Munjal University

I am thrilled to note that the faculty of Mathematics in the School of Engineering & Technology (SoET) of the BML Munjal University is organizing the *International Conference on Computational Partial Differential Equations and Applications ICCPDEA (2022)* during September 06-08, 2022.

Mathematics, perhaps, is the most fundamental science which is sitting at the core of most of the disciplines, whether it is sciences, engineering, management, economics, commerce, or arts. Any professional is incomplete in today's technological driven world, if he or she does not have the knowledge of mathematics in some way or the other. Mathematics, in general, and the partial differential equations, in particular play a key role in describing several laws of nature and in the design and development of technologies for the future.

I am confident that the conference will provide a unique platform for academia, industry professionals, researchers and students, for fruitful deliberations and exchange of ideas in the emerging areas of Mathematics. I am sure that the recommendations from the conference will go a long way in defining the applications of partial differential equations to solve many problems in the society thereby improving the living standards.

I extend my warm greeting and felicitations to the organizers and the participants and wish the conference a grand success.

(Prof. Manoj K Arora)

Message from the Dean & Conference Chairperson

Prof. Anirban Chakraborti
Chairperson (ICCPDEA-2022)
Dean (Research) & Dean (School of Engineering & Technology),
BML Munjal University

I am delighted that the School of Engineering & Technology (SoET), BML Munjal University is organizing the *International Conference on Computational Partial Differential Equations and Applications (ICCPDEA-2022)* during September 06-08, 2022. Partial differential equations and their applications play a significant role in establishing new frontiers, innovations and discoveries in academia, research, industry, and other important technological inventions. I am confident that this conference will serve as a bridge to bring mathematicians from all over the world together and provide a common platform for them to share their latest research and inventions in the field of computational partial differential equations. It will also encourage young and aspiring mathematicians to share their valuable ideas and theories during this conference.

I wish the conference and all participants great success in their endeavors.

(Prof. Anirban Chakraborti)

Message from the Conference Chairperson

Prof. Neela Nataraj
Chairperson (ICCPDEA-2022)
Institute Chair Professor & Dean (Faculty Affairs)
Indian Institute of Technology Bombay, Mumbai, India

It gives me immense pleasure to be part of the International Conference on Computational Partial Differential Equations and Applications (ICCPDEA-2022), being organized by the Department of Applied Sciences of BML Munjal University during September 06-08, 2022. I sincerely thank the plenary and invited speakers, delegates from industry and academia, and all participants from India and abroad for attending the conference. I extend a warm welcome to one and all!

I believe this international conference will bring together experts working in the area of 'computational PDEs' nationally and internationally and provide an excellent opportunity for researchers, scientists, and industrialists to engage and interact effectively on the latest developments in the field of 'computational PDEs'. I hope the conference will be a fantastic platform for forging new academic and industrial collaborations.

I place on record due appreciation to the members of the organizing team and the members of various committees for their sincere efforts. I wish all the participants intense and rewarding scientific discussions, networking, and a pleasant stay at the BML Munjal University!

(Prof. Neela Nataraj)

About BMU

BML Munjal University (BMU) is an initiative by the founders of the Hero Group. The university offers undergraduate and/or postgraduate programs in Engineering, Management & Commerce and provides avenues for research in all the schools. BMU has created a unique teaching learning pedagogy based on *5 'i' principles* namely *information, inquiry, innovation, implementation & impact* derived from the *3* '*i*'s founding i.e., *inquiry, innovation, and impact* with a strong emphasis on immersive multidisciplinary approach ensuring that close to 50% is experiential learning.

BMU aims to be a leading university for the quality and impact of its teaching, research, and linkages with major stakeholders. The focus of the university is to find creative solutions to problems through application of knowledge. The university aims to create a talented community of students and faculty who excel in teaching, learning and research, in a creative and stimulating environment. It collaborates with other institutions for development of science, technology, and arts in the global context.

School of Engineering & Technology (SOET)

SOET offers B.Tech. programs in *CSE, CSC, ME, & ECE.* The innovative and cutting-edge B. Tech. programmes have been a special interest to students who wish to be a part of a close-knit community of 'thinkers' and 'doers'; who have an aptitude for engineering applications, interest in research, and want to bring about a change in the world. Over the years the graduates from SOET are designing and building outstanding solutions, creating, and managing enterprises for the development of the global economy. It has gained immensely for a strong Industry-Academia collaboration which includes over 15 labs and courses with Industries such as Siemens, Shell, IBM, KPMG, Hero, Intel, Axis and TI. Further, the university works with over 200+ companies to ensure experiential learning in collaboration with Industries, the students undergoing Engineering programs would work for over 30 weeks in Industry before they finish their B. Tech Program. Additionally, SOET's curriculum structure and the research environment enable a creative & conducive environment for nurturing the spirit of enquiry, creativity, problem-solving, innovation and entrepreneurship focused on Sustainable and Inclusive Development. Centers of Excellence and state-of-the-art Labs have been set up on the BMU campus by Siemens, Shell, Intel, IBM. Eminent Institution & Organisations such as: BMU's Research Partners are Fraunhofer Gesellschaft, CSIR, CEERI-India, Hero MotoCorp.

School of Management (SOM)

SOM offers various courses in MBA and BBA with specializations in Finance, Marketing, Human Resources, Operations, and Business Analytics. The MBA programmes at BMU take a long-term view of business education and prepare students for long and fulfilling careers. Mentored by *Imperial College, London* the university's multi-disciplinary, application-based curriculum, has been providing life skills and practical knowledge for innovators, thought-leaders, and entrepreneurs. Our students have been reinventing the future of doing business in new ways. Through various specializations, SOM has been successfully teaching every candidate to thrive in the complex business environment of their respective field of specialization, to emerge as leaders in their domain. Collaborating with renowned universities such as Singapore Management University, Carleton University, Kent State University, University of California, Berkeley, Aston University, North South University, Loughborough University, CUOA University, University of Warwick, University of North Georgia, University of Michigan-Flint and Saint Mary's College of California has played an important role in enhancing student learning experience.

School of Law (SOL)

In an increasingly complex and interconnected world where efforts to understand and define the changing dynamics of economic, technological, and financial environments are already underway, lawyers need to equip themselves with additional knowledge of business management, commerce and policy making. SOL developed a curriculum in consultation with leading practitioners in the field to ensure that the students approach law not merely as an academic subject to be mastered but as budding practitioners learning the skills of the trade. B.A., LL.B. (Hons.) programs are providing a multi-dimensional approach to understanding law through the study of History, Political Science, Sociology and Economics.

Research at BMU

At BMU research is an integral part of all teaching, learning, industrial and societal engagements. The special focus on R&D is to develop and deliver sustainable and Inclusive Innovation. The university is in the process of fully operationalizing its **I**nstitute for **I**nclusive **I**nnovation. Prominent research fields where University Faculty is indulged are Applied Physics, Chemistry, Mathematics, Biology and Computer Sciences. BMU has established advanced technology research centers in areas including:

- ***Center for Advanced Materials and Devices (CAMD)*** for developing advanced materials, sensors and ICs, using novel materials including polymer, amorphous semiconductors, metal oxide, nanomaterials and surface engineering.
- ***Siemens Center of Excellence in Automation, Mechatronics and Robotics (ARM)*** to work in the areas of Product Development, Advanced Manufacturing, Automation, Instrumentation, Mechatronics, 3D Printing and Micro-machining.
- ***ICT enabled platforms*** for activities including High Performance Computing, IoT, Analytics, Marketing, Cloud Computing, Mobility and Social Media.
- ***HPC Server:*** The University has a central high performance computing cluster namely the **SuperHero**. The SuperHero consists of 6 compute nodes (1 master and 5 slave). Each node is a dual core Intel Xeon 4116 processor with 20 cores on each processor (total 120 cores) powered by Intel Cluster Management Studio. The available memory on each node is 96GB with a total of 576 GB RAM along with 24TB IB enabled shared storage.
- ***GPU Server:*** The University also hosts another central facility for high performance computations namely the GPU Server which was established in Dec 2021. The GPU server consists of 2 Graphics cards (of 24GB memory each) which belong to the ZOTAC GeForce RTX 3090 Trinity series based on the NVIDIA Ampere architecture. Built with enhanced RT Cores and Tensor Cores, new streaming multiprocessors, and superfast GDDR6X memory, the RTX 3090 Trinity gives rise to the amplified computing and gaming experience with ultra-graphics fidelity. Some key features of the GPU server include:
    - 2nd Gen Ray Tracing Cores
    - 3rd Gen Tensor Cores
    - SPECTRA 2.0 RGB Lighting
    - IceStorm 2.0 Advanced Cooling
    - NVIDIA NVLink (SLI-ready), VR Ready

  Total available memory on the GPU server is 128 GB along with 4TB SSD storage for fast data transmission. The users can exploit the massively parallel processing power of the GPU server together with CUDA or OpenCL for high end simulations purposes.

These facilities are geared to not only impart experiential learning to students, but also provide a platform for research to students and faculty. Further, the centers also provide the scope to work with industries from skill development to incremental innovation, consultancy and joint R&D including disruptive technology development.

BMU has 3 state-of-the-art centres for carrying out cutting edge and advanced research:

1. **Centre for Computational and Complexity Sciences (CCCS)** aims to foster the research collaborations in cutting-edge areas of complex systems. The centre will be focused on achieving scientific breakthroughs by addressing the challenges from the perspective of complex systems. The centre aims to facilitate cross disciplinary research and educational opportunities in the area of non-linear and adaptive systems. Research areas which are aimed at this centre viz., Computational Neuroscience, Stochastic Modeling, Statistical Modeling, Mathematical Modeling, Econo-Physics and Socio-Physics, Pattern Recognition, Network Theory, Geospatial Science, Renewable Energy Systems.

2. **Centre for Teaching and Learning (CTL)** is a new age centre of Excellence that supports and accredits the academic and professional development of new and in-service faculty members, which in turn enhances the experience of learners in higher education. The centre provides a dynamic forum for a community of competent, thoughtful practitioners to share ideas and to develop a discourse to reflect upon teaching, learning and academic practice and experience, and to challenge each other's thinking in a supportive and committed environment.

3. **Centre on Law, Regulation and Technology (CLRT)** advocates legal and economic regulation that places consumer welfare and innovation at the core of the modern economy. CLRT aims at blending academic rigour with policy research to inform decision making on economic activities related but not limited to telecommunications, new technology, and digitization. The centre endeavors to harness the process of digitization, through a robust legal and regulatory framework, towards ensuring welfare. Through its interdisciplinary research work, the centre aims to periodically contribute to policy discourse through reports, expert analysis, and research papers.

About the Conference

The International Conference on Computational Partial Differential Equations and Applications (ICCPDEA-2022) is being organized by the BML Munjal University. The conference aims at bringing together leading researchers from academia, industry and laboratories world-wide working in the diverse field of partial differential equations (PDEs) and their applications. The conference aims to disseminate knowledge on mathematical and computational aspects of partial differential equations and provide opportunities for collaboration and exchange of research ideas in the interdisciplinary field of partial differential equations, their solutions using advanced computational methods and applications in a variety of fields. The ICCPDEA-2022 will foster knowledge sharing, research, and skill enhancement among the participants.

The ICCPDEA-2022 will also honor Prof. A.K. Pani (IIT Bombay) and Prof. Carsten Carstensen (Humboldt-Universität zu Berlin) on the occasion of their 65th and 60th birthdays in a special session. The conference will feature plenary, and invited talks from eminent researchers, practitioners, senior mathematicians, and scientists from India and abroad. A number of contributed talks will also be presented by the young mathematicians and researchers in the conference.

A special session with industry experts is planned during the conference to listen and understand problems faced by industries in their respective domains and possible solutions using advanced computational and mathematical algorithms with particular focus on problems in Computer & IT industry, Electrical, Electronics Engineering, Telecommunications, Mechanical & Structural Engineering, Materials & Metallurgical Engineering, and Space industry.

This conference is the first of its kind in this part of the country where BML Munjal University is taking a lead to organize a meet of Mathematicians who are working in the domain of computational partial differential equations and numerical analysis. The national/local organizing committee of the conference is excited to host this conference since the outcomes of the conference will be immensely fertile and progressive for the researchers, academicians, scientists and speakers from the industry who are participating in the event from various parts of India and abroad to exchange and disseminate recent developments and advances in the field of computational partial differential equations and applications. As a results, new research directions and collaborations are expected to evolve. Young researchers will get motivation to pursue further research in related fields by using this platform as an opportunity by interacting with the leading experts who are working in the field of computational partial differential equations.

Committees

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- Dr. Akhlaq Husain, BML Munjal University Gurgaon, India
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- **Website Team**
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  - Rahul Saraf (B.Tech. CSE)

- **Conference Booklet (Editor)**
  - Dr. Deepti Sharma

Schedule of Events

Day #1 (Sep 06, 2022)		
Time	**Registration & Inaugural, Venue: Auditorium**	
08:30am-9:15am	Registration (Registration Desk)	
09:15am-10:00am	Opening Ceremony	
10:00am-10:20am	**High Tea (E2 Cafeteria)**	
Session-I	**Chair: Prof. Neela Nataraj, Venue: GBL-01**	
10:30am-11:15am	**Prof. Amiya K. Pani (PT1)** *(Title: Global stabilization of the Viscous Burgers' equation by nonlinear Neumann boundary feedback control: Theory and finite element analysis)*	
11:15am-12:00pm	**Prof. Carsten Carstensen (PT2)** *(Title: Towards adaptive hybrid high-order methods (HHO))*	
Session-II	**PS-I Chair: Prof. Prabha Sharma, Venue: HUB-A**	**PS-II Chair: Prof. Malay Banerjee, Venue: HUB-C**
12:00pm-12:30pm	**Prof. Rajen Sinha (IT1)** *(Title: Local a posteriori error estimates for boundary control problems governed by nonlinear parabolic equations)*	**Prof. Zhi Zhou (IT2)** *(Title: Numerical analysis of diffusion coefficient identification for elliptic and parabolic systems)*
12:30pm-1:00pm	**Prof. Thirupati Gudi (IT3)** *(Title: Dirichlet boundary optimal control problem: Energy space formulation and approximation)*	**Prof. Buyang Li (IT4)** *(Title: Exponential convolution quadrature for nonlinear subdiffusion equations with nonsmooth initial data)*
01:00pm-02:00pm	**Lunch Break (E2 Cafeteria)**	
Session-III	**Industry Session, Chair: Prof. A.K. Prasada Rao, Venue: GBL-01**	
02:00pm-02:15pm	**Mr. Nagendra Naram** (American Towers Corporation)	
02:15pm-02:30pm	**Mr. Devavrat Walinjkar** (CAIRN India, Oil & Gas Division of Vedanta Group)	
02:30pm-02:45pm	**Mr. Vikrant Singh** (BatX Energies)	
02:45pm-03:00pm	**Mr. Nagesh A.S.** (Hero Electric)	
Session-IV	**PS-I, Chair: Prof. Apala Majumdar, Venue: HUB-A**	**PS-II, Chair: Prof. Anil K. Pundir, Venue: HUB-C**

03:00pm-03:30pm	**Prof. Malay Banejree** (IT5) *(Title: Numerical detection of bifurcations of spatio-temporal patterns)*	**Prof. Aekta Aggarwal** (IT6) *(Title: Recent results in numerical approximations of hyperbolic systems)*
03:30pm-03:45pm	**Tea/Coffee Break (HUB Foyer)**	
Session-V	**Chair: Prof. Amiya K. Pani, Venue: GBL-01**	
03:45pm-04:30pm	**Prof. Daniele Boffi** (PT3) *(Title: On the coupling of fluids and solids)*	
04:30pm-05:15pm	**Prof. C.S. Upadhyay** (PT4) *(Title: Experiences with multi-scale modeling of the thermo-inelastic response of composite materials)*	
Session-VI	**Special Session (In honor of Prof. Amiya K. Pani & Prof. Carsten Carstensen)** **Chair: Prof. Neela Nataraj, Venue: GBL-01**	
05:15pm-07:00pm	Session for honoring/wishing Prof. Amiya K. Pani & Prof. Carsten Carstensen	
Conference Dinner (07:30pm-9:30pm), Venue: Red Fox Hotel, Bhiwadi		
Day #2 (Sep 07, 2022)		
Session-I	**Chair: Prof. Olivier Pironneau, Venue: GBL-01**	
09:00am-09:45am	**Prof. M. Vanninathan** (PT5) *(Title: Macro dispersion coefficients)*	
Session-II	**Chair: Prof. Daniele Boffi, Venue: GBL-01**	
09:45am-10:30am	**Francois Golse, Frederic Hecht, Olivier Pironneau, Pierre-Henri Tournier and Didier Smetz** (PT6) *(Title: Numerical Methods for the Radiative Transfer Equations for the Atmosphere)*	
Session-III	**PS-I, Chair: Prof. Thirupati Gudi, Venue: HUB-A**	**PS-II, Chair: Prof. Harish Kumar, Venue: HUB-C**
10:30am-11:00am	**Prof. Michele Ruggeri** (IT7) *(Title: Numerical methods for inertial spin dynamics in ferromagnets and antiferromagnets)*	**Prof. Utpal Manna** (IT8) *(Title: Wong-Zakai approximations in micromagnetism)*
11:00am-11:30am	**Prof. Heiko Gimperlin** (IT9) *(Title: Adaptive finite and boundary element methods for strongly nonlinear interface problems)*	**Prof. Apala Majumdar** (IT10) *(Title: Solution landscapes for nematic liquid crystals with elastic anisotropy in two dimensions)*
11:30am-11:40am	**Tea/Coffee Break (HUB Foyer)**	

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<tr><td>Session-IV</td><td colspan="3">Chair: Prof. C.S. Upadhyay, Venue: GBL-01</td></tr>
<tr><td>11:40am-12:25pm</td><td colspan="3">Prof. Rathish Kumar (PT8)
(Title: PDE Based Image Analysis: Theory, Computation and Application)</td></tr>
<tr><td>Session-V</td><td>PS-I, Chair: Prof. Michele Ruggeri, Venue: HUB-A</td><td colspan="2">PS-II, Chair: Prof. Apala Majumdar, Venue: HUB-C</td></tr>
<tr><td>12:25pm-12:55pm</td><td>Prof. Ricardo Ruiz Baier (IT11)
(Title: Mixed formulations for poroelasticity/free flow using total pressure)</td><td colspan="2">Prof. Harish Kumar (IT14)
(Title: High-order finite-difference entropy stable schemes for two-fluid relativistic plasma flow equations)</td></tr>
<tr><td>12:55pm-01:25pm</td><td>Prof. Dietmar Gallistl (IT13)
(Title: Convergence of a regularized finite element discretization of the two–dimensional Monge–Ampere equation)</td><td colspan="2">Dr. Akhlaq Husain
(Title: Spectral element methods for 3D elliptic problems on non-smooth domains)</td></tr>
<tr><td>01:25pm-02:15pm</td><td colspan="3">Lunch Break (E2 Cafeteria)</td></tr>
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<tr><td>Session-VI</td><td colspan="3">Chair: Prof. Rajen K. Sinha, Venue: GBL-01</td></tr>
<tr><td>02:15pm-03:00pm</td><td colspan="3">Prof. S. Sundar (PT7)
(Title: Modelling pedestrian crowd dynamics and interaction with obstacles)</td></tr>
<tr><td>Session-VII</td><td>PS-I, Chair: Prof. Arbaz Khan, Venue: HUB-A</td><td>PS-II, Chair: Prof. Utpal Manna, Venue: Hub-B</td><td>PS-III, Chair: Prof. Subhashree M., Venue: HUB-C</td></tr>
<tr><td>03:00pm-03:20pm</td><td>Prof. Dhanumjaya Palla (ET1)
(Title: Orthogonal spline collocation method for two-dimensional Helmholtz problems with interfaces)</td><td>Prof. Anil K. Pundir (ET2)
(Title: Virtual element methods for optimal control problems involving elliptic partial differential equations)</td><td>Prof. Sarvesh Kumar (ET3)
(Title: Three and four fields mixed formulations in poroelasticity)</td></tr>
<tr><td>03:20pm-03:40pm</td><td>Prof. Lokpati Tripathi (ET4)
(Title: An H^1-Galerkin mixed FEM for time fractional partial differential equations with an application to finance)</td><td>Prof. Asha Kisan Dond (ET5)
(Title: A posteriori error analysis for a distributed optimal control problem governed by the Von Karman equation)</td><td>Prof. Saumya Bajpai (ET6)
(Title: A three-step two-grid finite element method for the Boussinesq system of equations)</td></tr>
<tr><td>03:40pm-04:00pm</td><td colspan="3">Tea/Coffee Break (HUB Foyer)</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td>Session-VIII</td><td colspan="3">Chair: Prof. Daniele Boffi, Venue: GBL-01</td></tr>
<tr><td>04:00pm-04:45pm</td><td colspan="3">Prof. E.J. Park (PT9)
(Title: Polygonal staggered Galerkin methods)</td></tr>
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Session-IX	**Industry Session, Chair: Prof. A.K. Prasada Rao, Venue: GBL-01**		
04:45pm-05:00pm	**Mr. Manu J. Nair** (EtherealX)		
Session-X	**PS-I, Chair: Prof. Neela Nataraj, Venue: HUB-A**	**PS-II, Chair: Prof. Harsha Hutridurga, Venue: HUB-B**	**PS-III, Chair: Prof. Subhashree M., Venue: HUB-C**
05:00pm-05:15pm	**Mr. Benedikt Gräßle HU** (CT1) *(Title: Stabilization-free reliable and efficient a posteriori error control for HHO)*	**Mr. James Dalby** (CT2) *(Title: One-dimensional ferronematics in a channel: order reconstruction, bifurcations and multistability)*	**Mr. Kallol Ray** (CT3) *(Title: A three step two-grid method for discontinuous Galerkin approximations to the time-dependent incompressible Navier-Stokes equations)*
05:15pm-05:30pm	**Mr. Swapnil Kale** (CT4) *(Title: Penalized domain embedding method to solve PDEs over curved domains with structured triangular mesh)*	**Mr. Wasim Akram** (CT5) *(Title: Feedback stabilization of a parabolic coupled system and its numerical study)*	**Ms. Swati** (CT6) *(Title: Lie symmetry reduction, optimal system, analytical solutions and conservation laws of Rosenau regularized long wave equation)*
05:30pm-05:45pm	**Ms. Aliya Kazmi** (CT7) *(Title: Least-squares spectral element preconditioners for elliptic boundary layer problems)*	**Dr. Bishnu Ghosh** (CT8) *(Title: A novel numerical scheme for 2D quasi-linear hyperbolic equation on an irrational domain: Application to uniform transmission line equation)*	**Dr. S. Karthikeyan** (CT9) *(Title: Lie group analysis of the effects of radiation on free convective heat and mass transfer flow upon an inclined stretched surface)*
Session-XI	**Chair: Prof. E. J. Park, Venue: GBL-01**		
05:45pm-06:30pm	**Prof. Graeme Fairweather** (PT10) *(Title: The reformulation and numerical solution of some nonclassical boundary value problems and initial/boundary value problems)*		
Session-XII	**Chair: Prof. Arbaz Khan, Venue: GBL-01**		
06:30pm-07:00pm	**Prof. David Mora H.** (IT15) *(Title: A virtual element method for problems in fluid mechanics)*		
Cultural Program (BMU Student Clubs) (07:00pm-8:00pm)			
Dinner (E2 Cafeteria) (08:00pm-09:30pm)			
Day #3 (Sep 08, 2022)			
Session-I	**Chair: Prof. Thirupati Gudi, Venue: HUB-A**		
09:00am-09:45am	**Prof. G.P. Raja Sekhar** (PT11) *(Title: Mathematical modeling of multi-phase flow models in oil reservoirs)*		

Session-II	**Chair: Prof. Utpal Manna, Venue: GBL-01**		
09:45am-10:30am	**Prof. Zhonghua Qiao** (PT12) *(Title: Energy stability and error analysis of a maximum bound principle preserving scheme for the dynamical Ginzburg-Landau equations of Super conductivity)*		
Session-III	**PS-I, Chair: Prof. Apala Majumdar, Venue: HUB-A**	**PS-II, Chair: Prof. Aekta Aggarwal, Venue: HUB-C**	
10:30am-11:00am	**Prof. Harsha Hutridurga** (IT16) *(Title: Convergence to equilibrium in degenerate systems)*	**Prof. Arbaz Khan** (IT17) *(Title: Stochastic Mixed Finite element approximation for linear elasticity with uncertain inputs)*	
11:00am-11:20am	**Tea/Coffee Break (HUB Foyer)**		
Session-IV	**PS-I, Chair: Prof. Saumya Bajpai, Venue: HUB-A**	**PS-II, Chair: Prof. Asha Kisan Dond, Venue: Hub-B**	**PS-III, Chair: Prof. Dhanumjaya P., Venue: HUB-C**
11:20am-11:40am	**Dr. Ajit Patel** (ET7) *(Title: Primal hybrid method for quasilinear parabolic problems)*	**Dr. Rekha Khot** (ET8) *(Title: Nonconforming virtual elements for the biharmonic equation with Morley degrees of freedom on polygonal meshes)*	**Dr. Deepjyoti Goswami** (ET9) *(Title: Discontinuous Galerkin finite element error analysis for Oldroyd model of order one)*
11:40am-12:00pm	**Dr. Sangita Yadav** (ET10) *(Title: HDG method for non-linear Klein-Gordon equations)*	**Dr. Gaddam Sharat** (ET11) *(Title: A C^0 interior penalty method for the von Karman obstacle problem)*	**Dr. Avijit Das** (ET12) *(Title: An efficient DWR-type a posteriori error bound of SDFEM for singularly perturbed convection-diffusion PDEs)*
Session-V	**Chair: Prof. Carsten Carstensen, Venue: GBL-01**		
12:00pm-12:45pm	**Prof. Alexandre Ern** (PT13) *(Title: Hybrid high-order methods for the biharmonic problem)*		
12:45pm-02:00pm	**Lunch Break (E2 Cafeteria)**		
Session-VI	**PS-I, Chair: Prof. Neela Nataraj, Venue: HUB-A**	**PS-II, Chair: Prof. Prof. Lokpati Tripathi, Venue: HUB-B**	**PS-III, Chair: Prof. Subhashree M., Venue: HUB-C**
02:00pm-02:15pm	**Mr. Joydev Haldar** (CT10) *(Title: A stable scheme to McKendrick-Von Foerster equation with diffusion)*	**Mr. Pradeep Sahu** (CT11) *(Title: Modified wave numbers for fractional derivatives)*	**Dr. Shantiram Mahata** (ET13) *(Title: Nonsmooth data optimal error estimates by*

02:15pm-02:30pm	**Mr. Aniruddha Seal** (CT12) *(Title: Convergence analysis of a second-order scheme for fractional differential equations with integral boundary conditions)*	**Ms. Jaspreet Kaur** (CT13) *(Title: An efficient numerical method for time-fractional Black-Scholes equation arising in finance)*	*energy arguments for subdiffusion equations with memory)*
02:30pm-02:45pm	**Mr. Bikram Bir** (CT14) *(Title: A penalized finite element method for the Oldroyd model of order one)*	**Ms. Sushmita Anand** (CT15) *(Title: Solitary wave solutions of the Degasperis-Procesi equation via Lie symmetry approach)*	**Mr. Krishan Kumar** (CT16) *(Title: Discontinuous Galerkin method for the Vlasov-Burgers equation)*
02:45pm-03:00pm	**Ms. Garima** (CT17) *(Title: Numerical method for 2D elliptical singularly perturbed problem with shifts of mixed type)*	**Mr. Tarun Sharma** (CT18) *(Title: Fractional Kirchhoff Hardy problems with weighted Choquard and singular nonlinearity)*	**Mr. Jai Tushar** (C19) *(Title: Virtual element methods for general linear elliptic interface problems on polygonal meshes with small edges)*
03:00pm-03:15pm	**Ms. Shweta** (CT20) *(Title: Evolution of shock waves in non-ideal gas with interstellar gas clouds)*	**Mr. Gaurav** (CT21) *(Title: On the existence of Simple Waves for 2-D non-ideal Magneto-hydrodynamics)*	**Ms. Neha Trivedi** (CT22) *(Title: Study of three collinear cracks in a composite medium)*
03:15pm-03:30pm	**Ms. Jyoti Jaglan** (CT23) *(Title: A new strong stability preserving multiderivative time marching method for stiff reaction diffusion systems)*	**Ms. Ravina Shokeen** (CT24) *(Title: Primal Hybrid Method for Strongly Non-linear Parabolic Problems)*	**Ms. Jyoti Yadav** (CT25) *(Title: An approximate analytical approach of generalized Boussinesq equation by variational iteration method)*
03:30pm-03:45pm	**Tea/Coffee Break (HUB Foyer)**		
Session-VII	**Chair: Convenors, Auditorium**		
03:45pm-04:15pm	**Closing Ceremony**		

Abbreviations: **PT:** Plenary Talk | **IT:** Invited Talk | **ET:** Exclusive Talk | **CT:** Contributed Talk

Plenary Speakers

Hybrid High-Order Methods for the Biharmonic Problem

Prof. Alexandre Ern
Université Paris-Est, Paris, France

Brief Bio

Prof. Alexandre Ern is a researcher at Universite Paris-Est, CERMICS, a Professor at Ecole des Ponts ParisTech and Associate Professor at Ecole Polytechnique. His research interest includes numerical methods (finite elements, DG, structure-preserving discretization), fluid and solid mechanics, environmental flows (hydrology, porous media). He is a member of the editorial boards of several high quality journals including SIAM, IMA, JSC, CMAM etc. He is the author of several books including the three-volume book on finite elements (Springer). He has guided many PhD and postdoctoral students.

Abstract

We start with a gentle introduction to the devising and analysis of hybrid high-order (HHO) methods for the Poisson model problem. Then, we address the biharmonic problem and we compare the proposed HHO methods to the literature, in particular to weak Galerkin methods. Finally, we briefly discuss how the error analysis can be carried out in the case of an exact solution with low regularity.

Global Stabilization of the Viscous Burger's Equation by Nonlinear Neumann Boundary Feedback Control: Theory and Finite Element Analysis

Prof. Amiya K. Pani
Indian Institute of Technology Bombay, India

Brief Bio

Prof. Amiya. K. Pani was the Institute Chair Professor at Indian Institute of Technology, Bombay. He received his PhD degree from Indian Institute of Technology, Kanpur. His research interest is primarily in the area of numerical approximations of partial differential equations. His expertise includes construction, stability and convergence analysis of finite element methods, finite difference schemes, orthogonal spline collocation methods for free boundary problems, partial integro differential equations, coupled equations in oil reservoir studies, evolutionary variational inequalities and scientific computations for industrial applications. He is currently working as a Professor in Department of Mathematics, BITS - Pilani, Goa campus.

Abstract
Starting with the objective of Computational PDEs, we plan to motivate the talk through examining some numerical experiments using a proposed finite element algorithm. In order to provide some mathematical justifications as to why numbers crunched by the said algorithm make sense, we discuss some global stabilization results for the viscous Burgers equation, say, around constant steady state solution using nonlinear Neumann boundary feedback laws. The feedback laws are derived using the classical approach of finding Lyapunov functional. Then, using C^0 −conforming finite elements, a priori error estimates for the state variable as well as for feedback control laws are established, which in turn repose faith on the numbers crunched by the proposed algorithm. This talk is concluded with some related problems.

PDE Based Image Analysis: Theory, Computation and Application

Prof. B. V. Rathish Kumar
Indian Institute of Technology Kanpur, India

Brief Bio
Prof. B.V. Rathish Kumar is a Professor in the Department of Mathematics and Statistics at Indian Institute of Technology Kanpur. He completed his PhD from SSSIHL, Prasanthi Nilayam. His areas of interest are parallel computing, numerical methods for PDEs, computational fluid dynamics, finite element analysis, image processing.

Abstract
Analysis of images is a very important aspect of various scientific and engineering applications. There are several approaches for image processing. Owing to the rich mathematical theory and insights that PDEs provide into the robust and efficient algorithmic development, the PDE route to image processing has become a topic of prime importance. In this talk, we will discuss in a nutshell some of the important theoretical and computational aspects of this approach with some suitable applications.

Towards Adaptive Hybrid High Order Methods (HHO)

Prof. Carsten Carstensen
Humboldt-Universität zu Berlin, Germany

Brief Bio

Prof. Carsten Carstensen is a Professor at Humboldt-Universität zu Berlin, Germany. His research interests are in applied and Numerical analysis. He was the Director of the Center for Computational Sciences at Humboldt-Universität from 01/2010-10/2014. He worked as Associate Professor at TU-Darmstadt (Germany), as Professor at Vienna University of Technology Austria and as Professor at the University of Kiel, Germany. He has been on the editorial boards of international journals of high repute including the SIAM Journal of Numerical analysis (2001-2013). He also worked as Research Professor at MSRI, Berkeley (USA).

Abstract

The novel methodology of skeletal schemes led to a new generation of nonstandard discretizations and HHO is one of many of those besides HDG, VEM, DPG that generalize naturally to nonlinear problems. Can a variational crime lead to discretizations superior to conforming ones? The key for the success of higher-order schemes is through adaptive mesh-refining and the basis of this is a reliable and efficient a posteriori error analysis. The later is a topic in its infancy at least for HHO [5]. While over-stabilization enables some progress for DG and VEM, it is a refined analysis [6] that makes a stabilization-free a posteriori error estimate possible for the HHO [1]. The presentation reports on recent progress for linear problems [1] and then focuses on two very different nonlinear applications within comparison to conforming FEM-- complementary advantages. The fine-tuned extra-stabilized direct computation of guaranteed lower eigenvalue bounds allows for optimal convergence rates of a variant of HHO [2]. The appealing robust parameter selection allows the adaptive computation with higher convergence rates in numerical benchmarks. The class of degenerate convex minimization problems with two-sided growth conditions and an appropriate convexity control [3,4] allows convergent adaptive mesh-refinement for the dual stress-type variable.

References

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Experiences with Multi-scale Modeling of the Thermo-inelastic Response of Composite Materials

Dr. C. S. Upadhyay
Indian Institute of Technology Kanpur, India

Brief Bio

Dr. C.S. Upadhyay is a Professor in the department of Aerospace Engineering at Indian Institute of Technology Kanpur. He completed his PhD from Texas A&M University. His research interests include solid mechanics, adaptive finite element methods, and structural optimization.

Abstract

The desire for speed, maneuverability and invincibility in modern vehicles has challenged material developers. Unidirectional, bi-directional, tri-directional and particulate polymer-matrix composites are increasingly used as materials of choice. For such heterogeneous materials, solving the usual equations of state is intractable thus forcing the adoption of methods of homogenization to get a macro-level effective homogeneous continuum.

Traditionally, several self-consistent methodologies were developed in the engineering community to obtain the macro-level effective material constants and equations of state. However, these methods were unable to give all the desired material constants. Further, these methods were unable to account for the inherent randomness in material distribution at the micro-level. Rigorous mathematical homogenization, based on asymptotic representation of the displacement and temperature fields, allows us to study this local material randomness. In this presentation, an overview of our efforts at understanding interior asymptotic analysis, along with its extension to the domain boundary and material interfaces will be presented. The results are very interesting and promise to aid in better design of interfaces.

The final part of the presentation will dwell on modeling of progressive damage in heterogeneous materials. The versatility of the multi-scale method developed will be demonstrated through application to a wide variety of engineering design problems.

On the Coupling of Fluids and Solids

Prof. Daniele Boffi
King Abdullah University of Science and Technology, KSA

Brief Bio

Daniele Boffi is a Professor of Numerical Analysis who has now joined the KAUST Computer, Electrical and Mathematical Sciences and Engineering (CEMSE) Division. He received his PhD in Mathematics from UnIPV, with a thesis on "Mixed finite elements for the Stokes problem," in 1996. His research interests are related to the numerical approximation of partial differential equations. His expertise includes the finite element methods, mixed finite elements, the numerical approximation of eigenvalue problems. His research is mainly applied to fluid-dynamics, interactions of fluids and structures, and electromagnetism.

Abstract

During the last years, the author and his collaborators have developed a numerical model for the simulation of fluid-structure interaction problems. Starting from the Immersed Boundary Method, our technology is now cast in the framework of a fictitious domain approach. The numerical simulation is based on the introduction of two fixed meshes: the first one corresponds to the fluid domain, extended into the solid one, and the second one is defined on the reference configuration of the solid domain. The coupling between the two is taken care of by a distributed Lagrange multiplier which is defined on the solid domain. In this talk we recall some theoretical results, including existence and uniqueness of the continuous solution for a linearized problem and the compatibility conditions for the finite element spaces, and discuss some implementation details related to the coupling between the fluid and the solid mesh.

Polygonal Staggered Galerkin Methods

Prof. Eun-Jae Park
Yonsei University, Seoul, Korea

Brief Bio

Eun-Jae Park is a Professor in the School of Mathematics and Computing (Computational Science & Engineering) at Yonsei University in Seoul, Korea. He earned his PhD in Mathematics from Purdue University in 1993 and has held visiting positions at the University of Trento, Italy (1994-1996), University of Wyoming (1996-1997), and University of Texas Austin (2006-2007). Currently, he is the director of the Brain Korea 21 Program: Yonsei Mathematical Sciences and Computation. His research interests include computational methods for partial differential equations such as locally conservative methods, polygonal and adaptive finite elements, domain decomposition, multiscale computation, and uncertainty quantification.

Abstract

In this talk, we first present the staggered discontinuous Galerkin method on general meshes for the Poisson equation [1]. Adaptive mesh refinement is an attractive tool for general meshes due to their flexibility and simplicity in handling hanging nodes. We derive a simple residual-type error estimator. Numerical results indicate that optimal convergence can be achieved for both the potential and vector variables, and the singularity can be well captured by the proposed error estimator. Then, some applications [2, 3, 4, 5] to interface problems are considered such as coupling of Darcy-Forchheimer and Stokes equations, and a single-phase flow in porous media with a fracture. In the case of s fractured porous media [5], the bulk variables are solved using staggered DG method and an interface variable is solved using the continuous Galerkin method. We derive optimal convergence for both pressure and velocity fields. Numerical experiments suggest that our method is more accurate when polygonal meshes are used among various mesh configurations; moreover, our method is robust to mesh distortion. These observations allow us to consider unfitted methods without any special treatment. With background meshes generated independent of fracture, numerical solutions converge in optimal order.

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Mathematical Modeling of Multi-Phase Flow Models in Oil Reservoirs

Prof. G. P. Raja Sekhar
Indian Institute of Technology Kharagpur, India

Brief Bio

G. P. Raja Sekhar is a Professor of Mathematics at Indian Institute of Technology Kharagpur, India. He works on viscous flows and flow through porous media. In particular, his recent interests on thermocapillary migration of viscous droplets, hydrodynamics of swimming micro-organisms, modeling anisotropic porous media with specific applications to biological problems.

Abstract

This lecture introduces various real-life scenarios where two-phase flow can be seen. It gives various mathematical governing equations for flow through porous media, flow through oil reservoirs etc. where the solid skeleton is assumed to be a rigid non-deformable matrix. The talk then introduces multi-phase flow models applied to enhanced oil recovery, the role of heterogeneity and anisotropy will be discussed with specific models.

The Reformulation and Numerical Solution of Some Nonclassical Boundary Value Problems and Initial/boundary Value Problems

Dr. Graeme Fairweather
American Mathematical Society, Ann Arbor, Michigan, USA

Brief Bio

Dr. Fairweather was educated at the University of St. Andrews, Scotland. He held faculty positions at Rice University, the University of Kentucky and the Colorado School of Mines where he was Head of the Department of Mathematical and Computer Sciences for fourteen years. Lately, he served as Executive Editor of Mathematical Reviews, a division of the American Mathematical Society. His research interests are in numerical analysis and scientific computing.

Abstract

Several physical phenomena are modeled by boundary value problems for ordinary differential equations or by initial-boundary value problems for parabolic or hyperbolic partial differential equations which are categorized as nonclassical. For example, an integral over the spatial domain of a function of the desired solution and/or its first spatial partial derivative may appear in boundary conditions and /or in the governing differential equation itself. Problems of this type arise in such diverse areas as chemical diffusion, heat conduction, thermos-elasticity, population dynamics, vibration problems, nuclear reaction dynamics and certain biological processes. In general, nonclassical problems are either not in the form required by widely available general purpose software packages, or the application of such software for their solution would be cumbersome and/or inefficient. In this presentation, we examine several examples of nonclassical problems in one space variable and show how they may be converted to standard form. Numerical methods for the solution of two nonclassical problems involving the diffusion equation are discussed in detail.

Modeling Pedestrian Crowd Dynamics and Interaction with Obstacles

Prof. S. Sundar
Indian Institute of Technology Madras, India
Director, NIT Mizoram, India

Brief Bio

Prof. S. Sundar is the Director of NIT Mizoram and the Chair Professor at Indian Institute of Technology Madras. He received his PhD degree from IIT Madras. His main research interests are numerics for PDEs and mathematical modeling & numerical simulation.

Abstract

Predicting the pedestrian crowd dynamics and interaction of pedestrians with obstacles (such as vehicles on roads, gas, flood, fire etc) is a real challenge from the mathematical framework. Developing suitable and workable computational models are important today in order to have a precise prediction and set automated control and that helps for better city planning, evacuation plans, crowd control and so on. In this talk I will be presenting one of our recent works on aforementioned problems starting from modeling, analysis, setting appropriate computationally viable numerical schemes and simulation.

Macro Dispersion Coefficients

Prof. M. Vanninathan
Tata Institute of Fundamental Research Bangalore, India

Brief Bio

Prof. Vanninathan did his PhD from University Pierre et Marie Curie, Paris, France in 1979. He was a researcher at Centre of Applicable Mathematics, Tata Institute of Fundamental Research, Bengaluru until his superannuation in 2016. He got an extended academic life at IIT-Bombay before his retirement in 2021. During his academic career he was elected Fellow of Academy of Sciences, Bengaluru. His research interests include PDE: Homogenization, control, fluid-structure interaction etc.

Abstract

In this talk, we consider two methods of homogenization of periodic structures: two-scale asymptotic expansion (TS) and Bloch wave expansion (BW). It is well-known that the coefficients in the first terms of these expansions coincide showing that the effective coefficients of diffusion are well-defined independently of the methods. It is then natural to compare higher order terms in both expansions. Somewhat surprisingly, the homogenized fourth-order tensor of TS is not equal to the fourth-order tensor arising in the BW in the elliptic case. However, for the wave equation driven by initial data, the two fourth-order tensors coincide so that an effective dispersion tensor is well-defined at macroscopic level independently of the methods.

Numerical Methods for the Radiative Transfer Equations for the Atmosphere

Prof. Olivier Pironneau
Université Pierre et Marie Curie (Paris VI), Paris, France

Brief Bio

Olivier Pironneau graduated from Ecole Polytechnique Paris and the University of California Berkeley with a PhD in Optimization and Control. He learned fluid mechanics at the University of Cambridge (UK) and Partial Differential Equations at INRIA, France. He became a University Professor first in Paris XIII in 1979 and then Paris VI-Sorbonne in 1985. He has been on the scientific board of many research institutions such INRIA, CNES, Sorbonne University, the Commission on Nuclear Waste CNE, the Natixis foundation, the Finnish Center for Supercomputing CSC; he was elected as a full member of Academie des Sciences in 2003. His scientific interests are at the triple point of applied Mathematics (partial differential equations, numerical methods, optimization), computer science and applied fields such as fluid mechanics, quantitative finance and lately, Radiative Transfer. He is the author of 6 books and more than 300 research papers.

Abstract

To study the temperature in a gas subjected to electromagnetic radiations, one may use the Radiative Transfer equations coupled with the Navier-Stokes equations. The problem has 7 dimensions; however, with minimal simplifications it is equivalent to a small number of integro-differential equations in 3 dimensions. We present the method and a numerical implementation using an H-matrix compression scheme. The result is very fast: 50K physical points, all directions of radiation and 680 frequencies require less than 5 minutes on an Apple M1 Laptop. The method is capable of handling variable absorption and scattering functions of spatial positions and frequencies. The implementation is done using htool[1], a matrix compression library interfaced with the PDE solver freefem++. Applications to the temperature in the French Chamonix valley are presented at different hours of the day with and without snow / clouds and with a variable absorption taken from the Gemini measurements. The result is precise enough to assert temperature differences due to increased absorption in the vibrational frequency subrange of greenhouse gasses.

Energy Stability and Error Analysis of a Maximum Bound Principle Preserving Scheme for the Dynamical Ginzburg-Landau Equations of Superconductivity

Prof. Zhonghua Qiao

Hong Kong Polytechnic University, Hong Kong

Brief Bio

Dr. Zhonghua Qiao is a Professor at the Hong Kong Polytechnic University. He obtained his PhD from Hong Kong Baptist University in 2006. He was a postdoctoral fellow at North Carolina State University in 2006-2008. His research focuses on Numerical analysis and scientific computing in general. Topics include adaptive grid methods, high-order methods, numerical solutions of nonlinear differential equations and computational fluid dynamics etc. He received the Early Career Award from the Hong Kong Research Grants Council (RGC) in 2013, the Hong Kong Mathematical Society Award for Young Scholars in 2018 and the RGC Research Fellow award in 2020.

Abstract

We focus on numerical study of the dynamical Ginzburg-Landau equations under the temporal gauge, and propose a decoupled numerical scheme based on the finite element method. For the variable A, the second type Nedelec element is employed for the space discretization and the backward Euler is applied for the time discretization where the nonlinear term is treated explicitly. For the order parameter, the first order exponential time differencing method is employed with the linear operator generated by the linear element method with lumping. The proposed numerical scheme is proved to preserve the discrete maximum bound principle for the order parameter and admit an unconditional energy decay property. An optimal error estimate is also given for the scheme which is verified by the numerical examples.

Invited Speakers

Solution Landscapes for Nematic Liquid Crystals with Elastic Anisotropy in Two Dimensions

Prof. Apala Majumdar
University of Strathclyde, UK

Brief Bio

Prof. Apala Majumdar is a Professor of Applied Mathematics in the University of Strathclyde, Glasgow, UK. She received her PhD in Applied Mathematics from the University of Bristol in 2006, supported by a CASE (Competitive Award in Science and Engineering) with Hewlett Packard. She subsequently worked as a research fellow at the University of Oxford, followed by her first faculty post at the University of Bath, and her move to Strathclyde in 2019. Her research has been supported by a prestigious research fellowship from the Engineering Physical Sciences Research Council and the Leverhulme Trust, and recognised by national prizes from the London Mathematical Society and the British Liquid Crystal Society.
More details about her research can be found at https://themajumdargroup.wordpress.com/

Abstract

We study the solution landscapes i.e., energy-minimizing and non-energy-minimizing solutions for a reduced Landau-de Gennes model applied to nematic liquid crystals on square domains, with tangent boundary conditions. The solution landscape is dictated by the critical points of a reduced Landau-de Gennes energy for the nematic order parameter, composed of an elastic energy density and a bulk thermotropic potential. We study the effects of elastic anisotropy, captured by a parameter L_2, on the solution landscapes. The Dirichlet energy density corresponds to $L_2 = 0$, and elastic anisotropy corresponds to non-zero values of this parameter. We study the asymptotic limits of small and large elastic anisotropy, and recover five classes of symmetric solution profiles with stable interior defects, including a novel "Constant" solution which is a largely constant solution with boundary layers near the square edges. We compute stability estimates for some solutions in terms of the anisotropy and geometrical parameter, supplemented by detailed bifurcation diagrams for the corresponding solution landscapes. In the case of elastic isotropy or the Dirichlet elastic energy density, we also compute error estimates for the finite-element (FEM) analysis of the reduced Landau-de Gennes model, and propose a novel abstract framework for the FEM analysis for variational models with Dirichlet elastic energy densities and polynomial potentials. This is joint work with Yucen Han, Lei Zhang, Joseph Harris, Neela Nataraj and Ruma Maity.

Stochastic Mixed Finite Element Approximation for Linear Elasticity with Uncertain Inputs

Prof. Arbaz Khan
Indian Institute of Technology Roorkee, India

Brief Bio

Prof. Arbaz Khan obtained his PhD from Indian Institute of Technology (IIT) Kanpur 2015. In his PhD work, he proposed a nonconforming least squares spectral element method for parabolic initial value problems with non-smooth data using parallel computers. From January to August 2015, he was working as an institute postdoc fellow at Department at the Aerospace Engineering, IIT Kanpur. From September 2015 to May 2017, he was working as a match postdoc fellow at the Mathematics Center, University of Heidelberg, Germany. From June 2017 to January 2020, he was working as a PDRA at the department of Mathematics, University of Manchester, UK. There, he completed projects based on Numerical analysis of adaptive UQ algorithms for PDEs with random inputs. He joined as an Assistant Professor IIT Roorkee in January, 2020. His research interests are numerical solutions of partial differential equations, scientific computing, parallel computing, numerical linear algebra, uncertainty quantification, stochastic partial differential equations.

Abstract

It is the aim of this talk to give an overview of some recent work [1], [2] on the use of stochastic Galerkin mixed finite element methods (SG-MFEMs) for parameter-dependent linear elasticity equations. Starting from a novel three-field PDE model in which the Young's modulus is represented as an affine function of a finite/countable set of parameters, we discuss SG-MFEM approximation and introduce a novel a posteriori error estimation scheme. We examine the error in the natural weighted norm with respect to which the weak formulation is stable. Exploiting the connection between this norm and the underlying PDE operator also leads to an efficient preconditioning strategy for the associated discrete problems. Unlike standard residual-based error estimation schemes, the proposed strategy requires the solution of auxiliary problems on carefully constructed detail spaces on both the spatial and parameter domains. We show that the proposed error estimator is reliable and efficient. The constants in the bounds are independent of the Poisson ratio as well as the SG-MFEM discretisation parameters, meaning that the estimator is robust in the incompressible limit. Finally, we also discuss proxies for the error reduction associated with potential enrichments of the SG-MFEM spaces and suggest how to use these to develop an adaptive algorithm that terminates when the estimated error falls below a user-prescribed tolerance.

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A Virtual Element Method for Problems in Fluid Mechanics

Prof. David Mora Herrera

Departamento de Matemática Universidad del Bío-Bío Concepción, Chile

Brief Bio

Prof. David Mora is a Professor at the Universidad del Bío-Bío, Concepción, Chile. His area of interest includes finite element methods, virtual element methods, numerical methods for eigenvalue problems, numerical methods applied to Models in fluid and solid mechanics.

Abstract

In this talk, we develop a virtual element discretization for the Brinkman equations formulated in terms of the stream-function of the velocity field. We write a variational formulation and propose a virtual element discretization of arbitrary order $k \geq 2$. The velocity is obtained as a postprocess from stream-function discrete and under standard assumptions on the computational domain we prove error estimates for the stream-function and velocity. Finally, we present some numerical results.

Convergence of a Regularized Finite Element Discretization of the Two-Dimensional Monge-Ampère Equation

Prof. Dietmar Gallistl

Friedrich-Schiller Universität Jena, Germany

Brief Bio

Prof. Dietmar Gallistl obtained his doctoral degree at Humboldt-Universität zu Berlin in 2014. Since 2019 he holds the Chair of Numerical Analysis at the University of Jena, Germany.

Abstract

This contribution proposes a regularization of the Monge–Ampere equation

$$\det D^2 u \ = \ f \text{ in } \Omega \quad \text{and} \quad u \ = \ g \text{ on } \partial\Omega.$$

in a planar convex domain Ω through uniformly elliptic Hamilton–Jacobi–Bellman equations. The regularized problem possesses a unique strong solution u_ϵ and is accessible to the discretization with finite elements. This work establishes locally uniform convergence of u_ϵ to the convex Alexandrov solution u to the Monge-Ampére equation as the regularization parameter ϵ approaches 0. A mixed finite element method for the approximation of u_ϵ is proposed, and the regularized finite element scheme is shown to be locally uniformly convergent. Numerical experiments provide empirical evidence for the efficient approximation of singular solutions u.

High-Order Finite-Difference Entropy Stable Schemes for Two-Fluid Relativistic Plasma Flow Equations

Prof. Harish Kumar
Indian Institute of Technology Delhi, India

Brief Bio
Prof. Harish Kumar is an Associate Professor in the Department of Mathematics, Indian Institute of Technology Delhi. He received his PhD from ETH Zurich in 2009.

Abstract
In this article, we propose high-order finite-difference entropy stable schemes for the two-fluid relativistic plasma flow equations. This is achieved by exploiting the structure of the equations, which consists of three independent flux components. The first two components describe the ion and electron flows, which are modeled using the relativistic hydrodynamics equation. The third component is Maxwell’s equations, which are linear systems. The coupling of the ion and electron flows, and electromagnetic fields is via source terms only. Furthermore, we also show that the source terms do not affect the entropy evolution. To design semi-discrete entropy stable schemes, we extend the RHD entropy stable schemes to three dimensions. This is then coupled with entropy stable discretization of Maxwell's equations. Finally, we use SSP-RK schemes to discretize in time. We also propose ARK-IMEX schemes to treat the stiff source terms; the resulting nonlinear set of algebraic equations is local (at each discretization point). These equations are solved using Newton's Method, which results in an efficient method. The proposed schemes are then tested using various test problems to demonstrate their stability, accuracy and efficiency.

Convergence to Equilibrium in Degenerate Systems

Prof. Harsha Hutridurga
Indian Institute of Technology Bombay, India

Brief Bio
Prof. Harsha Hutridurga is an Assistant Professor at the Indian Institute of Technology (IIT) Bombay. His research interests are in the theory of homogenization, mathematical statistical mechanics, theory of meta-materials and Numerical analysis. He is an applied Mathematician by training, with degrees from the Tata

Institute of Fundamental Research and the École Polytechnique. Before moving to IIT Bombay, he was a postdoctoral research fellow at the Imperial College London and in the Cambridge University.

Abstract
In this talk, we will address the large time behaviour of a reaction diffusion system involving degeneracies in diffusion. The nonlinearity of the system comes from mass action kinetics. We demonstrate that there is the so-called “Indirect diffusion effect”. More specifically, we show an effective diffusion for the non-diffusive species which is incurred by a combination of diffusion from diffusive species and reversible reaction between the species. We employ the celebrated entropy method to derive explicit convergence rates.

Adaptive Finite and Boundary Element Methods for Strongly Nonlinear Interface Problems

Prof. Heiko Gimperlein
Leopold-Franzens-Universitat Innsbruck, Innsbruck
Austria

Brief Bio
Dr. Heiko Gimperlein is a Professor of Engineering Mathematics at Leopold-Franzens-Universität Innsbruck Innsbruck, Austria. He has completed his PhD from Leibniz University Hannover, Germany. His research interest includes Partial differential equations and numerical analysis, in particular pseudodifferential and boundary integral operators, microlocal analysis, theoretical numerical analysis of boundary problems applications in engineering, computer science and the natural sciences. He has worked at Heriot-Watt University and Maxwell Institute for Mathematical Sciences as assistant professor/associate professor/ professor during 2013–2022 and as a postdoctoral fellow at the University of Copenhagen during July 2010–July 2013.

Abstract
We analyze adaptive finite element and boundary element formulations for nonlinear transmission and contact problems. In the model problem, the p-Laplacian or a double-well potential in a bounded domain Ω is coupled to the homogeneous Laplace equation in $\mathbb{R}^n \setminus \overline{\Omega}$. We discuss well-posedness, the appearance of microstructure in the nonconvex case and apriori/a posteriori error estimates for Galerkin approximations.

Exponential Convolution Quadrature for Nonlinear Subdiffusion Equations with Nonsmooth Initial Data

Prof. Li Buyang
Hong Kong Polytechnic University, Hongkong

Brief Bio

Prof. Li Buyang is an Associate Professor in the department of Applied Mathematics at the Hong Kong Polytechnic University. He has completed his PhD from City University of Hong Kong. His research interest includes Numerical methods and analysis for partial differential equations. He got first prize for young computational Mathematicians, awarded by China Society for Computational Mathematics, 2013 (at The 6th paper competition for young Computational Mathematicians, 12th National universities Annual Conference of Computational Mathematics).

Abstract

An exponential type of convolution quadrature is proposed as a time-stepping method for the nonlinear sub diffusion equation with bounded measurable initial data. The method combines contour integral representation of the solution, quadrature approximation of contour integrals, multistep exponential integrators for ordinary differential equations, and locally refined step sizes to resolve the initial singularity. The proposed k-step exponential convolution quadrature can have kth-order convergence for bounded measurable solutions of the nonlinear sub diffusion equation based on natural regularity of the solution with bounded measurable initial data.

Numerical Detection of Bifurcations of Spatio-Temporal Patterns

Prof. Malay Banerjee
Indian Institute of Technology Kanpur, India

Brief Bio

Prof. Malay Banerjee obtained his PhD from University of Calcutta in Applied Mathematics under the guidance of Prof. C. G. Chakrabarti. He served in Presidency College, Kolkata and Scottish Church College, Kolkata before joining Indian Institute of Technology (IIT), Kanpur. He joined IIT Kanpur in 2008. He is currently the Professor in the Dept. of Math. & Stat., IIT Kanpur and Shri Deva Raj Chair Prof. at IIT Kanpur. His main research interests are Nonlinear Dynamics, Mathematical Ecology and Epidemiology. He is an Associate Editor for Applied Mathematics and Computation, International Journal of Bifurcation & Chaos and Mathematical Modeling of Natural Phenomena. He is an editor for the Ecological Complexity and “Theoretical and Mathematical Ecology" section of the journal ‘Mathematics’.

Abstract
Self-organizing spatial patterns are produced by a wide range of spatio-temporal models for interacting populations distributed over their habitat. Turing instability is a well-known mechanism behind the formation of stationary spatial patterns by reaction-diffusion type equations of population biology. Main objective of this talk is to discuss the existence of various stationary patterns within a bounded domain and their bifurcation through numerical bifurcation analysis.

Numerical Methods for Inertial Spin Dynamics in Ferromagnets and Antiferromagnets

Prof. Michele Ruggeri
University of Strathclyde, UK

Brief Bio
Prof. Michele Ruggeri obtained his PhD in Technical Mathematics in 2016 from TU Wien (Vienna, Austria). Since January 2022, he has been a Strathclyde Chancellor’s Fellow at the Department of Mathematics and Statistics of the University of Strathclyde. His main research interest is the Numerical analysis of (nonlinear) partial differential equations in materials science and engineering, in particular in liquid crystal theory, micromagnetism and spintronics. He is also interested in fundamental questions in the analysis of finite element methods, uncertainty quantification and model order reduction methods.

Abstract
We consider the numerical approximation of inertial extensions of the Landau–Lifshitz–Gilbert (LLG) equation that are relevant for the modeling of the dynamics of the magnetization in ferromagnets at subpicosecond time scales and the dynamics of the order parameter (the so-called Nèel vector) describing the magnetic state of an antiferromagnet. To discretize the problems, we propose fully discrete numerical schemes, implicit in time and based on first-order finite elements in space, which preserve the inherent unit-length constraint of the extended LLG equations at the vertices of the underlying mesh, and generate approximations that converge towards weak solutions of the problems. Numerical experiments validate the theoretical results and show the applicability of the methods for the simulation of magnetic processes involving ferromagnets and antiferromagnets.

Local a Posteriori Error Estimates for Boundary Control Problems Governed by Nonlinear Parabolic Equations

Prof. Rajen Kumar Sinha
Indian Institute of Technology Guwahati, India

Brief Bio

Prof. Rajen Sinha is a Professor in the Department of Mathematics, Indian Institute of Technology Guwahati. His main research interests include finite element methods for PDEs and partial integro-differential equations; finite volume element methods; mixed finite element methods; interface problems; a posteriori error analysis; adaptive finite element methods; optimal control problems; composite finite element methods.

Abstract

In this talk we discuss some local a posteriori error estimates of finite element approximation to nonlinear parabolic boundary control problems in a bounded convex domain with Lipschitz boundary. We use piecewise linear and continuous finite elements for the approximation of the state and co-state variables, and the control variable is approximated by using the piecewise constant functions. The time discretization scheme is based on the backward Euler method. A reliable type local a posteriori error estimate for Neumann boundary control problems in the $L^2\left([0,T];L^2(\partial\Omega)\right)$ –norm is established. The derived estimators are of local character in the sense that the leading terms of the estimators depend on the small neighbourhood of the boundary. These new local a posteriori error bounds can be used to study the behaviour of the state and co-state variables near the boundary. We report numerical tests to illustrate the effectiveness of the error indicators.

Mixed Formulations for Poroelasticity/Free-Flow Using Total Pressure

Prof. Ricardo Ruiz Baier
Monash University, Australia

Brief Bio

Prof. Ricardo Ruiz Baier is an Associate Professor of Computational Mathematics at Monash, and has collaborated recently with Prof. Amiya K. Pani on the Numerical analysis of vorticity-based formulations for incompressible flow. He works on the design and analysis of numerical methods for partial differential equations. His areas of interest and expertise also include fundamental topics in scientific computing, as well as a number of applications such as multiphase flow and transport in porous media and cardiac electromechanics.

Abstract

We consider a multiphysics model for the flow of Newtonian fluid coupled with Biot consolidation equations through an interface and incorporating total pressure. A mixed-primal finite element scheme is proposed solving for the pairs fluid velocity - pressure and displacement - total poroelastic pressure using Stokes-stable elements, and where the formulation does not require Lagrange multipliers to set up the usual transmission conditions on the interface. We address the construction of suitable robust preconditioners in an abstract setting. Our numerical study is framed in the context of applicative problems pertaining to brain multiphysics.

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[2] Q. Hong, J. Kraus, J. Xu, and L. Zikatanov, A robust multigrid method for discontinuous Galerkin discretizations of Stokes and linear elasticity equations. Numer. Math. 132(1) (2016) 23–49.
[3] R. Ruiz-Baier, M. Taffetani, H. D. Westermeyer, and I. Yotov, The Biot–Stokes coupling using total pressure: formulation, analysis and application to interfacial flow in the eye. Comput. Methods Appl. Mech. Engrg., 389 (2022) e114384(1–30).

Dirichlet Boundary Optimal Control Problem: Energy Space Formulation and Approximation

Prof. Thirupathi Gudi
Indian Institute of Science Bangalore, India

Brief Bio

Prof. Thirupathi Gudi obtained his PhD from Indian Institute of Technology Bombay under the research guidance of Professor Amiya K. Pani and Professor Neela Nataraj. Post his PhD, he did his postdoctoral research under the direction of Professor Carsten Carstensen for six months. He was a distinguished postdoctoral fellow at the Center for Computations and Technology under the guidance of Professor Susanne C. Brenner. Since May 2010 he is a faculty member at the Department of Mathematics, Indian Institute of Science Bengaluru.

Abstract

We discuss the energy space-based formulation for the Dirichlet boundary optimal control problem. Finite element analysis for an unconstrained and constrained control problems will be discussed with further applications to a linear parabolic problem. The talk is based on the joint work with Sudipto Chowdhury, A. K. Nandakumaran, Ramesh Ch. Sau and Gouranga Mallick.

Wong-Zakai Approximations in Micromagnetism

Prof. Utpal Manna
Indian Institute of Science Education and Research
Thiruvananthapuram, India

Brief Bio

Dr. Utpal Manna is a Professor of Mathematics at the Indian Institute of Science Education and Research Thiruvananthapuram (IISERTVM), Kerala India. He obtained his PhD from the University of Wyoming, USA in the year 2007. Prior to joining IISERTVM in 2009 he was working as a post-doctoral fellow at the Max Planck Institute for Mathematics in the Sciences, Leipzig, Germany during, 2007-2009. His research includes stochastic partial differential equations stochastic analysis, Navier-Stokes equations, Landau-Lifshitz-Gilbert equations (ferromagnetism) and nematic liquid crystals.

Abstract

In this talk, we will consider the stochastic Landau-Lifshitz-Gilbert equation (SLLGE), which represents the magnetisation dynamics of ferromagnetic material below the Curie temperature. Firstly, by introducing a suitable transformation, we convert the SLLGE to a highly nonlinear time-dependent partial differential equation with random coefficients, which is not fully parabolic. We then prove that there exists a pathwise unique solution to this equation and that this solution enjoys the maximal regularity property. Following regular approximation of the Brownian motion and using reverse transformation, we show the existence of a strong solution of SLLGE taking values in a two-dimensional unit sphere in $\mathbb{R}^3$. The construction of the solution and its corresponding convergence results are based on Wong–Zakai approximation.

If time permits, we shall also discuss analogous results for the Landau-Lifshitz-Bloch equation, which represents the magnetisation dynamics of ferromagnetic material above the Curie temperature. The first part of the work is with Zdzislaw Brzezniak and Debopriya Mukherjee, and the last part is with Soham Gokhale.

Numerical Analysis of Diffusion Coefficient Identification for Elliptic and Parabolic Systems

Dr. Zhi Zhou
Hong Kong Polytechnic University, Hong Kong

Brief Bio

Dr. Zhi Zhou received his PhD degree in Mathematics from Texas A&M University in 2015. Previously, he was a postdoctoral scientist in the Department of applied Physics and applied Mathematics at Columbia University (2015-2017). He is currently an Assistant Professor in the Department of Applied Mathematics, The Hong Kong Polytechnic University. His research lies in broad areas of numerical modelling, simulation and analysis of partial differential equations.

Abstract

Parameter identifications for differential equations represent a wide class of inverse problems. Conventionally, this class of inverse problems could be solved via an optimization approach, which is then discretized for practical implementation for practical numerical implementation. Then one important issue is to derive a priori error estimates for the numerical reconstruction of the desired parameter. In this talk, we present our recent efforts to derive convergence rates for a discrete scheme for recovering a spatially dependent diffusion coefficient in an elliptic or parabolic type problem, by suitably exploiting relevant stability results.

Recent Results in Numerical Approximations of Hyperbolic Systems

Dr. Aekta Aggarwal

Indian Institute of Management, Indore, India

Brief Bio

Dr. Aekta Aggarwal is working as an Associate Professor in the Department of Operations Management and Quantitative Techniques Area, Indian Institute of Management, Indore. She holds a PhD in Mathematics from the Tata Institute of Fundamental Research Bengaluru and specializes in applied Mathematics. Prior to joining Tata Institute of Fundamental Research, she was a post-doctoral researcher in the team OPALE, INRIA, France, and worked on mathematical models of pedestrian and traffic flow. She holds an M.Sc. (Applied Mathematics) from TIFR, Bangalore, and B.A. (Hons.) in Mathematics from Lady Shri Ram College for Women, University of Delhi.

Abstract

The hyperbolic partial differential equations are known to model various physical phenomena. While the theoretical results for these systems remain quite limited, there have been some recent developments towards the numerical approximations of these systems. In this talk, we present some recent results, obtained for the models, modeling granular flow, traffic and cloud formation.

Industry Session

About the Session

The special industry session during the conference is aimed at listening and understanding problems faced by industry experts in their respective domains and possible solutions using advanced computational and mathematical algorithms with particular focus on problems in Computer & IT industry, Electrical & Electronics Engineering, Mechanical & Structural Engineering, Oil & Gas, Materials & Metallurgical Engineering and Space industry. It covers applications and relevance of Partial Differential Equations & Numerical Algorithms in the following industries:

- Mechanical/Automobile/Manufacturing/Design/Thermal: Challenges in electric vehicles design and development, Vibrations, Heat transfer, Acoustics, Fluid flows/ two-phase flows, elasticity problems, modelling/simulation of solid and structural mechanical problems
- Electrical/Electronics/Telecommunication: Electrical networks, signal processing, transmission lines, electrostatistics & electrodynamics
- Oil and gas industry: oil and gas dynamics, flow in reservoirs including simulations, modelling of petroleum extraction
- Aerospace: Aerodynamics, Propulsion, Structural dynamics

A platform to share and exchange ideas

Industry participants are expected to highlight problems which they are facing, particularly those that can be answered in the framework of mathematical and computational algorithms, partial differential equations (PDEs), mathematical simulation software and scientific computing. The industry participants need not to elaborate the problem as a mathematical model but a broad idea of the challenges they are facing so that the experts and researchers from academia can understand and try to provide an answer through a robust mathematical model and numerical algorithms using PDEs.

Specific topics relevant to the industry

The speakers (plenary, invited, exclusive and contributed talks) will broadly cover topics ranging in the interdisciplinary field of PDEs, Numerical Algorithms, Scientific computing which have vast applications and solutions to problems in Mechanical, Aerospace Engineering, Software & IT, Weather Forecasting, Environmental Engineering, Fluid Flows etc.

Industry Speakers

- **Mr. Nagendra Naram (American Towers Corporation)**

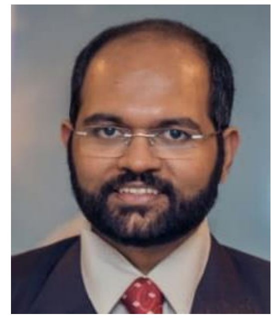
Brief Profile

Mr. Nagendra Naram has 30 years of industry experience spanned across Engineering, Chemical, Paints, Telecom, Information Technology and Telecom Infrastructure fields. He has worked with Kanpha Chemmo Organics Ltd, Asian Paints India Limited, Tata Cellular, D.E. Shaw & Co. Currently, he is working with American Tower Corporation (ATC) as National Deployment Head. ATC provides passive infrastructure support to Telecom companies viz. Airtel, Reliance Jio, BSNL, Vodafone, Idea. He has exposure in Project Management, Infra Development, Telecom and IT Facilities development, Plant Engineering, Operations and Maintenance, Business Development and P&L Management.

Educational qualifications of Mr. Nagendra include B.E. (Mech Engineering), M. Tech. (Industrial Engg. & Management), Diploma in Maintenance Management, M.I.E. (Mech), Chartered Engineer, and Executive MBA.

- **Mr. Nagesh A.S. (Hero Electric)**

Brief Profile



Mr. Nagesh is an automotive industry professional with a successful track record of leading multiple high-tech solutions from concept to mass market launch. A hands-on engineering leader, he has developed technologies for a broad range of automobiles ranging from trucks/ buses, to tractors, cars and two wheelers.
Currently he heads the Electrical & Electronics Research and Development at Hero Electric Vehicles Pvt. Ltd. His focus areas are electric powertrain, traction batteries and Internet of Things.
Nagesh has academic qualifications in Electronics, Computer science and Data science. He believes that industry-academia partnerships provide a win-win proposition for all involved and is an enthusiastic promoter of collaborations with universities.

- **Mr. Vikrant Singh (BatX Energies)**

Brief Profile

Vikrant Singh co-founded BatX Energies Pvt. Ltd. along with Utkarsh Singh in July 2020, with the aim to provide green solutions, taking care of nature by providing quality and sustainability. A seasoned entrepreneur, passionate for innovation and sustainability, and a brilliant young mind with an engineering background, Vikrant brings with him profound knowledge of energy storage and operational brilliance to implement it. Having envisaged that recycling of lithium-ion battery materials is the key for growth in electric transportation, he ensured that the company is committed towards a circular economy. With several accolades under his belt and profound engineering experience, Vikrant Singh is an impeccable personality to lead the EV revolution with his innovations. Vikrant is also the Co-Founder and Director (05/2019 - 07/2020) of Batene India Pvt. Ltd. Gurgaon, INDIA. He is recipient of several technology awards including the Best Safety Award (Hero Future Energy) and Best Innovation Award (Virtualis motorsports, 2017). He was the President and Vice President of the student run Automobile Club during his undergraduate studies at the BML Munjal University.

- **Mr. Manu J. Nair (EtherealX)**

Brief Profile

Manu is a Mechanical Engineer by qualification with a strong passion for space since his early days as an aspiring astronaut. Having published experimental research papers in Power Systems and Nano Science, Manu is now trained in Atmospheric Science, Solar Mechanics, and in operating Suborbital Spaceflight Airborne Imagery Equipment setup to capture Noctilucent Clouds in the upper mesosphere while having donned a pressurized Intra-vehicular Activity (IVA) Spacesuit. He is a Scientist-Astronaut Graduate of the prestigious project Polar Suborbital Science in the Upper Mesosphere (PoSSUM) - aeronomy research program of the International Institute for Astronautical Sciences. Manu has developed and managed strategic partnerships with satellite manufacturers, small launch vehicle manufacturers, and nationalized space agencies from across the globe. He has introduced new technology products such as Auxiliary Propulsion Systems (APS), Life Support Systems (LSS), Hybrid Propulsion, Retro Thrusters, and Ascent Propulsion. He was briefly a part of the Indian Space Research Organisation's (ISRO) Project Gaganyaan - India's first human spaceflight mission and program, in carrying out a live project developing the waste management system (WMS) for astronauts in microgravity. He has led a team for Bill Clinton's annual challenge of the Hult Prize in 2018 as a Global Regional Finalist in Singapore. He was the President (Student Council) during his undergraduate studies at the BML Munjal University.

- **Mr. Devavrat Walinjkar (CAIRN India, Oil & Gas Division of Vedanta Group)**

Brief Profile

Devavrat Walinjkar is a Management Professional with over 3 years of experience in the Natural Resources and Oil & Gas industry. Currently serving as the Lead – Strategy and Planning, Cairn Oil & Gas, he has worked across functions of Strategy, Planning, Operations, Projects and HR. Devavrat graduated in Metallurgical and Materials Engineering from IIT Kharagpur and MBA from IIM Ahmedabad.

Exclusive Talks

Primal Hybrid Method for Quasilinear Parabolic Problems

Ravina Shokeen[1], Ajit Patel[2], Amiya K Pani[3]
[1,2]The LNM Institute of Information technology, Jaipur
[3]Birla Institute of Technology and Science, Pilani - Goa Campus
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Abstract
In this article, a second order quasi-linear parabolic initial-boundary value problem is approximated by using primal hybrid finite element method and Lagrange multipliers. Semidiscrete and backward Euler based fully discrete schemes are discussed and optimal order error estimates are established by applying modified elliptic projection. Optimal order error estimates in maximum norm are also derived. Earlier results on maximum-norm superconvergence of the gradient in piecewise linear finite-element approximations of elliptic and parabolic problems are now carried over to the quasilinear case using the primal hybrid method. Finally, the results on numerical experiments confirm our theoretical findings.

Virtual Element Methods for Optimal Control Problems Involving Elliptic Partial Differential Equations

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Abstract
In this talk, I shall demonstrate virtual element methods for approximating the optimal control problem governed by the elliptic equation with distributed control. Virtual element discretization approaches are used for approximating the control variable, which depends on the state and costate variables appearing in the formulation. This approach seeks control approximation in a discrete virtual space consisting of polynomial and non-polynomial functions. Moreover, the discretize-then-optimize approach is used for the computation of optimal control when the virtual element method is employed for the control. A virtual element method is used to seek a numerical solution of state and costate equations, and optimal a priori error estimates are established in suitable norms for the state, adjoint, and control variables. Numerical experiments are conducted over various convex and concave polygonal meshes to verify the theoretical findings and robustness of the method under mesh distortion.

A Posteriori Error Analysis for a Distributed Optimal Control Problem Governed by the Von Kármán Equation

Sudipto Chowdhury[1], Asha K. Dond[2], Devika Shylaja[3], Neela Nataraj[4]
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Abstract
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 discretized using piecewise constant functions. The derived posteriori error estimates are efficient, and the numerical results confirm it.

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An efficient DWR-type a posteriori error bound of SDFEM for singularly perturbed convection-diffusion PDEs

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Abstract
This article deals with the residual-based a posteriori error estimation in the standard energy norm for the streamline-diffusion finite element method (SDFEM) for singularly perturbed convection-diffusion equations. The well-known dual-weighted residual (DWR) technique has been adopted to elevate the accuracy of the error estimator. Our main contribution is finding an efficient computable DWR-type robust residual-based a posteriori error bound for the SDFEM. The local lower error bound has also been provided. An adaptive mesh refinement algorithm has been addressed and lastly, some numerical experiments are carried out to justify the theoretical proofs.

Orthogonal Spline Collocation Method for Two-Dimensional Helmholtz Problems with Interfaces

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Abstract
Orthogonal spline collocation (OSC) is implemented for the numerical solution of $2D$ Helmholtz problems with discontinuous coefficients in the unit square. A matrix decomposition algorithm is used to solve the collocation matrix system at a cost of $O(N^2 \log N)$ on an $N \times N$ partition of the unit square. The results of numerical experiments demonstrate the efficacy of this approach, exhibiting optimal global estimates in various norms and super convergence phenomena for a broad spectrum of wave numbers.

Discontinuous Galerkin Finite Element Error Analysis for Oldroyd Model of Order One

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Abstract

In this paper, we apply a discontinuous finite element Galerkin method for the equations of motion arising in the $2D$ Oldroyd model of order one. We present new *a priori* and regularity results for the discontinuous solutions, and thereby show consistency and well-posedness of the discontinuous Galerkin (DG) scheme. We derive optimal error estimates in $L^\infty(L^2)$ –norms for the velocity and in $L^\infty(L^2)$ –norm for the pressure in the semi-discrete case with the initial data u and the source function f in $L^\infty(L^2)$ space. These estimates are established with the help of L^2 –projection and modified Stokes-Volterra operator on appropriate discontinuous Galerkin spaces, and with the standard duality arguments. Estimates are shown to be uniform under the smallness assumption on data. Then, a fully discrete scheme based on the backward Euler method is analyzed and optimal error estimates are derived. Finally numerical examples validate our theoretical findings.

Discontinuous Galerkin Method for the Vlasov-Burgers' Equation

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Abstract

In this talk, I will present our recent work dealing with approximating solutions to a system of differential equations modeling thin sprays. In this model, the spray particle distribution function satisfies a Vlasov-type equation whereas the background medium is modeled by the viscous Burgers' equation and the coupling is via a drag term. Our method of choice to approximate solutions to this system is the discontinuous Galerkin approach. Our numerical scheme is based on the coupling of discontinuous Galerkin approximation for the Vlasov equation and local discontinuous Galerkin approximation for the viscous Burgers' equation. In both these approximation schemes, we employ generalized numerical fluxes. I shall present results on optimal rates of convergence in the case of smooth compactly supported initial data, based on generalized Gauss-Radau projections.

An H^1-Galerkin Mixed FEM for Time Fractional Partial Differential Equations with an Application to Finance

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Abstract

In this talk, after a brief introduction to option derivatives and the time-fractional Black-Scholes model, we will be discussing an H^1-Galerkin mixed finite element method for approximating the solution of time-fractional partial differential equations. The talk will conclude with an application of the proposed method to the fractional Black-Scholes model for pricing European style options.

Nonconforming Virtual Elements for the Biharmonic Equation with Morley Degrees of Freedom on Polygonal Meshes

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Abstract
The lowest-order nonconforming virtual element is an extension of the Morley finite element on triangles to polygons. We approximate the weak solution to the biharmonic problem in a polygonal domain Ω with a general source function and discuss abstract framework, which fits to all available discrete spaces for nonconforming virtual element method in literature for the biharmonic problem. The a priori and a posteriori error analysis circumvents any trace of second derivatives and all the results hold even for small $\sigma = 0$. The main tool is a computable conforming companion operator J from the non-conforming virtual element space to the Sobolev space V. This is a right-inverse of the interpolation operator and leads to the optimal error estimates in piecewise Sobolev norms. The design of J modifies the discrete right-hand side and allows a quasi-best approximation property. An explicit residual-based a posteriori error estimator is reliable and efficient up to data oscillation. Numerical examples show the predicted empirical convergence rates for uniform and the optimal rates for adaptive mesh-refinement.

HDG Method for Non-linear Klein-Gordon Equation

Shipra Gupta[1], Amiya K Pani[2] and Sangita Yadav[3]
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Abstract
Here, HDG method is proposed and analyzed for the nonlinear Klein-Gordon problem with non-Lipschitz source function. A priori error estimates are derived, and it is proved that approximation of the flux and the displacement converge with order h^{k+1} where, h as discretization parameter and k as degree of the polynomial of the approximation. A post-processed solution is also introduced depending on the approximate solution obtained using HDG method and it is proved that the post-processed solution has convergence rate $k + 2, k \geq 1$.

Three and Four Fields Mixed Formulations in Poroelasticity

Sarvesh Kumar
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Abstract
In this talk, we propose two different formulations for the approximation of the linear poroelasticity equation. The first formulation is a three-field formulation in which the steady-state version of the system is recast in terms of displacement, pressure, and volumetric stress. We will discuss and analyze continuous and finite element discretization for this formulation. The second formulation is based on four fields, and in this formulation, the system's primary variables are the solid displacement, the fluid pressure, the fluid flux, and the total pressure. For the discretization of this formulation, we employ a discontinuous finite volume to approximate solid displacement and mixed methods to approximate fluid flux and the other two pressures. We will also discuss the virtual element discretization for the non-stationary linear poroelasticity equation.

A three-step two-grid finite element method for the Boussinesq system of equations

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Abstract

This talk presents an error analysis of a three-step two-level Galerkin finite element method applied to the two-dimensional transient Boussinesq system of equations. In **Step I**, the problem is discretized in the spatial direction by employing a finite element method on a coarser mesh $\mathcal{T}_H$ with mesh size H. Then, in **Step II**, the nonlinear system is linearized around the coarser grid solution, similar to Newton's type iteration, and the resulting linear system is solved on a finer mesh $\mathcal{T}_h$ with mesh size h. In Step III, a correction is accomplished by solving a linear problem on the finer mesh and an updated final approximate solution is obtained. Optimal error estimates in $L^\infty(L^2)$ −norm, when $h = O(H^{2-\delta})$, in $L^\infty(H^1)$ −norm, when $h = O(H^{4-\delta})$ for the velocity and in $L^\infty(L^2)$ −norm, when $h = O(H^{2-\delta})$, in $L^\infty(H^1)$ −norm, when $h = O(H^{4-\delta})$ for the temperature and, in $L^\infty(L^2)$ −norm, when $h = O(H^{4-\delta})$ for the pressure, $\delta > 0$ arbitrarily small, are derived. Then, a complete discretization is achieved by applying backward Euler method in the time direction and fully discrete error estimates are established. Finally, the talk is concluded by providing numerical results and verifying the theoretical findings.

Nonsmooth Data Optimal Error Estimates by Energy Arguments for Subdiffusion Equations with Memory

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Abstract

This talk discusses the semidiscrete Galerkin finite element approximation for time fractional diffusion equations with memory in a bounded convex polygonal domain. We use novel energy arguments in conjunction with repeated applications of time integral operators to study the error analysis. Our error estimates cover both smooth and nonsmooth initial data cases. Since the continuous solution u of such models has singularity at $t = 0$ even for smooth initial data, we use t^j, $j = 1, 2$, type of weights to overcome the singular behaviour at $t = 0$. Optimal order error estimates in both $L^2(\Omega)$- and $H^1(\Omega)$-norms are proved with respect to both convergence order of the approximate solution and regularity of the initial data. Moreover, a quasi-optimal pointwise in time error bound in the maximum norm is shown to hold for smooth initial data. In the end, we provide numerical results to support our theoretical findings.

Contributory Talks

Least-squares Spectral Element Preconditioners for Elliptic Boundary Layer Problems

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Abstract
In this talk, we propose preconditioners for the system of linear equations that arise from a discretization of second order elliptic boundary layer problems in two dimensions using least squares spectral element methods. These preconditioners are constructed using separation of variables technique and are easy to invert being diagonalizable. We show that the preconditioners are spectrally equivalent to the quadratic forms by which we approximate them and are robust with respect to the perturbation parameter. Numerical simulations reflect the effectiveness of these preconditioners for several benchmark problems.

Convergence Analysis of a Second-Order Scheme for Fractional Differential Equations with Integral Boundary Conditions

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Abstract
A fractional differential equation with integral boundary conditions at both the boundary points is considered in this article. The highest order derivative appears in the fractional differential equation is a Caputo derivative of order α where $1 < \alpha < 2$. The Caputo derivative is approximated by a spline method and trapezoidal rule is used to approximate the integral type boundary conditions. We have proved that the proposed method is of second order convergence. Numerical experiments have been carried out in favor of the scheme.

Stabilization-Free Reliable and Efficient a Posteriori Error Control for HHO

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Abstract
The established a posteriori error analysis of the hybrid high-order methods (HHO) in [4] treats the stabilization as part of the error and as part of the error estimator. But it follows from [3] that the stabilization is in fact efficient. This leads to reliable and efficient explicit residual-based a posteriori error estimates for the error in the piecewise energy norm (up to data oscillations). This talk presents recent work [1], where we prove that the original and the VEM inspired stabilizations for HHO [2, 4] are locally equivalent and derive two classes of stabilization-free guaranteed upper bounds (GUB). Numerical evidence in a Poisson model problem supports that the GUB leads to realistic upper bounds and the associated adaptive mesh-refining algorithm recovers the optimal convergence rates in computational benchmarks. The presentation is based on joint ongoing work with Prof. C. Carstensen from Berlin and Dr. N. T. Tran from Jena.

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A Penalized Finite Element Method for the Oldroyd Model of Order One

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Abstract

In this paper, a fully discrete finite element penalty method is presented for a two-dimensional Oldroyd model of order one, in which the spacial discretization is based on conforming finite element method and the time discretization is based on the first order backward Euler scheme. Some new regularity results which are valid uniformly in time are derived for the solution of the penalized problem with initial data in H_0^1. Moreover, the discrete solution is shown to be valid uniformly in time. Optimal error estimates are derived for the semidiscrete as well as the fully discrete case with non-smooth initial data. These error estimates hold uniformly in time under smallness conditions. Finally, some numerical experiments are conducted to validate our theoretical findings.

A Novel Numerical Scheme for 2D Quasi-Linear Hyperbolic Equation on an Irrational Domain: Application to Uniform Transmission Line Equation

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Abstract

In this work, a compact finite difference method (implicit) of order two in time and space directions using unequal mesh is developed for the numerical solution of 2D quasi-linear hyperbolic partial differential equations on an irrational domain. The stability analysis of the model problem for unequal mesh is discussed and it is shown that the developed scheme is unconditionally stable for 2D uniform transmission line equation. For linear difference equations on an irrational domain, the alternating direction implicit method is discussed. The numerical technique for the solution at first time level is derived briefly. The projected technique is scrutinized on several physical problems on an irrational domain to exhibit the accuracy and effectiveness of the suggested method.

Numerical method for 2D Elliptical Singularly Perturbed Problem with Shifts of Mixed Type

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Abstract
The purpose of this work is to present the numerical technique for two-dimensional elliptic singularly perturbed problems having positive and negative shifts in both directions of the convection terms, whose solution exhibits regular boundary layers. The study of this class of problems was started in mid eighties, but all the studies were restricted to 1D. The Taylor series expansion is used to handle the shift terms and the emerging problem is discretized using the fitted mesh method. The error estimate of upwind scheme on piecewise uniform Shishkin mesh is established to show that the method is ϵ-uniform. The effect of positive and negative shift terms on the behavior of solution is explicated by executing some numerical experiments.

On the existence of Simple Waves for 2-D non-ideal Magneto-hydrodynamics

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Abstract
In this article, a method called the characteristic decomposition method is used to show the presence of simple waves for the 2-D compressible flow in a non-ideal magneto-hydrodynamics system. Here, a steady and pseudo-steady state magneto-hydrodynamics system has been considered. For the 2×2 strictly quasilinear hyperbolic systems, a sufficient condition has been established for the existence of characteristic decomposition. This decomposition ensures the presence of simple wave adjacent to a region of constant state for the system under consideration. Further, this result has been extended as an application of the characteristic decomposition in a pseudo-steady state, and we prove the existence of simple wave in a full magneto- hydrodynamics system by taking the vorticity and the entropy to be constant along the pseudo-flow characteristics. These results are the extension of the fundamental theorem of Courant and Friedrichs.

Virtual Element Methods for General Linear Elliptic Interface Problems on Polygonal Meshes with Small Edges

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Abstract
In this article, we discuss and analyze a conforming virtual element discretization with boundary stabilization term proposed in [1] (suitable for small edges that appeared in the mesh generation) to approximate general linear elliptic problems with discontinuous diffusivity coefficient across the interface. One of the critical features of the proposed virtual element method is to allow the generation of fitted meshes which are independent of the location of the interface. The fitted polygonal meshes naturally admit elements with small edges, and standard virtual element methods/finite element methods fail to handle meshes with arbitrary small edges. With the help of certain projection operators, nearly optimal error estimates are established under realistic assumptions and low regularity of the solution. Numerical experiments are conducted to show the proposed method's flexibility, robustness, and accuracy and validate the theoretical rate of convergence.

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One-Dimensional Ferronematics in a Channel: Order Reconstruction, Bifurcations and Multistability

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Abstract

We study a model system with nematic and magnetic order, within a channel geometry modelled by an interval $[-D, D]$. The system is characterised by a tensor-valued nematic order parameter $\boldsymbol{Q}$ and a vector-valued magnetisation $\boldsymbol{M}$, and the observable states are modelled as stable critical points of an appropriately defined free energy which includes a nemato-magnetic coupling term, characterised by a parameter c. We (i) derive L^∞ bounds for $\boldsymbol{Q}$ and $\boldsymbol{M}$; (ii) prove a uniqueness result in specified parameter regimes; (iii) analyse order reconstruction solutions, possessing domain walls, and their stabilities as a function of D and c and (iv) perform numerical studies that elucidate the interplay of c and D for multistability.

An Efficient Numerical Method for Time-Fractional Black-Scholes Equation Arising in Finance

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Abstract

In the financial market, option is the most important financial derivative and determining the value of option has been a significant problem in both theory and practical application.The Black-Scholes model proposed in 1973, describes the behaviour of underlying assets approximately but it fails to capture the sudden movements of stock prices over time in the real market. This shows the deficacy of the classical B-S model in the real market. With the rising interest of researchers in fractional calculus, it has been observed that the change in price of underlying stock following fractal transmission system is modelled by time-fractional Black-Scholes PDE:

$$\begin{cases} \dfrac{\partial^\alpha V(S,t)}{\partial t^\alpha} + \dfrac{1}{2}\alpha^2\sigma^2 \dfrac{\partial^2 V(S,t)}{\partial S^2} + rS\dfrac{\partial V(S,t)}{\partial S} - rV(S,t) = 0, (S,t) \in (0,\infty) \times (0,T] \\ V(0,t) = p(t), V(S,t) = q(t) \text{ as } S \to \infty \\ V(S,t) = V(S) \end{cases}$$

where $0 < \alpha \leq 1$, $\sigma\ (\geq 0)$ is the volatility of the returns from underlying asset S, r is the risk-free interest rate and T is the maturity time.

Here, we propose a numerical method to solve time-fractional Black-Scholes PDE governing European options on a uniform mesh based on cubic spline. The time fractional derivative defined in the modified Riemann-Liouville sense is transformed into Caputo fractional derivative through variable transformation. The discretization of fractional derivatives is performed using the classical L^1 –scheme and the spatial derivatives are discretized by the cubic spline method. The stability and convergence of the proposed method is analyzed with second order accuracy in space and $(2-\alpha)$ order accuracy in time. Numerical experiments are performed to verify the accuracy of the present method validating theoretical results. Finally, three different types of European options modelled by time-fractional Black-Scholes PDE are priced using the proposed method as an application and in consequence, the impact of order of time-fractional derivative on the option price is also presented with figures.

A Stable Scheme to McKendrick-Von Foerster Equation with Diffusion

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Abstract
An implicit finite difference scheme is proposed to approximate the solution to the McKendrick-Von Foerster equation with diffusion (M-V-D). The main difficulty in employing the standard analysis to study the properties of this scheme is due to the presence of nonlinear and nonlocal terms in the Robin boundary condition in the M-V-D. In order to analyse the stability and well posedness of the numerical scheme, the notion of upper solution is introduced and used effectively with the help of the discrete maximum principle. A relation between the numerical solutions to the M-V-D and the steady state problem is established.

A new strong stability preserving multiderivative time marching method for stiff reaction diffusion systems

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Abstract
The present study derived a new class of implicit explicit strong stability preserving (SSP) multi derivative Runge-Kutta methods for the numerical simulation of stiff reaction-diffusion systems. A backward-in-time assumption on the operator derivative is required for the unconditional SSP property. We demonstrate that the developed method satisfied this backward derivative condition. The accuracy of the developed method has been shown using L^∞ error. Moreover, we have also compared the L^∞ error of the present methods to the methods available in the literature, which shows that the developed method performed better even for larger value of time steps. Furthermore, the robustness and efficiency of the derived method are validated by numerical simulations of the Brusslator, Gray-Scott, and Schnakenberg models.

An approximate analytical approach of generalized boussinesq equation by variational iteration method

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Abstract
The paper's main objective is to solve a complex dispersive waves problem. An analytical approach with a variational iteration method has been applied to get an approximate solution to the generalized Boussinesq

equation. To demonstrate the proposed method's accuracy, convergence analysis has been shown. For consistency of the solution, comparison of the variational iteration method solutions have been made with the optimal homotopy asymptotic method and the exact solutions in different cases. The tabular values and graphical representation have been shown for examining the results with the use of Maple and Matlab software.

A Three Step Two-Grid Method for Discontinuous Galerkin Approximations to the Time-Dependent Incompressible Navier-Stokes Equations

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Abstract
In this work, we consider a three step two-grid discontinuous Galerkin finite element method for solving the two-dimensional time-dependent incompressible Navier-Stokes equations. In the first stage, the problem is discretized in spatial direction by employing discontinuous Galerkin method on a coarse mesh with mesh size H. Then, in step two, the nonlinear system is linearized around the coarse grid solution, which is similar to Newton's type iteration and the resulting linear system is solved on a finer mesh with mesh size h. In the third step, a correction is obtained through solving a linear problem on the finer mesh. The well-posedness and optimal error estimates for the velocity and pressure in the semi-discrete case are established. Then, a fully discrete scheme based on backward Euler method is analyzed and optimal a priori error estimates are derived. Finally, numerical experiments are carried out to validate our theoretical results.

Study of Three Collinear Cracks in a Composite Medium

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Abstract
The article deals with the collinear Griffith cracks under the time-harmonic waves, situated in an orthotropic strip sandwiched between two identical half-planes. The outer cracks are considered to be situated on either side of the central crack. The mathematical model is solved by applying the Fourier transform, and then the unknown functions have been determined using the Schmidt method. The approximate analytical expressions of the stress intensity factors (SIFs) and Stress Magnification Factor (SMF) have been obtained at the tips of the cracks. The values of the SIFs and SMFs for the considered composite with Graphite epoxy material as the strip and E-glass epoxy as the half-plane are computed numerically for different crack lengths and wave numbers, and the obtained results are displayed graphically.The salient feature of the article is the pictorial presentations of the possibilities of arrest of the central crack due to the presence of outer cracks through finding the stress magnification factor for different particular cases

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Modified Wave Numbers for Fractional Derivatives

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Abstract
In this work, modified wave numbers are derived for various approximations of Reimann Liouville fractional derivatives. Considering these modified wave numbers, Fourier analysis of differencing errors is presented to quantify the resolution characteristics of various approximations. Numerical illustrations are provided to validate the theoretical results.

Primal Hybrid Method for Strongly Non-linear Parabolic Problems

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Abstract
In this paper, a second order strongly non-linear parabolic initial-boundary value problem is approximated by using primal hybrid method and Lagrange multipliers. Semi-discrete and backward Euler based complete discrete schemes are discussed and optimal order error estimates are derived by using modified elliptic projection. Optimal order error estimates in L^∞- norm are also established. Earlier results on the superconvergence of the gradient in L^∞- norm for piecewise linear finite element of elliptic and parabolic problems are now derived for strongly non-linear parabolic problems using primal hybrid finite element method. Finally, the numerical experiments have been carried out to ratify our theoretical findings.

Evolution of shock waves in non-ideal gas with interstellar gas clouds

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Abstract
A systematic method is used to study the problem of propagation of planar, cylindrically symmetric and spherically symmetric shock waves of the one-dimensional motion of a inviscid, self-gravitating, non-ideal interstellar gas cloud. The analytic solution of the problem is resolved, which specifies non-linear behavior in the physical plane. The transport equation, which describes the evolution of weak discontinuity in non-ideal gas is derived. It is observed that the nature of the solution completely depends on the cooling-heating function and self-gravitating parameter. Using the computational package MATHEMATICA, all computations are performed.

Solitary-Wave Solutions of the Degasperis-Procesi Equation via Lie Symmetry Approach

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Abstract
In this article, we construct exact closed-form solutions for the (2+1)-dimensional Degasperis Procesi equation. By employing the Similarity transformation method to transform non-linear Partial differential equations into the corresponding ordinary differential equations via reducing the number of independent variables in each proceeding step. These obtained soliton solutions exhibit a rich, extensive behavior which plots with the help of MATLAB software.

Penalized Domain Embedding Method to Solve PDEs Over Curved Domains with Structured Triangular Mesh

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Abstract
To find a numerical solution to partial differential equations, the meshing of a given domain is an intrinsic job, which becomes very challenging when the boundary of a domain is curved or moving. As the rectangular domains have an obvious cartesian or uniform mesh with the availability of fast solvers, we embed the curved complex domain into a rectangular domain and use the penalty or the regularization parameters to impose the boundary conditions. Here the given PDE is extended and suitably redefined on the rectangular domain with the aid of penalty or regularization parameters. Dirichlet boundary condition is imposed with the high penalty parameter, while small regularization parameters impose the Neumann and Robin boundary conditions. The numerical stability of the method with respect to these penalty or regularization parameters is proved. Mathematical analysis and error estimates are provided for the proposed method. Error estimates strongly depend on both the mesh size and the penalty or regularization parameters, and several numerical experiments are performed to validate the theoretical analysis.

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Lie Symmetry Reduction, Optimal system, Analytical Solutions and Conservation Laws of Rosenau Regularized Long wave equation

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Abstract
In the study of discrete systems, the wave-wave and wave-wall interactions cannot be described by the well-known KdV equation. Rosenau Regularized Long Wave (RRLW) equation, proposed by Rosenau to conquer the short coming of KdV equation, which is given as [1]

$$v_t + v_{xxxxt} - v_{xxt} + v_x + vv_x = 0$$

We have applied the Lie symmetry analysis method to solve RRLW equation. We obtained the infinitesimal generators of the equation after using the method, and after that we got the reduced ordinary differential equation, which is solved by using the power series method. Also, the convergence of power series solution is discussed. These solutions are new and more general than the known solutions. We use new theorem of conservation laws to acquire the conservation laws for RRLW equation.

Lie Group Analysis of the Effects of Radiation on Free Convective Heat and Mass Transfer Flow upon an Inclined Stretched Surface

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Abstract
An analysis using the theory of Lie groups is performed to study the effects of radiation on free convective heat and mass transfer flow upon an inclined stretched surface. By employing rigorous algebraic computations, the subsidiary equations are formed using the infinitesimals and the partial differential equations that govern the flow are transformed into a system of ordinary differential equations using scaling symmetries. The resulting system is then solved numerically using a fourth order Runge-Kutta algorithm together with the shooting method. A code using MATHEMATICA is formulated and the outcomes are depicted with various sketches. It is evident that both thermal and concentration boundary layer thicknesses reduce while rising thermal Grashof number and Schmidt number. The opposite phenomena takes place whenever the solutal Grashof number rises. Further, it is witnessed that when the radiation increases, the concentration decreases, but the velocity and temperature increase.

Fractional Kirchhoff Hardy Problems with Weighted Choquard and Singular Nonlinearity

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Abstract
In this article, we deal with the existence and multiplicity of the following fractional Kirchhoff Hardy problem involving weighted Choquard and singular nonlinearity:

$$\begin{cases} M(\|u\|^2)(-)^s u - \gamma \dfrac{u}{|x|^{2s}} = \lambda \dfrac{l(x)}{u^q} + \dfrac{1}{|x|^{\alpha}} + \left(\displaystyle\int_{\Omega} \dfrac{r(y)}{|y|^{\alpha}} \dfrac{|u(y)|^p}{|x-y|^{\mu}}\, dy\right) r(x)|u|^{p-2} \quad \text{in } \Omega \\ u > 0 \ \text{ in } \Omega, \quad u = 0 \ \text{ in } \mathbb{R}^N \setminus \Omega, \end{cases}$$

where $\Omega \subseteq \mathbb{R}^N$ is an open bounded domain with smooth boundary containing 0 in its interior, $N > 2s$ with $s \in (0,1),\ 0 < q < 1,\ 0 < \mu < N,\ \gamma$ and λ are positive parameters, $\theta \in [1, p)$ with $1 < p < 2^{\star}_{\mu,s,\alpha}$, where $2^{\star}_{\mu,s,\alpha}$ is the upper critical exponent in the sense of weighted Hardy-Littlewood-Sobolev inequality. Moreover, M models a Kirchhoff coefficient, l is a positive weight and r is a sign changing function. Under the suitable assumption on l and r, we established the existence of two positive solutions to the above problem by Nehari-manifold and fibering map analysis with respect to the parameters. Moreover, the results obtained here are new even for $s = 1$.

Feedback Stabilization of a Parabolic Coupled System and its Numerical Study

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Abstract
In the first part of the talk, we study feedback stabilization of a parabolic coupled system by using localized interior controls. The system is feedback stabilizable with exponential decay $-\omega < 0$ for any $\omega > 0$. 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 (uniformly) 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 error estimate of stabilized solutions as well as stabilizing feedback controls is obtained. We validate the theoretical result by showing some numerical implementation.

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Science Engineering and Research Board, India

Science and Engineering Research Board (SERB) is a premier funding agency established by an Act of Parliament (SERB Act 2008) to support basic research in frontier areas of Science and Engineering. Creation of SERB is considered as an important institutional milestone in the Indian S&T ecosystem. SERB has contributed in developing robust, comprehensive and sophisticated research facilities and infrastructures across the country which is being efficiently utilized by the scientific community in taking the quality of science to the next higher level. SERB has a vision "to position science and technology as the fulcrum for social and economic change by supporting relevant, competitive and quality scientific research and development". Its mission states, "As the premier national research funding agency, "is to raise the quality and footprint of Indian science and engineering to the highest global levels in an accelerated mode, through calibrated support for research and development".

Other main objectives of SERB include evolving a system of approach (i) to expeditiously provide funding for individuals, academic institutions, research and development laboratories, industrial concerns and other agencies for such research; (ii) to monitor and evaluate, by adopting modern management practices. Also, the board serves as a leading agency for planning and promoting internationally competitive research in emerging areas, identifying major inter-disciplinary research areas, individuals, groups or institutions and funding them for undertaking research. Furthermore, the board scouts, mentors, incentivizes and rewards exceptional performers, teams and institutions. SERB encourages and provides funding for organizing national and international conferences. Please refer to https://serb.gov.in/page/about for more information about SERB, India.

Rockman Industries, India

Established in 1960 Rockman Industries started as a bicycle component manufacturer. The company is now transformed into an industry leader for Aluminium die casting, machined and painted assemblies supplier. Many renowned motorcycle manufacturers and automobile OEMs across the world are customers of Rockman's components.

Apart from being the industry leader in two-wheeler and four-wheeler alloy wheels, it manufactures cylinder head, cylinder block, crankcase, crankcase covers, oil pan, transmission housing and other mechanical components. After acquisition of a British-Indian enterprise, Rockman Advanced Composites Pvt. Ltd., earlier Moldex Composites has forayed into carbon composites. Strength and capabilities of Rockman industries:

- 140,000 + tons of Aluminium Processing.
- 13 mn+ installed capacity of alloy wheels annually.
- 3 casting processes- HPDC, LPDC & GDC.
- 8 plants located at Ludhiana, Haridwar, Bawal, Mangli, Chennai, Tirupati, Halol and Surat.

Please refer to https://www.rockman.in/ for more information about Rockman Industries, India.

Hero Electric, India

Hero Electric is the first and largest manufacturer of electric 2-wheelers in India. It is a market leader and trailblazer in the electric Two-Wheeler industry in the country. For over a decade it has been a front runner in electric mobility. It has been offering ecological 2-wheelers to many consumers. Making the country greener and enabling 'Zero pollution' transportation is part of its mission of 'No Emission'. Hero electric has always been a quality conscious manufacturer, where all processes are closely inspected, rigorously tested by quality engineers and 46 stringent quality checks before it reaches our customers. A SA 8000 certified organization Hero electric is environmentally conscious, socially responsible and professionally ethical in its business operations. For more information about Hero Electric, please visit https://heroelectric.in/

BatX Energies, India

BatX Energies produces battery grade materials by recycling end-of-life Lithium-Ion Batteries to create a sustainable energy source which is also eco-friendly. Using our proprietary "Net Zero Waste" and "Zero Emissions" process, we extract high-grade products that we extract from Lithium-ion batteries. Our main aim is to develop Green Tech Solutions which empowers the Global Clean Energy Transition creating a Circular Economy and Sustainability ethos. Our products include Black Mass (less than 1% Li impurity) which contains Lithium, Cobalt, Nickel and Manganese along with Graphite, high quality Lithium Carbonate, premium grade Cobalt Sulphate, high-purity Nickel Sulphate, high-grade Manganese Carbonate, Secondary Products such as high-grade Plastic, Aluminium, Steel and Copper. Please refer to https://batxenergies.com/ for more information about Rockman Industries, India.

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