INTERNATIONAL CONFERENCE ON

MATHEMATICAL ANALYSIS AND APPLICATIONS

December 15–17, 2022

Department of Mathematics

NATIONAL INSTITUTE OF TECHNOLOGY

TIRUCHIRAPPALLI – 620 015

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Contents

Department of Mathematics
National Institute of Technology
Tiruchirappalli

About the Department

The Institute. The National Institute of Technology (formerly known as Regional Engineering College) Tiruchirappalli, situated in the heart of Tamil Nadu on the banks of river Cauvery, was started as a joint and co-operative venture of the Government of India and the Government of Tamil Nadu in 1964 with a view to catering to the needs of manpower in technology for the country. The college has been conferred with autonomy in financial and administrative matters to achieve rapid development. Because of this rich experience, this institution was granted Deemed University Status with the approval of the UGC/AICTE and Govt. of India in the year 2003 and renamed as National Institute of Technology. NITT is an Institution of National Importance under the Ministry of Human Resource and Development (MHRD), Government of India. NIT-T was registered under Societies Registration Act XXVII of 1975.

The Institute has been imparting technical education in core branches of science and engineering, besides pushing the frontier areas in research. With a vibrant campus and enviable facilities, the Institute provides 10 undergraduate, 29 postgraduate and Ph.D. programmes. NITT is ranked no. 1 among the NITs, and 10th in the National Institutional Ranking Framework (NIRF), MHRD, Govt. of India. The hallmark of the campus is the good facilities which caters to the academic and extracurricular interests of the students. The Octagon is the pride of the campus equipped with modern facilities like a CAD/CAM Lab, Local Area Network, High-Speed Internet connection, and other seminar and conference facilities. It is maintained and run by the Computer Support Group (CSG) of the institute.

Apart from this, the campus provides ample opportunities for developing extracurricular skills which include NCC, NSS, Students Chapters of IEEE, social clubs, and sports & games. The Alumni of this institution have excelled in various spheres and are positioned very well globally in a number of leading Government, Public Sector & Private Organizations. NIT-T hosts two intercollegiate fests namely Festember (Cultural) and Pragyan (Technical) and an inter-department fest namely NITTfest (Cultural) annually. These fests draw students from most colleges of South India and are hugely popular. Apart from this, each department conducts Symposium. The institute has a total campus area of 800 acres. This includes good hostel facilities, Hospital, Post & Telegraph, Telecom Center, fully computerized State Bank of India (SBI) NIT branch with ATM facility, Bookstall, Reprographic Center, Canteen, Swimming pool and Co-op. Stores.

The Department. The Department of Mathematics is one of the pioneering and the most distinguished departments in NITT. Applying multi-disciplinary research and teaching methods, the department strongly believes in finding mathematical solutions for various social-economic, technological and work related processes and challenges. The department is committed to outstanding graduate training to produce leading scholars in various fields of mathematics. Since its inception, the department has been supporting

Ph.D. graduates to carry out challenging research work of wide ranging industrial and social implications. From the academic year 2019-20, the department is offering M.Sc. Mathematics.

The following are the faculty members of the department:

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Prof. R. Ponalagusamy
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Prof. T.N. Janakiraman

Professors
Prof. V. Kumaran
Prof. V. Ravichandran
Prof. P. Saikrishnan

Associate Professors
Dr. R. Tamil Selvi
Dr. V. Lakshmana Gomathi Nayagam
Dr. V. Shanthi

Assistant Professors
Dr. I. Jeyaraman
Dr. N. Prakash
Dr. Jitraj Saha
Dr. Vamsinadh Thota
Dr. N. Shivaranjani
Dr. M. Sivanesan
Dr. Atul Kumar Verma
Dr. Abhijit Das
Dr. R. Gowthami
Dr. N. Balasubramani
Dr. Gautam Singh

About the Conference

The main objective of the conference is to provide platform for academicians, researchers, students and industry professionals to present their research work and to be a stage for exchanging ideas in the field of mathematics and applied mathematics. This national conference cover the topics like Differential equations, Real and Complex Analysis, Functional Analysis, Numerical Analysis, Optimization.

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Vimal Kumar

Programme

Program

Day – I (15.12.2022)

09.00am – 09.30am	Registration
09.30am – 10.00am	Inauguration
10.00am – 10.15am	Tea
10.15am – 11.00am	Invited Talk I1 (Tarun Das)
11.00am – 11.45am	Invited Talk I2 (Ruchi Das)
11.45am – 01.00pm	Parallel Sessions – I
01.00pm – 02.00pm	Lunch
02.00pm – 02.45pm	Invited Talk I3 (E. Natarajan)
02.45pm – 03.30pm	Invited Talk I4 (P. Vellaisamy)
03.30pm – 03.45pm	Tea
03.45pm – 05.00pm	Parallel Sessions – II

Day – II (16.12.2022)

09.30am – 10.15am	Invited Talk I5 (Anbhu Swaminathan)
10.15am – 11.00am	Invited Talk I6 (K. S. Charak)
11.00am – 11.15am	Tea
11.15am – 12.00pm	Parallel Sessions - III
12.00pm – 01.00pm	Parallel Sessions - IV
01.00pm – 02.00pm	Lunch
02.00pm – 02.45pm	Invited Talk I7 (Prakash Veeraraghavan)
02.45pm – 03.30pm	Invited Talk I8 (Adam Lecko)
03.30pm – 03.45pm	Tea
03.45pm	Excursion

Day – III (17.12.2022)

09.30am – 10.15am	Invited Talk I9 (Satyajit Roy)
10.15am – 11.00am	Invited Talk I10 (S. Ponnusamy)
11.00am – 11.15am	Tea
11.15am – 11.45am	Invited Talk I11 (Nisha Bohra)
11.45am – 01.00pm	Parallel Sessions - V
01.00pm – 02.00pm	Lunch
02.00pm – 02.45pm	Invited Talk I12 (See Keong Lee)
02.45pm – 04.00pm	Parallel Sessions - VI
04.00pm – 04.15pm	Tea

PAPER PRESENTATION

	Room A (A13 Hall)	Room B (A11 Hall)	Room C (A12 Hall)
Day-I (15.12.2022)			
Session - I (11.45am – 01.00pm)	T13-T18	T65-W70	T71-W76
Session - II (03.45pm – 05.00pm)	T29-W34	T54-W60	W77-W82
Day-II (16.12.2022)			
Session - III (11.15am – 12.00pm)	T35-W37	W61-W64	T83-T86
Session - IV (12.00pm– 01.00pm)	T19-T22	T43-W47	T93-W97
Day-III (17.12.2022)			
Session - V (11.45am – 01.00pm)	T38-W42	W48-W53	T87-W92
Session - VI (02.45pm – 04.00pm)	W23-W28	-	T98-W104

Note: T - Presenting Offline; W - Presenting Online

Abstracts

Invited Talks

Persistent And Expansive Dynamical Systems ... A Reflection I1

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Both Persistent and Expansivity are significant notions in the study of dynamical systems. We shall present some interesting results and shall also talk about recurrence phenomena. Finally, we shall see some of our recent results.

Sensitivity and Chaos in Nonautonomous Dynamical Systems I2

Ruchi Das
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Kolyada and Snoha initiated the study of nonautonomous dynamical systems in 1976 and proved many remarkable results. We shall discuss some of these and other interesting results proved in the related directions. We shall conclude giving glimpses of some of our findings.

Virtual element methods for the nonlinear convection-diffusion problems I3

E. Natarajan
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In this talk we will introduce Virtual element method (VEM) and its develop- ment for the nonlinear convection-diffusion equation. VEM is the discretiza- tion technique implemented over polygonal meshes. This technique is seen as a natural generalization of the traditional Galerkin finite element method and mathematically carries the functional space setup wherein the discrete space consists of polynomial as well as non-polynomial functions. One of the more promising advantage of this technique other than its generalization is the easier development of C^1 and C^2 elements. Nonlinear convection-diffusion problems occur in several physical ap- plications including fluid dynamics, chemical reactors etc.,. Developing effi- cient numerical method is still a challenging task and we will develop the VEM discretization over the polygonal meshes. We use the projection operators to suitably evaluate the integrals involving its polynomial and non-pol- ynomial counterparts. We will introduce the stabilizer in order to reduce the spurious oscillations that is present in the problem. We will present the con- vergence analysis in energy norm

with its necessary approximation proper- ties. In the end, we will present few numerical experiments over different pol- ygonal meshes and discuss its performance. The oscillations near the boundary layers gets reduced with the effect of stabilizers and smooth solutions are obtained with higher order of VEM.

I4 A Probabilistic Approach to Adomian Polynomials

P. Vellaisamy
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The Adomian decomposition method (ADM) is a powerful tool to solve several nonlinear functional equations and a large class of initial/boundary value prob- lems. First, we briefly discuss the salient aspects and the uses of this method. The main focus of this talk is to discuss a probabilistic approach to compute the Adomian polynomials (AP's), which is the main part of the ADM. We will discuss a probabilis- tic interpretation for the AP's, both for the one-variable and the multi-variable case. We derive some new recurrence relations for the computation AP's. Some suitable ex- amples will be discussed to show that the probabilistic approach to compute the AP's is much simpler than the analytical or combinatorial approach.

Joint work with **F. Viens**, Department of Statistics and Probability, Michigan State University, East Lansing, MI 48824, USA.

I5 Ratio of hypergeometric functions in Geometric Function Theory

Anbhu Swaminathan
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Extremal functions of many subclasses of univalent function theory have the hypergeometric type representation. Hence the role of hypergeometric functions in determining the theory of classes of univalent functions in well known. In this talk, the role of ratio of hypergeometric functions in determining certain properties of functions in subclasses of univalent functions will be underlined. The results leading further generalizations of ratio of hypergeometric functions will be discussed. Open problems and directions for future research will be outlined.

References

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A Recent Development in Normal Families of Meromorphic Functions I6

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Theory of normal families of meromorphic functions initiated by Paul Montel in 1907 now forms an integral part of function theory. In fact, this theory is responsible for many exciting advances in the area of complex dynamics, but there has also been many far reaching internal developments in the theory during the last over hundred years. In my talk, I shall present some recent developments around the Fundamental Normality Test due to Montel: A family of meromorphic function on a domain each member of which omits three given values in the extended complex plane, happens to be a normal family.

Algorithms: The past, present and the future I7

Prakash Veeraraghavan
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Generalized Fekete-Szegö functionals I8

Adam Lecko
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Let $\mathcal{S}$ be the class of all injective and holomorphic functions f in the unit disk $\mathbf{D}$ with classical normalization $f(0) = 0 = f'(0) - 1$. The talk deals with the following coefficient

functionals

$$\mathcal{S} \ni f \mapsto |\,\mathrm{c}_3(f) - \lambda\,\mathrm{c}_2(f)^2| - \mu|\,\mathrm{c}_2(f)|, \quad \lambda \in \mathbf{C},\, \mu \in \mathbf{R}, \tag{1}$$

where $\mathrm{c}_n(f)$ denotes the n-th coefficient of $f \in \mathcal{S}$. These functionals reduce to the classical Fekete-Szegö functionals for $\mu = 0$. The case where $\mu = 1$ is of special interest due to deep relationship to successive initial coefficients problems. To be more specific:

- If $\lambda = 0$, then the functional (1) corresponds to the successive coefficients for $f \in \mathcal{S}$.
- If $\lambda = 1/2$, then the functional (1) corresponds to the successive logarithmic coefficients for $f \in \mathcal{S}$.
- If $\lambda = 3/2$, then the functional (1) corresponds to the successive coefficients of the inverse function of $f \in \mathcal{S}$.
- If $\lambda = 2$, then the functional (1) corresponds to the successive logarithmic coefficients of the inverse function of $f \in \mathcal{S}$.

The sharp lower and upper estimations of the functional (1) are discussed and the extremal functions are determined for certain $\lambda \in \mathbf{C}$ provided $\mu = 1$. The results are applicable to some standard subclasses of $\mathcal{S}$.

Joint work with **Dariusz Partyka** (John Paul II Catholic University of Lublin (Lublin) and University College of Applied Sciences in Chełm (Chełm))

I9 Role of Mathematical modeling in industrial waste management system using mixed convection phenomena

Satyajit Roy
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Numerical investigations are performed to analyze heat flow visualization and entropy generation during mixed convection within square and entrapped triangular cavities involving various velocity and thermal boundary conditions. The Galerkin finite element method with penalty parameter is used to obtain the solutions of non-linear coupled partial differential equations governing fluid flow and thermal fields. Computations are carried out for various fluids of industrial importance with a wide range of parameter values and results are obtained in terms of streamlines, isotherms, heatlines and entropy generation etc. Heat transfer rates along the walls are obtained in terms of local and average Nusselt numbers. The effects of moving walls on total entropy generation and average Nusselt number have also been analyzed for fluid media and fluid saturated porous media. Role of Mathematical modeling in industrial waste management system using mixed convection phenomena.

I10 Landau-Bloch Theorems for analytic and harmonic mappings

S. Ponnusamy
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Briot-Bouquet differential subordination and its applications I11

Nisha Bohra
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Let h be a univalent function in unit disk $\mathbb{D}$ with $h(0) = a$. Let p be analytic in $\mathbb{D}$ of the form $p(z) = a + a_n z^n + a_{n+1} z^{n+1} + \cdots$ where $a \in \mathbb{C}$ and n is a positive integer. Let p and h satisfy the differential subordination

$$p(z) + \frac{zp'(z)}{\beta p(z) + \gamma} \prec h(z),$$

where β and γ are complex numbers with $\beta \neq 0$. This first order differential subordination is called the Briot-Bouquet differential subordination. In my talk, I will present some recent work on Briot-Bouquet differential subordination problem and interesting applications of it in univalent function theory.

A subclass of analytic functions satisfying a differential inequality I12

See Keong Lee
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Let $\mathbb{D} = \{z : |z| < 1\}$ be the unit disc on the complex plane $\mathbb{C}$. The class $\mathcal{U}(\lambda, \mu)$, which consists of analytic functions of the form $f(z) = z + \sum_{n=2}^{\infty} a_n z^n$ and satisfying the inequality

$$\left| \left(\frac{z}{f(z)} \right)^2 f'(z) - \mu \right| < \lambda$$

for $z \in \mathbb{D}, 0 < \lambda \leq 1$ and $\mu \in \mathbb{C}$, will be studied. Conditions on the parameters μ and λ will be given that ensures the univalency of the functions in this class. Among the properties to be investigated are the growth theorem and some sharp coefficient bounds.

Contributed Talks

A: Analysis and Topology

T13 On functions starlike with respect to n-ply symmetric and conjugate points

Somya Malik
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For given non-negative real numbers α_k with $\sum_{k=1}^{m} \alpha_k = 1$ and normalized analytic functions f_k, $k = 1, \ldots, m$, defined on the open unit disc, let the functions F and F_n be defined by $F(z) := \sum_{k=1}^{m} \alpha_k f_k(z)$, and $F_n(z) := n^{-1} \sum_{j=0}^{n-1} e^{-2j\pi i/n} F(e^{2j\pi i/n} z)$. We study the functions f_k satisfying the subordination $z f_k'(z)/F_n(z) \prec h(z)$ where the function h is a convex univalent function with positive real part. We also consider the analogues of the classes of starlike functions with respect to symmetric and conjugate points. Inclusion and convolution results are proved for these and related classes. Our classes generalize several well-known classes and connection with the previous works are indicated.

Joint work with **V. Ravichandran** (ravic@nitt.edu)

T14 Improved Bohr radius for a subfamily of univalent logharmonic mappings

Akash Meher
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An analytic function f defined in the open unit disk $\mathbb{D}$ is k-fold symmetric if $f(e^{2\pi i/k} z) = e^{2\pi i/k} f(z)$, where k is a positive integer. Logharmonic mappings are the solutions of the non-linear elliptic partial differential equation $\frac{\overline{f_{\overline{z}}}}{\overline{f}} = \omega \frac{f_z}{f}$, where ω is analytic in $\mathbb{D}$ with $|\omega| < 1$. In this talk, we consider $S_{LH}^{k*}(\alpha)$, the class of k-fold symmetric starlike univalent logharmonic mappings of order α, introduced by Alizadeh et al. (Afr. Mat., 33(2), 1–11 (2022)). We delineate this functions class with various examples. The improved Bohr radius for the family $S_{LH}^{k*}(\alpha)$ is established. We compare our finding with previously obtained results numerically as well as graphically.

Joint work with **Priyabrat Gochhayat** (email: pgochhayat@gmail.com)

T15 Some results on Generalized Cesàro Stable of Janowski Function

T.G. Bhaskar
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Let g_1 and g_2 be any two analytic functions defined in the unit disc which are normalized by the condition $g_1(0) = 1 = g_2(0)$ and $\sigma_n^{b-1,c}(z)$ be the n^{th} Cesàro mean of type $(b-1, c)$

for $1+b>c>0$. Then g_1 is generalized Cesàro stable with respect to g_2, whenever

$$\frac{\sigma_n^{b-1,c}(g_1,z)}{g_1(z)} \prec \frac{1}{g_2(z)} \quad (z\in\Delta,\ n\in\mathbb{N}_0),$$

where $\sigma_n^{b-1,c}(g,z)=\dfrac{1}{B_n}\displaystyle\sum_{j=0}^{n} B_{n-j}b_jz^j=\sigma_n^{b-1,c}(z)*g(z)$. The main aim of this article is to prove that $((Az+1)/(Bz+1))^\eta$ is generalized Cesàro stable with respect to $(1/(Bz+1)^\eta)$ but not with respect to itself for $-1\le B<A\le 0$ and $0<\eta\le 1$. As an application, we obtain new and existing results on Cesàro stability and stability.

Joint work with **M.P.Jeyaraman** (email: jeyaraman_mp@yahoo.co.in)

Coefficient functional of a class of analytic functions T16

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For $\alpha\ge 0,\beta<1$ and $\gamma\ge 0$, the class $\Re_\beta(\alpha,\gamma)$ satisfies the condition

$$Re\left(e^{i\varphi}(1-\alpha+2\gamma)\frac{f(z)}{z}+(\alpha-2\gamma)f'(z)+\gamma zf''(z)-\beta\right)>0,\varphi\in R,z\in D$$

is taken into consideration. We find the n^{th} coefficient of $f\in\Re_\beta(\alpha,\gamma)$ and sharp bounds of coefficient functional, namely zalcman functional, second order Hankel determinant, third order Toeplitz and Hermitian Toeplitz determinants. Certain applications of the results are also considered.

Joint work with **M.P.Jeyaraman** (email: jeyaraman_mp@yahoo.co.in)

Inclusion theorems of certain integral transform related to normalized hypergeometric functions T17

Manas Kumar Giri
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Conditions on the parameters a,b, and c are given so that the normalized Gaussian hypergeometric function $zF(a,b;c;z)$ where

$$F(a,b;c;z)=\prod_{n=0}^{\infty}\frac{(a)_n(b)_n}{(c)_n(1)_n}z^n,\quad |z|<1$$

belongs to a certain class of analytic functions, is obtained. The inclusion properties of the Hohlov integral transform involving $zF(a,b;c;z)$ are obtained using Taylor coefficients of functions in certain classes. For specific values of these parameters, the various results are deduced and compared to the existing literature.

Joint work with **Raghavendar. K** (email: raghavendar248@gmail.com)

T18 On (p, q)–extended generalized Bessel functions and associated properties

S. Saravanan
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Analogous to the recent interesting (p, q)–extended Bessel function $J_{\nu,p,q}(z)$ and the (p, q)–extended modified Bessel function $I_{\nu,p,q}(z)$ of the first kind of order ν by making use of two additional parameters in the integrand by Maŝirevič *et al.* [(p, q)–extended Bessel and modified Bessel functions of the first kind, *Results in Mathematics* **72** (2017), 617–632], we introduce (p, q)–extended generalized Bessel function. Systematic investigation of its properties, among others various integral representations, hypergeometric representations, Mellin transforms and so on are also obtained.

T19 Starlikeness Using Schwarzian Derivatives

Asha Sebastian
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A function $f : \mathbb{D} := \{z \in \mathbb{C} : |z| < 1\} \to \mathbb{C}$ is starlike if $tf(z) \in f(\mathbb{D})$ for all $z \in \mathbb{D}$ and $t \in [0, 1]$. Let $\mathcal{A}$ be the class of all analytic functions $f : \mathbb{D} \to \mathbb{C}$ normalized by the condition $f(0) = f'(0) - 1 = 0$. Let $\mathcal{S} \subset \mathcal{A}$ consists of univalent functions and $\mathcal{S}^* \subset \mathcal{A}$ be the class of starlike functions. A function $f \in \mathcal{A}$ is convex if $f(\mathbb{D})$ is convex and the class of all convex functions is denoted by $\mathcal{K}$. Analytically, starlike and convex functions are characterized by $\operatorname{Re} Q_{ST} > 0$ and $\operatorname{Re} Q_{CV} > 0$ where $Q_{ST} := zf'(z)/f(z)$ and $Q_{CV} := 1 + zf''(z)/f'(z)$. For a normalised analytic function f defined on the open unit disk in the complex plane, we determine several sufficient conditions for starlikeness in terms of the quotients Q_{ST}, Q_{CV} and the Schwarzian derivative $Q_{SD} := z^2\big((f''(z)/f'(z))' - (f''(z)/f'(z))^2/2\big)$. These conditions were obtained by using the admissibility criteria of starlikeness in the theory of second order differential subordination.

Joint work with **V. Ravichandran** (ravic@nitt.edu)

T20 Differential Subordination for Analytic and Meromorphic Multivalent Functions

S. Madhumitha
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In this presentation, we discuss certain differential subordination implications for multivalent functions defined on the unit disc $\mathbb{D}$ and meromorphic multivalent functions on

the punctured unit disc $\mathbb{D}\backslash\{0\}$. The results obtained generalize several earlier known results on differential inequalities.

Joint work with **V. Ravichandran** (ravic@nitt.edu)

Radius of starlikeness of a subclass of normalised analytic functions T21

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Let $\mathcal{CV}[A,B]$ be the class of Janowski convex functions. We consider the class $\mathcal{C}^{\alpha}[A,B]$ of all normalized analytic functions g where $g(z) = z(f'(z))^{\alpha}$ for some $f \in \mathcal{CV}[A,B]$, $\alpha > 0$. We find the radii constants for functions f in the class $\mathcal{C}^{\alpha}[A,B]$ to belong to various classes like the class of Janowski starlike functions, $\mathcal{ST}_e$, $\mathcal{ST}_C$, $\mathcal{ST}_{Ne}$ and so on. The radii obtained are sharp.

Joint work with **V. Ravichandran** (ravic@nitt.edu), **P. Saikrishnan** (psai@nitt.edu)

Analytic functions associated with the lemniscate of Bernoulli T22

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The function $\sqrt{1+z}$ maps the unit disk $\mathbb{D}$ onto the interior of the lemniscate of Bernoulli $\Omega = \{w \in \mathbb{C} : |w^2 - 1| < 1\}$ in the right half-plane. A starlike univalent function f is characterized by $zf'(z)/f(z)$; several subclasses of starlike functions were studied in the past by restricting $zf'(z)/f(z)$ to take values in a region, on the right-half plane. Every starlike function on $\mathbb{D}$ with $zf'(z)/f(z) \in \Omega$ is related to the analytic function $p : \mathbb{D} \to \mathbb{C}$ with $p(z) \in \Omega$ for all $z \in \mathbb{D}$. Using the admissibility criteria of the first and second order differential subordination theory, we investigate several subordination results related to the lemniscate of Bernoulli.

Joint work with **V. Ravichandran** (ravic@nitt.edu)

Certain characterisation results for p-valent functions under a generalised integral operator W23

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For p-valent analytic functions f_j for $j = 1, ..., n$, an integral operator F_p is considered. Certain characterisation results including a convexity result are derived for the operator F_p. Several more subordination results for a p-valent function $\prod_{j=1}^{n} \left(\frac{f_j(z)}{z^p}\right)^{\alpha_j}$ and a generalised integral oerator F_p using admissible class conditions are also obtained.

Joint work with **Poonam Sharma** (email: sharma_poonam@lkouniv.ac.in)

W24 **Hankel and Toeplitz determinants of third and fourth order order reciprocal of bounded turning functions subordinate to** $1 + tanz$

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The main purpose of this work is to compute Hankel and Toeplitz determinants of third and fourth order for the reciprocal of bounded turning functions subordinate to $1 + tanz$.We also consider Feketo-Szego inequality and Zalcman conjecture for the functions in this class.

Joint work with **R. Bharavi Sharma**, Department of Mathematics, Kakatiya University, Warangal (rbsharma005@gmail.com) and **K.Ganesh**, Department of Mathematics, Jits, Karimnagar (ganesh.koride82@gmail.com)

W25 **On fourth Hankel determinant for bounded turning functions associated with nephroid domain**

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The main purpose of this paper is to compute an upper bound of fourth Hankel determinant for bounded turning functions associated with a Ma-Minda type function $\varphi_{Ne}(z) = 1 + z - \frac{z^3}{3}$ that maps the open unit disk onto the interior of the Nephroid domain in the right half of complex plane.

Joint work with **R. Bharavi Sharma**, Department of Mathematics, Kakatiya University, Warangal, India. (email: rbsharma005@gmail.com)

W26 **Toeplitz Determinants for a Subclass of Quasi Convex Mappings in Higher Dimensions**

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In this paper, we establish the sharp bounds of certain Toeplitz determinants formed over the coefficients of a normalized convex function f defined on the unit disk $\mathbb{U}$ such that $z = 0$ is a zero of order $k+1$ of $f(z) - z$. Furthermore, these results are extended to higher dimensions by determining the bounds of Toeplitz determinants for a subclass of quasi convex mappings of type B.

Joint work with **S. Sivaprasad Kumar** (email: spkumar@dce.ac.in)

Coefficient functionals for a class associated with Hyperbolic Cosine function W27

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A subclass of starlike functions associated with Cosine hyperbolic function, namely $\mathcal{S}_s^*(\varrho)$, defined as

$$\mathcal{S}_s^*(\varrho) = \left\{ f \in \mathcal{A} : \frac{2zf'(z)}{f(z) - f(-z)} = \cosh \sqrt{w(z)}, \quad z \in \mathbb{D} \right\},$$

where $w(z)$ is a Schwarz function, is introduced. Sharp bounds on certain functionals related to this class are studied.

Joint work with **S. Sivaprasad Kumar** (email: spkumar@dce.ac.in)

Partial sums for a generalised class of analytic functions W28

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In this article, we determine the ratio of the function with its $n^{th}-$partial sum when the function belonging to a generalized class which consists of univalent as well as non univalent analytic functions. Moreover, we studied the meromorphic functions corresponding to a function in $\mathcal{S}$.

Joint work with **S. Sivaprasad Kumar** (email: spkumar@dce.ac.in)

Binary Soft Functions T29

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Present paper deals with the concept of binary soft functions defined on two binary soft topological spaces. Further, characterized the binary soft continuous func- tions, binary soft semi-continuous functions and investigated interrelation between them.

Joint work with **P. G. Patil** (email: pgpatil@kud.ac.in)

Study of Semi-Slant Submanifolds in locally conformal Kähler Manifolds W30

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In this paper we study semi-slant submanifolds in locally conformal Kähler manifolds.

We establish characterisations for a semi-slant submanifold to be a Riemannian product of the leaves of the holomorphic and slant distributions, and give the expression for holomorphic bisectional curvature of a semi-slant product manifold. Next we study when a semi-slant submanifold can be immersed as a warped product of the leaves of the holomorphic and slant distributions and establish inequalities for the norm of the second fundamental form. Finally we conclude by studying totally umbilical semi-slant submanifolds of locally conformal Kähler manifolds.

W31 **Quasi bi-slant submanifolds of para-Kenmotsu manifolds**

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In this paper, we study quasi bi-slant submanifolds of a para-Kenmotsu manifold. We obtain the necessary and sufficient conditions for the integrability of distributions which are involved in the definition of such manifolds. We also prove that the slant distributions which defines a totally umbilical foliation on submanifold of a para-Kenmotsu manifold is either invariant or anti-invariant.

Joint work with **Rajendra Prasad** (rp.manpur@rediffmail.com)

W32 **A note on transversal hypersurfaces of para-Kenmotsu manifolds**

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The purpose of this paper is to study transversal hypersurfaces of para-Kenmotsu manifolds. First, it is proved that every transversal hypersurface of an almost paracontact manifold admits an almost product pseudo- Riemannian structure (J, G). After that, we show that every transversal hypersurface of an almost paracontact manifold also admits a $(f, g, \mu, \nu, \lambda)$-structure and we derive some results allied with relationship between induced almost product pseudo-Riemannian structure (J, G) and induced $(f, g, \mu, \nu, \lambda)$-structure. An example of transversal hypersurface of a para-Kenmotsu manifold admitting $(f, g, \mu, \nu, \lambda)$-structure is also illustrated.

Joint work with **Rajendra Prasad** (email: rp.manpur@rediffmail.com)

W33 **Conformal η-ricci soliton on Lorentzian-para Kenmotsu manifolds**

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The objective of the present paper is to study conformal η-Ricci soliton on Lorentzian-Para Kenmotsu manifolds with certain curvature con- ditions. We obtain some important

results of conformal η-Ricci soliton on Lorentzian Para-Kenmotsu manifolds satisfying curvature conditions $R(\xi, X).S = 0, C(\xi, X).S = 0$ and quasi conformaly flat condition. Finally, the existence of conformal η-Ricci soliton in Lorentzian-Para Kenmotsu manifold has been proved by constructing non-trivial examples.

Joint work with **Rajendra Prasad** (email: rp.manpur@rediffmail.com)

Generalizations of Chainability and Compactness, and the Hypertopologies W34

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We consider two properties: one for a metric space and other for the subsets of a metric space. The first one is weaker than chainability, finite chainability, and Menger convexity; and the second one is weaker than compactness. We discuss several results related to these two properties. Further, we study some relations among some well known hypertopologies, with respect to these considered properties.

Joint work with **Saikat Mukherjee** (email: saikat.mukherjee@nitm.ac.in)

New Contra and Almost Contra Continuous Multifunctions T35

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This paper investigate the properties of upper and lower contra gpα-continuous multifunctions and obtain their characterizations and properties of multifunctions. Further, properties of weakly gpα-continuous multifunctions are studied in this paper.

Joint work with **P. G. Patil** (email: pgpatil@kud.ac.in)

Analysis of Non-self-adjoint Bent Waveguide Eigenvalue Problem T36

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Nowadays, Optics-Photonics based technology is vigorously explored as the next step to micro-electronics based technology. Optical waveguides are one of the primary circuit components of optical circuits. In the case of waveguides, one needs to know so-called guided modes and their propagation constants. Various forms of straight waveguides and optical fibers are studied quite well in terms of their mathematical models, numerical simulation schemes, and actual fabrications. Mathematically, straight optical waveguides are modeled as self-adjoint eigenvalue problems on the unbounded domain, e.g., one-dimensional waveguides are studied on the interval $(-\infty, \infty)$. Here the guided modes

appear as eigenfunctions corresponding to real eigenvalues. The Strum–Liouville theory describes such self-adjoint eigenvalue problems [1], but there is no such theory that explains the behavior of the non-self-adjoint problems, which are crucial in several applications [2].

Another essential form of optical waveguides is bent waveguides. In this work, we mathematically show that the optical bent waveguide eigenvalue problem is a non-self-adjoint eigenvalue problem on the unbounded domain with complex eigenvalues [3-4]. We show that the imaginary part of these eigenvalues is negative, confirming its manifestation in the lossy/leaky nature of the bent waveguide modes. We also show that as the bending radius tends to ∞, these eigenvalues become real, and the corresponding non-self-adjoint eigenvalue problem of bent waveguides becomes the self-adjoint eigenvalue problem of straight waveguides. By posing the eigenvalue problem in the function theoretic setting, we will also discuss the mathematical properties of the bent waveguide eigenvalue problem. This work also examines the finite number of eigenvalues and the orthogonality of eigenfunctions. In the process, this work addresses the question of when a bounded operator defined on Banach space has a finite number of eigenvalues.

Joint work with **Kirankumar R. Hiremath** (k.r.hiremath@iitj.ac.in)

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W37 On the first set $J_n(\alpha, \beta, k : x)$ of bi-orthogonal polynomials suggested by the Jacob polynomials

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Madhekar and Thakare succeeded in constructing a pair of bi-orthogonal polynomials $J_n(\alpha, \beta, k : x)$ and $k_n(\alpha, \beta, k : x)$ that are suggested by Jacobi polynomials. In the sense that for k = 1 both these polynomials reduces to Jacobi polynomials. Madhekar and Thakare obtained recurrence relations, operational formulae, generating functions, bi-orthogonality, multi-linear and multilateral generating function involving bi-orthogonal polynomials suggested by Jacobi polynomials. In the present paper we obtained some interesting results with some particular cases for the first set $J_n(\alpha, \beta, k : x)$.

Approximate fixed point theorems for various Contractive type Mappings T38

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In this paper we prove approximate fixed points for contractive type mappings in a metric space. The aim of this paper is to establish approximate fixed point results in metric space (not necesarily complete) by using contraction mappings such as B-contraction, convex contraction, etc. Our results are extensions of several results including Kannan Mapping, Chatterjea Mapping and S. A. M. Mohsenalhosseini Mapping etc. Some examples are provided to illustrate our results.

Joint work with **P. S. Srinivasan** and **M. Marudai**
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On approximation of functions with exponential growth by using modified Lupaş-Kantrovich operators W39

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As part of this study, we propose a modification of the so-known Lupaş-Kantrovich that preserve exponential function e^{-x}. To support this claim, we estimate the convergence rate of the operators in terms of both the usual and exponentiated modulus of continuity. Our analysis also includes a global estimate and quantitative Voronovskaya results. Demonstrating the effectiveness of modified operators, we provided a result and supporting graphs.

Joint work with **Naokant Deo** (email: naokantdeo@dce.ac.in)

Reverse order law for closed densely defined operators on Hilbert spaces W40

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We present some results to characterize the reverse order law for Moore-Penrose inverse of closed densely defined operators on Hilbert spaces. Recently, Fa-peng and Yi-feng have investigated the reverse order law for Moore-Penrose inverse of closed operators with closed range. We use basic properties of Moore-Penrose inverse to prove results without the assumption of closed ranges. Some examples are also provided to illustrate failure cases to hold the reverse order law for unbounded operator settings.

Joint work with **P. Sam Johnson** (email: msam@nitk.edu.in)

W41 **Frame theoretic approach to solve operator equations**

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Given an invertible bounded operator T on a Hilbert space $\mathcal{H}$ and $y \in \mathcal{H}$, finding solution of the operator equation $Tx = y$ may be difficult due to complication of inverting the operator. There are number of algorithms available in literature to find approximate solutions of the operator equation. However, numerical efficiency, computational costs and number of iterations of these algorithms are not always good. Using frame theoretical concepts, some algorithms to get faster convergence of the solution are derived. The process of preconditioning the equation yields faster convergence of solution. By choosing frame bounds of a frame appropriately, we discuss some methods of solving the preconditioned equation so as to improve numerical efficiency and convergence rate of approximation methods.

Joint work with **P. Sam Johnson** (email: sam@nitk.edu.in) and **Harikrishnan P.K.**, Department of Mathematics, Manipal Institute of Technology, Manipal Academy of Higher Education Manipal 576 104, India (email: pk.harikrishnan@manipal.edu)

W42 **Coincidence Point theorems in Partially Ordered Ultrametric Spaces**

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In this paper, Using rational contractions we prove some new coincidence point results via p-adic distance over partially ordered ultrametric space. Furthermore, the results are established with suitable examples to strengthen our main results.

Joint work with **Uma Jayaraman** (email: umaj@srmist.edu.in)

B: Algebra, Graph Theory and Statistics

T43 **M/M (a,b) /2/K interdependent queueing model with controllable arrival rates**

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This study focuses on systems that provide services in batches instead of personalized one-to-one assistance. These models are beneficial in a wide variety of contexts, such

as data transmission, networking, elevators, the supply chain process, etc. This study considers that two parallel servers are homogeneous, and the service is under a general bulk service rule. The input is assumed to be Poisson (single arrivals at each epoch of Poisson occurrence) and controllable. For service, each server is equally likely to take a batch when both two servers are accessible. The service time is assumed to be independent of batch size for simplicity's sake. M/M (a,b)/2/K is the notation for the system. Furthermore, it is an interdependent queuing model. This queuing system constitutes two homogenous servers and a finite customer waiting space.

Joint work with **M. Thiagarajan** (email: mathsthiags@yahoo.co.in)

Poisson input and exponential service time finite population interdependent queueing model with breakdown and controllable arrival rates T44

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This article focuses on Poisson Input and exponential service time finite population interdependent queueing model with breakdown and controllable arrival rate are considered. We discovered that the equa- tions for the steady state are derived. We have found the mean number of clients in the system. To calculate the anticipated clients' waiting time at the system, we use "Little's formula." Numerical results and graphical analysis are presented at the end, which strongly support the theoretical results. An appropriate conclusion is offered. This article has a finite population.

Joint work with **M. Thiagarajan** (email: mathsthiags@yahoo.co.in)

Modelling of bidirectional transport system using exclusion processes T45

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Non-equilibrium stochastic transport processes emanate intriguing features owing to the contact with surrounding phenomena. Totally Asymmetric Simple Exclusion Processes (TASEP) is one of the appropriate models to understand the steady state behavior of such transport processes. Inspired by vehicular traffic scenarios, we construct the model in which two successive speed bumps are placed with sufficient gaps to minimize the possibility of accidence and maximize the pedestrian road crossing scenarios. The impact of the different bottleneck strengths on stationary characteristics of the system has been investigated through phase diagrams, density profiles, phase transition, finite size effect, and shock position by utilizing hybrid mean field theory, and the obtained findings are validated through the Monte Carlo simulation. The interplay between bottlenecks and boundary dynamics results in various exciting features, including a unique kind of reentrance transition.

Joint work with **Dr. Atul Kumar Verma**.

W46 Multi-server PHF queueing model controlled by energy harvesting as a model of unreliable data file transmission in IoT cloud

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The article presents a multiserver retrial queueing model controlled by energy harvesting nodes. Taking cues from recent works on the energy harvesting technology, we posit that the queueing model optimizes the energy resources can be stored for communication purpose. The system modelled as a Continuous time Markov Chain with coupling of two queues, namely, retrial queue and energy queue. In particular, the harvested energy discretizing into energy units, the system is modelled as a first queue, whereas the second queue is developed to hold the subsidary amount of data packets from losing. From the vantage point of the analysis, shows that the amount of energy possessed by sensor may still be insufficient for successful communication. Adapting the critic, we formulate the multiserver queueing model as a PHF distribution with block-triangular transition generator matrix. We introduce a Markov Fluid queue approach to find the stationary solution. Finally, we investigate the system performance measures to validate the system utilization. Numerical experiments will be shown to the proposed model.

Joint work with **V Vidhya**

W47 Performance Analysis of Markovian Queuing model With I-Retrial Queue

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Israeli queue confined as I-queue is a single server multi distinct queue, polling type system. Arrival are according to the Poisson process and the batch-size service is provided and it does not rely on its bulk-job size.Taking prompt from recent work of Israeli queue, the present paper merges a retrial queuing model with Israeli queue. To aim of study is to obtain the study-state probability distribution using Matrix Analytic Method and some numerical illustration are provided to validate our result

Joint work with **Vidhya V**

W48 Inference on the Ratio of Variances of Two Normal Populations with a Common Unknown Mean

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This study looks at how to infer the ratio of variances for two normal populations with a common unknown mean. We concentrate on calculating confidence intervals and testing a hypothesis on the ratio of variances when the mean is unknown. We derive several confidence intervals and test procedures for the ratio of variances using the well-known generalized p-value approach. The coverage probability and average length are used to evaluate the performances of proposed confidence intervals, whereas the size values and power functions are used to evaluate the performances of all test procedures numerically using the Monte Carlo simulation procedure. We make a few recommendations for using confidence intervals and test procedures in practice based on our simulation investigations.

Joint work with **Manas Ranjan Tripathy** (email: manasmath@yahoo.co.in)

M/M/1/K/N interdependent queueing model with vacation and controllable arrival rates W49

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In this paper an M/M/1/K/N interdependent queueing model with vacation and controllable arrival rates is considered. The steady state solutions of the model are derived. Matlab is used to find numerical examples and graphical analysis are given for better understanding.

Joint work with **M. Thiagarajan** (email: mathsthiags@yahoo.co.in)

Two Phase of Service in M/G/1 Queueing System with Retrial Customers W50

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The topic of a single server retrial queueing system with two phases of service for retrial customers is investigated in this article. Consumers are allowed to balk at certain times. The steady-state probability generating function for system size and orbit size is derived by using the supplementary variable technique. The system performance measures and some special cases are described. The effect of the system parameters is examined through numerical examples.

Joint work with **K. Indhira** (email: kindhira@vit.ac.in)

Generalized λ statistical convergence via ideal sequence of functions over non-Archimedean fields W51

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Savas and Das introduced $I-[V,\lambda]$-summability and $I-\lambda$ statistical convergence over reals. In this article, Ideal-λ statistical convergence and $I-[Vf,\lambda]$-summability for sequence of functions are defined over a non-trivially valued non-archimedean field $\mathcal{K}$, and verified some of its properties. Further, validated $I-\lambda$ statistical convergence for sum of sequences of functions over $\mathcal{K}$, and provided examples for a 7-adic non-Archimedean field.

W52 (λ,μ)-statistical convergence of double sequences in n-normed spaces over non-Archimedean fields

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Statistical convergence has been discussed in various fields of mathematics namely approximation theory, measure theory, probability theory, trigonometric series, number theory, etc. Summability theory andfunctional analysis are two disciplines that heavily rely on the idea of statistical convergence. In this paper we discuss the concept of (λ,μ)-statistical convergence of double sequences in n-normed spaces over non-Archimedean fields. Let $\lambda=(\lambda_p)$ and $\mu=(\mu_q)$ are two non-decreasing sequences tend to ∞ and such that $\lambda_p+1\leq\lambda_p+1$, $\lambda_1=1;\mu_q+1\leq\mu_q+1,\mu_1=1$. Furthermore, we obtain some inclusion relations between the statistical convergence of double sequences and (λ,μ)-statistical convergence of double sequence. Throughout this article, K denotes complete, non-trivially valued, non-Archimedean fields.

Joint work with **K. Suja** (email: sujak@srmist.edu.in).

W53 On statistical $M_{\lambda_m,n,p}$ summability for triple sequences over non-Archimedean fields

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The main aim of this work is to investigate some important properties of statistical convergence sequence in non-Archimedean fields. Statistical convergence has been discussed in various fields of mathematics namely approximation theory, measure theory, probability theory, trigonometric series, number theory, etc. The concept of summability over valued fields is a significant area of mathematics that has many applications in analytic continuation, quantum mechanics, probability theory, Fourier analysis, approximation theory, and fixed point theory. The theory of statistical convergence plays a notable space in

the summability theory and functional analysis. The purpose of this work is to provide certain characterizations for triple sequences by using the $M_{\lambda_m,n,p}$ method of summability over non-Archimedean fields. Moreover, we obtain some inclusion relations between statistical convergence and statistical$M_{\lambda_m,n,p}$ summability for triple sequences over non-Archimedean fields. Throughout this article, K denotes complete, non-trivially valued, non-Archimedean fields.

Joint work with **K. Suja** (email: sujak@srmist.edu.in).

Spectrum and Inverses of Eccentricity Matrices of Certain graph classes T54

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The eccentricity matrix $E(G)$ of a simple connected graph G is derived from the distance matrix $D(G)$ of G by keeping the greatest distance in each row and column and setting the rest of the entries to zero. The eccentric eigenvalues of G are the eigenvalues of $E(G)$, and the eccentric spectrum of G is the set of all eccentric eigenvalues. We present the inverses, when they exist, and the Moore-Penrose inverses of eccentricity matrices of a cycle, double star, a spider graph and its induced subgraphs. We compute the eccentric spectrum of the spider graph and its induced subgraphs and the composition of two graphs, $G[H]$, where G is a diametrical graph and H is any connected graph. Further, we characterize trees whose second largest eccentric eigenvalue is $-2+\sqrt{13}$.

Joint work with **I Jeyaraman** (email: jeyaraman@nitt.edu)

Analogizing of OPCATD-number with graph coloring T55

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The concept of Outer Perfect Connected At Most Twin Domination Number of a Graph was introduced by G. Mahadevan et.al., A set $S(\subseteq V(G))$ is said to be an outer perfect connected at most twin dominating set $(OPCATD) - set$, if for every vertex $v \in V - S$, $1 \leq |N(v) \cap S| \leq 2$, $\langle V - S \rangle$ is connected and has a perfect matching. The minimum cardinality of OPCATD-set is called the outer perfect connected at most twin domination number (OPCATD-number) and is denoted by $\gamma_{opcat}(G)$. The minimum number of colors required to color all the vertices in such a way that adjacent vertices do not receive the same color is called the chromatic number and is denoted by $\chi(G)$. In this paper we obtain the general relationship between OPCATD and Chroamtic number of a graph.

Joint work with **G. Mahadevan**, **C. Sivagnanam** and **S. Kaviya**

T56 **QSPR and stability analysis of large cycloarene oligomers using topological indices and associated graph entropy**

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Topological indices are a class of graph invariants that can be correlated with a chemical compound's physicochemical properties. The Quantitative Structural Activity Relationship(QSAR) and Quantitative Structural Property Relationship (QSPR) models created using various degree-based topological indices are quite useful to predict various physical and chemical properties of different classes of molecules. Graph entropy is a technique which is introduced to quantify the complexity of graphs and to characterize physical properties of chemical compounds. Cycloarenes, a subclass of polycyclic aromatic hydrocarbons, are made by assembling benzene rings in a circular pattern. These molecules have received a lot of interest recently due to the rapid practical use resulting from the underlying molecular structure. This work derives the analytical expressions for various topological descriptors for the cycloarenes, along with its hexagonal oligomers using an efficient edge partition method. Coherent topological indices are chosen for QSAR/QSPR modelling after correlating underlying electronic features of the tesselations with numerical values of indices. The relative stability of oligomers is studied using Shannon's information entropy.

Joint work with **Joseph Clement**

W57 **Character degree graph of solvable groups with odd degree**

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Let G be a finite group, let $Irr(G)$ be the set of all complex irreducible characters of G and let $cd(G)$ be the set of all degrees of characters in $Irr(G)$. Let $\rho(G)$ be the set of primes that divide degrees in $cd(G)$. The character degree graph $\Delta(G)$ of G is the simple undirected graph with vertex set $\rho(G)$ and in which two distinct vertices p and q are adjacent if there exists a character degree $r \in cd(G)$ such that r is divisible by the product pq. In this paper, we obtain a necessary condition for the character degree graph $\Delta(G)$ with all of its vertices are odd degree of a finite solvable group G.

Joint work with **C. Selvaraj**, Department of Mathematics, Periyar University, Salem - 636 011 (email: selvavlr@yahoo.com)

W58 **Generalization of restrained triple connected outer perfect domination number for square of cartesian product graphs**

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A restrained dominating set S is said to be a restrained triple-connected outer perfect dominating set, if $\langle S\rangle$ is a triple connected dominating set and $\langle V-S\rangle$ has a perfect matching. The minimum cardinality of a restrained triple connected outer perfect dominating set (rtopd-set) is called restrained triple connected outer perfect domination number (rtopd-number) and is denoted by $\gamma_{rtop}(G)$. In this paper, we produce general results for square of cartesian product graphs.

Joint work with **G. Mahadevan** (email: drgmaha2014@gmail.com) and **C. Sivagnanam**, Department of General Requirments, University of Technology and Applied Sciences- Sur, Sultanate of Oman (email: choshi71@gmail.com)

Probing the corona domination number for the Cartesian product of graphs W59

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A dominating set S of a graph H is said to be a corona dominating set (CD–set) if every vertex in $\langle S\rangle$ is either a pendant vertex or a support vertex. The minimum cardinality of a corona dominating set is called the corona domination number and is denoted by $\gamma_{CD}(H)$. In this article, we study the CD-number for $P_r\Box P_s, Pr\Box C_s$, $C_r\Box C_s$ and identify their exact γ_{CD} values.

Joint work with **G. Mahadevan** (email: drgmaha2014@gmail.com) and **C. Sivagnanam**, Department of General Requirments, University of Technology and Applied Sciences- Sur, Sultanate of Oman (email: choshi71@gmail.com)

TCC-Domination Number on Triangular Grid and Sierpinski Gasket W60

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Recently the concept of Triple connected certified domination was initiated by G.Mahadevan et al. A subset $S \subseteq V_G$ is called triple connected certified dominating set with the condition that, every vertex in S has either zero or at least two neighbours in $V-S$ and $\langle S\rangle$ is triple connected is called triple connected certified domination number of a graph. The smallest dominating set taken among all the triple connected certified dominating sets is called triple connected certified domination number and is denoted by $\gamma_{TCC}(G)$. In this paper, we have generalized this parameter for triangular grid and Sierpinski gasket

Joint work with **G. Mahadevan** (email: drgmaha2014@gmail.com) and **C. Sivagnanam**, Department of General Requirments, University of Technology and Applied Sciences- Sur, Sultanate of Oman (email: choshi71@gmail.com)

W61 m-clean properties on Bi-amalgamated rings

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Let $\phi : R \to S$ and $\phi' : R \to T$ be two ring homomorphisms and let J and J' be ideals of S and T, respectively, such that $\phi^{-1}(J) = \phi'^{-1}(J')$. In this paper, we investigate the transfer of the m-clean property to the bi-amalgamation of R with (S, T) along (J, J') with respect to (ϕ, ϕ') (denoted by $R \bowtie^{\phi\phi'} (J, J')$). Our aim is to provide the necessary and sufficient condition for $R \bowtie^{\phi\phi'} (J, J')$ to be a m-clean ring.

Joint work with **Prof. C. Selvaraj** (email: selvavlr@yahoo.com)

W62 Ideals on feebly clean type rings

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In this article, we introduce the concept of feebly clean ideal and feebly nil clean ideal. An ideal I of a ring R is feebly clean ideal if for every $r \in I$, there exists a unit $u \in R$ and two orthogonal idempotent e, f such that $r = u + e - f$. An ideal I of a ring R is feebly nil clean ideal if for every $r \in I$, there exists a nilpotenet element $n \in R$ and two orthogonal idempotent e, f such that $r = n + e - f$. We discuss some interesting properties of feebly clean ideal, feebly nil clean ideal and its relation with feebly clean ring , febbly nil clean ring have been discussed.

Joint work with **Prof. C. Selvaraj** (email: selvavlr@yahoo.com)

W63 Function space as an algebraic ordered extension of algebra and its ideals

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In this article we have shown that the function space $C^+(\mathbf{X})$ of all non-negative continuous functions on a topological space $\mathbf{X}$ is a topological exponential algebra under the compact open topology. Exponential algebra is a new algebraic structure consisting of a semigroup structure, a scalar multiplication, an internal multiplication and a partial order. This structure can be considered as an algebraic ordered extension of the concept of

algebra. We have discussed the ideals and maximal ideals of $C^+(\mathbf{X})$. We find an ideal of $C^+(\mathbf{X})$ which is not a maximal ideal in general; actually maximality of that ideal depends on the topology of $\mathbf{X}$.

Joint work with **Sandip Jana**, Department of Pure Mathematics, University of Calcutta, 35, Ballygunge Circular Road, Kolkata-700019 (sjpm@caluniv.ac.in)

A zero-radius parabola under the Möbius-invariant geometry of dual numbers W64

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We incorporate the Erlangen program of Felix Klein to study the geometry associated with dual numbers. It defines those properties as geometry that do not change or are invariant under a particular group action. We have considered Möbius action as the group action with $SL(2;\mathbb{R})$ as the group, acting on the space of dual numbers. We have further used the Iwasawa decomposition to classify $SL(2;\mathbb{R})$ into three subgroups A, N and K which cause three distinct actions on the same space. Using the reflection property of the parabola, we have derived the length associated with a dual number under this geometry. We see that the orbits under the subgroup K are parabolas that are upward-facing, have a vertical axis with their focus not being preserved under the Möbius action. It is the last feature of these orbits that pushed us to investigate if such orbits with an invariant focus exist under an $SL(2;\mathbb{R})$-action. For this, we have equated the length of certain parameters to zero, which indeed gave us a figure whose focus remains invariant under the $SL(2;\mathbb{R})$-action. We call this the zero-radius parabola. Along with its distinguish feature of having an invariant focus, we have also discussed its symmetry-related properties.

Joint work with **Debapriya Biswas** (e-mail id: priya@maths.iitkgp.ac.in)

Fuzzy modelling of fractional order tumor system and Stability Analysis T65

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The natural phenomena and systems are effectively represented by modelling with the aid of mathematical concepts and tools. Using mathematical concepts in analysing the biological systems has provoked the interest of many contemporary researchers. In this paper, we present the modelling of tumor system based on the normal cells, tumor cells and effector-immune cells along with the drug toxicity and drug concentration in fuzzy environment. The fuzziness is applied as fuzzy number to define the tumor transmission. Further, the tumor free equilibrium and basic health risk reproduction number are derived. Finally, the stability of this fuzzy caputo tumor model is analysed.

Joint work with **Dhanalakshmi Palanisami** (email: dhanamath@buc.edu.in)

T66 **Kernel induced fast and robust intuitionistic fuzzy c-means clustering for medical image segmentation**

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In this framework, an approach to segment the tumor regions of the medical images has been proposed. Usually, medical images are more uncertain and low-illumined due to external factors. The foremost procedure is to remove those ambiguities by converting the grayscale intensities of the crisp image to the membership value of the fuzzy image. Then, the obtained fuzzy image is further transformed into an intuitionistic fuzzy image by employing a novel intuitionistic fuzzy generator. Furthermore, the morphological reconstruction is executed to the resultant intuitionistic fuzzy image to sustain the edge information. In this accordance, the sensitivity of outliers is eradicated by applying the proposed fast and robust kernel-based intuitionistic fuzzy c means clustering algorithm for the reconstructed morphological image. Thus, the optimal clustering is accomplished for the medical images and effectively suppresses the interference caused between the pixels. Finally, the experiment is carried out using the medical image datasets and the results were analysed using the objective metrics. Thus, the efficacy of the proposed algorithm is shown and compared with existing clustering algorithms.

T67 **A novel approach of segmenting medical images using fast and robust intuitionistic fuzzy c-means clustering**

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This work aims to present an unsupervised approach of medical image segmentation to detect the tumor region. Due to the lack of preciseness in medical images, the initial step is to model the uncertainty by transferring the crisp medical image to a fuzzy image. Then, the new intuitionistic fuzzy set is constructed through the novel intuitionistic fuzzy generator, which enhances the fuzzy image and this helps for further clustering process. As a subsequent procedure, morphological reconstruction has been undertaken to preserve the contour details, which promotes better segmentation results. With this connection, a novel, fast and robust intuitionistic fuzzy c means clustering is proposed that clusters the reconstructed image into meaningful parts with accuracy in the shape and size of the tumor. However, incorporating the intuitionistic fuzzy set in the objective function helps to detect the regions clearly from the imprecise data and prevalently converges the cluster center to its appropriate location. Also, the experiment is performed with MR brain images, and the proposed method's superiority is validated through the objective metrics.

A modern parametric ranking procedure for intuitionistic fuzzy numbers and implementation in decision making problems W68

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Decision Making (DM) is a cognitive process that is used for cracking problems in daily life. Due to the complexity of the present socio-economic scenario, DM has become a prominent endeavour, that aims to attain an optimal or satisfactory solution. DM becomes sophisticated when there is uncertainty. To outfit this uncertainty, Intuitionistic Fuzzy Numbers (IFNs) are implemented. In this study, a new method is proposed to demonstrate the effectiveness of IFNs in real-life decision-making with a new ranking procedure. This method overcomes the inadequacies found in previous works wherein, complicated calculations, inconsistent results against human intuition, and same ranking for different situations are perceived. Due to the perplexity of the problem, finding an appropriate ranking method was challenging. As a result, a parametric ranking technique based on the area measurement was developed. It can be observed that the proposed method serves ease and efficacy in its application when compared to other methods in the existing literature. Furthermore, the proposed method provides a complete ranking for TRIFNs. Also, it explains the validity of the new approach in multi-criteria decision-making problems (MCDM). An illustrative example is also promulgated to exemplify the selection of an ideal vaccine in the pandemic backdrop.

Joint work with **Geetha Sivaraman** (email: geetha76sivaraman@gmail.com)

On a class of variable delay fuzzy fractional stochastic differential system with non-instantaneous impulses W69

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Fuzzy modelling of dynamical control systems characterized by fuzzy stochastic process driven by Brownian motion. This work propound a new system namely variable delay fuzzy fractional stochastic differential equation with non-instantaneous impulses driven by m-dimensional Brownian motion. Stochastic differential equation with variable delay and fuzzy setting is investigated. The major work is to study the existence and uniqueness of global as well as local solutions for the propound system with fuzzy metrices, Banach fixed point theorem as the main tools. A numerical instance is also presented for the efficasy of the results.

Joint work with **K. Banupriya**, Department of Mathematics and Computer Applications, PSG College of Arts and science, Coimbatore, Tamil Nadu (email: banupriyapsg3@gmail.com) and **R. Maheswari**, Department of Mathematics, Sri Eshwar College of Engineering, Coimbatore, Tamil Nadu (email: mahesenthil21@gmail.com)

W70 Forecasting of rainfall in Chennai using Takagi-Sugeno fuzzy inference system

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Weather is a dynamic phenomenon that fluctuates frequently. Understanding the future climate can be difficult, that is why weather forecasting is highly essential. A normal rainfall event in one region may be considered a torrent in another, and may result in flash flooding. Weather forecasting is critical in saving lives and materials by predicting natural disasters such as cyclonic storms, tsunamis, tornadoes, and extreme rainfall. This research explores the use of fuzzy logic and develops a fuzzified model for rainfall prediction to evaluate the reliability of the fuzzy logic technique within the specified approximation of rainfall rate. The Sugeno- Type Fuzzy Inference System has been implemented to forecast rainfall in Chennai. However, forecasting rainfall is a challenging task due to the dynamic nature of tropical meteorological characteristics such as air pressure, temperature, humidity, dew point, and wind speed. Those variables were applied in this analysis. Each variable has three Membership functions. Every implementation is carried out using MATLAB 9.12. Root Mean Square Error (RMSE), and the Mean Absolute Error (MAE) were calculated, and on the basis of the results obtained, it can be suggested that fuzzy methodology is efficiently capable of handling scattered data. The accuracy of the proposed Fuzzy Inference System model yields 87.29%.

Joint work with **Kumaravel R**, Department of Career Development Centre, SRM Institute of Science and Technology, Chennai (kumaravr@srmist.edu.in)

C: Differential Equations and Applied Mathematics

T71 Direct Discontinuous Galerkin Method for Singularly Perturbed Parabolic Problems

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A Direct Discontinuous Galerkin (DDG) method is applied for numerical approxi- mation of singularly perturbed parabolic problems. We applied fully discrete scheme that is backward Euler method for time and DDG method for space variable. We have shown that method is stable and of the optimal order of convergence. Numerical results are given to verify our theoretical findings.

W72 Anisotropic Picone identities for Half linear Conformable Elliptic equations

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This article is devoted to investigate the anisotropic picone identities for half linear Conformable elliptic equations. In this paper, we have discuss the Hardy type inequality.

Joint work with **V. Sadhasivam** (email: ovsadha@gmail.com)

Picone identities for a certain class of Conformable half linear anisotropic biharmonic equations W73

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In this paper, we obtain the new results for Picone identities for a certain class of Conformable half linear anisotropic biharmonic equations and also we have discussed anisotropic Hardy type inequality are proved.

Joint work with **V. Sadhasivam** (email: ovsadha@gmail.com)

Characterization of first order 2-dimensional neutral delay difference systems W74

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This work is concerned with necessary and sufficient conditions for oscillation of all solutions of 2-dim first order neutral delay difference system with constant coefficient of the form:

$$\Delta \begin{bmatrix} x(n)-px(n-m) \\ y(n)-py(n-m) \end{bmatrix} = \begin{bmatrix} a & b \\ c & d \end{bmatrix} \begin{bmatrix} x(n-\alpha) \\ y(n-\beta) \end{bmatrix}, n \geq n_0,$$

where $a, b, c, d, p \in \mathbb{R}$, $m > 1$, $\alpha, \beta \in \mathbb{N}$ and $n \in \mathbb{N}(n_0) = \{n_0, n_0+1, \cdots\}$ by constructing several suitable characteristic equations. Also, an effort has been made to apply some results to nonlinear neutral systems aheading linearized oscillation theory and we need the following hypotheses for our use in the linearized oscillation method:

- (H_1) $p(n) \geq 1$ for $n > n_0$ and $\limsup_{n\to\infty} p(n) = p_0 \in (1, \infty)$;
- (H_2) $\lim_{n\to\infty} a(n) = a_0 \in (0,\infty)$, $\lim_{n\to\infty} b(n) = b_0 \in (0,\infty)$, $\lim_{n\to\infty} c(n) = c_0 \in (0,\infty)$, $\lim_{n\to\infty} d(n) = d_0 \in (0,\infty)$;
- (H_3) $\lim_{|s|\to\infty} \frac{h_1(s)}{s} = 1, \lim_{|s|\to\infty} \frac{h_2(s)}{s} = 1$;
- (H_4) $sq_{11}(s) > 0, s \neq 0, |q_{11}(s)| \geq q_{10}$, for $|s| \geq \xi_0 > 0$
  $sq_{12}(s) > 0, s \neq 0, |q_{12}(s)| \geq q_{20}$, for $|s| \geq \xi_0 > 0$
  and $\lim_{|s|\to\infty} \frac{q_{11}(s)}{s} = 1$, $\lim_{|s|\to\infty} \frac{q_{12}(s)}{s} = 1$.

For our work we refer the books [1-3] and the motivation came from [4-5]. We verify our results by some illustrative examples.

Joint work with **Arun K. Tripathy** (email: arun_tripathy70@rediffmail.com)

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W75 **Localized Nonlinear Wave structures in a (3+1)D Kadomtsev-Petviashvili-Boussinesq Model**

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Nonlinear waves arising in different physical systems continue to be one of the exciting contexts of active interest. Particularly, their dy- namics in higher-dimensional nonlinear models reveal several interest- ing characteristics that are not possible in the lower (1+1)-dimensional counterparts. Focused on this perspective, we explore the evolution of different localized waves like solitons, lumps and interactive waves in a (3+1)-dimensional nonlinear model, which is nothing but the (3+1)D Kadomtsev-Petviashvili-Boussinesq equation. The rogue waves of or- der one and two are obtained using the Hirota bilinear method and the appropriate polynomial test functions and their evolutionary dynam- ics is discussed in detail. We also found another family of interaction wave profiles using the generalized three wave method, which results into different nonlinear wave structures. Our results show significant outcomes on higher-dimensional nonlinear waves under different phys- ical settings and it will be helpful for further understanding in several higher dimensional nonlinear systems.

Joint work with **Arundhathy U. Nair, K. Sakkaravarthi** and **K. Murugesan**

W76 **A Uniform Haar Wavelet Technique to Solve a System of Partially Singularly Perturbed Problems**

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In order to numerically approximate the solution of a linear system of singularly perturbed problems, the Uniform Haar Wavelet Method (UHWM) is presented in this study.

For both the p-mesh point and the uniform Shishkin mesh point, the approximate solution is taken into account. Different meshes are taken into consideration for linear and second-order systems of singularly perturbed value problems, which lessen the concerns of singular behavior and provide an approximation up to the given order. Our technique, which does the computation, outperforms the parameter uniform method, the classical finite difference operator method, and the non-uniform method. The method's uniform convergence in terms of both the singular perturbation parameter and error estimation is demonstrated.

Dynamical analysis for solutions of a new extension of (3+1)-dimensional Ito equation W77

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The exclusive aim of proposed work is to fabricate some novel solutions for a new extension of (3+1)-dimensional Ito equation by using Hirota's bilinear form. The obtained bilinear equation is analyzed to report a diverse class of solutions consisting of multitudinous arbitrary constants, including bright solitons, dark solitons and periodic solitons. Moreover, few interaction solutions are constructed for better understanding of physical phenomenon. Gained solutions have been characterized graphically to present deep insight of dynamical functioning of addressed solutions for a studied equation.

Stability and hyperstability of generalized Drygas functional equation on non-Archimedean normed space W78

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In this paper, we discuss the stability of the following drygas functional equation

$$g(ax+by)+g(ax-by)=2g(ax)+g(by)+g(-by)$$

where $a, b \in \mathbb{N}$ in non-Archimedean normed space. Also we investigate the hyperstability for the same and proved some theorems in non-Archimedean normed space.

Joint work with **S. Sangeetha** (email: sangeets@srmist.edu.in)

Stability of a Jensen Type Cubic and Quartic Functional Equation over Non-Archimedean Normed Space W79

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In this paper, we introduce the Cubic and Quartic Jensen type functional equation

$$f\left(\frac{3x+y}{2}\right)+f\left(\frac{x+3y}{2}\right)=12f\left(\frac{x+y}{2}\right)+2[f(x)+f(y)]$$

$$f\left(\frac{3x+y}{2}\right)+f\left(\frac{x+3y}{2}\right)$$

$$=24f\left(\frac{x+y}{2}\right)-6f\left(\frac{x-y}{2}\right)+4[f(x)+f(y)]$$

and discussed the Hyers-Ulam stability over Non-Archimedean Normed space.

Joint work with **S. Sangeetha** (email:sangeets@srmist.edu.in)

W80 Investigations on Malmquist type delay differential equation over non-Archimedean field

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In this article, we have established the analogue of famous Mokhon'ko lemma for the rational function of two non-linear differential operators over non-Archimedean field. By applying the above mentioned lemma, we study the delay differential equation $\Omega = \Phi_1/\Phi_2$, where Ω is delay differential operator and $\Phi_1, |Phi_2$ are differential operators, and obtain some bounds on the $\deg(\Phi_i)(i = 1, 2)$. At the end, we also investigated on the existence of solutions of a system of Malmquist type delay differential equation over non-Archimedean field.

Joint work with **Abhijit Banerjee**, Department of Mathematics, University of Kalyani, Nadia- 741235. Email: abanerjee_kal@yahoo.co.in

W81 Generalized Hyers–Ulam–Rassias stability of Euler-Lagrange type cubic functional equation in non-Archimedean Quasi-Banach Spaces

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Aim of our present investigation is to prove generalized Hyers-Ulam-Rassias stability for the Euler-Lagrange cubic functional equation

$$f(ax+y)+f(x+ay)=(a+1)(a-1)^2[f(x)+f(y)]+a(a+1)f(x+y)$$

in non-Archimedean quasi-Banach spaces. In this paper, we obtain the stability results for the aforementioned functional equation with an illustrative example for non-Archimedean case.

Joint work with **Uma Jayaraman** (email: umaj@srmist.edu.in)

Stability of Duodecic functional equation in non-Archimedean normed spaces: a fixed point approach W82

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In this paper, we consider the generalized Hyers-Ulam stability of Duodecic functional equation

$$g_d(u+6v) - 12g_d(u+5v) + 66g_d(u+4v) - 220g_d(u+3v) + 495g_d(u+2v)$$
$$-792g_d(u+v) + 924g_d(u) - 792g_d(u-v) + 495g_d(u-2v)$$
$$-220g_d(u-3v) + 66g_d(u-4v) - 12g_d(u-5v) + g_d(u-6v) = 12!g_d(v)$$

in non-Archimedean normed space by the fixed point approach.

Joint work with **S. Sangeetha** (email: sangeets@srmist.edu.in)

Platelet substitution model with subtypes of A for age-dependent demand T83

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In blood products, one of the most quickly perishable components is platelets. As a consequence, blood banks face a short of platelets. Even donors are hesitant to donate platelets after the Pandemic. Platelets are complex to manage. Even donors are hesitant to donate platelets after the Pandemic. Therefore, inventory managers have the herculean task of utilizing the platelets bag as efficiently as possible without wastage. ABO compatibility is considered when handling platelets in inventory management and medical practice. But, there have been people in India who possess the subtypes of the A blood group. Consequently, this paper seeks to minimize platelet wastage while maintaining a specified level of service. Platelet transfusion is a common practice for patients who are suffered from oncology, hematology, traumatology, and general surgery. Depending on the treatment, the demand for platelets is classified as age-dependent and age-independent with blood sub-types for adequate service levels. The model is designed considering the product's shelf-life, patient treatment, cross-matching for the treatment of traumatology and general surgery, and the subtypes of the blood group A. According to the availability and demand of inventory, issuing preferred single donor platelets, pooled platelets, or random donor platelets. This research presents a new A_1A_2BO compatibility chart for platelets based on the ABO system. The platelet inventory management model considers both the Rh factor and blood group before cross-matching begins in platelet transfusion. Due to this, patients can be saved from the reactions caused by mismatching. With all these conditions, the model minimizes the outdated and unavailability of the platelets.

Joint work with **Umamaheswari S** (e-mail: umamaheswari.suk@vit.ac.in)

T84 **A green energy circular system with carbon capturing and waste minimization in a smart grid power management**

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Sustainable electricity production is an energy-efficient strategy aimed at both economic progress and environmental conservation. The power generation sector is the major contributor to global emissions and waste. In this context, a circular sustainable smart electric supply chain system is introduced in this paper with an aim of maximizing the profit with the minimum amount of emissions and waste generated from the power generation units. The power plant in this system consists of four power generation units that generate electricity from coal, waste, wind, and solar plants. A smart grid management system is used in this system for an efficient power supply according to the demands of the customer, and it enhances the system to distribute the power from renewable energies. In this system, the carbon dioxide from the thermal plants is captured and converted to natural gas to reduce emissions. Municipal and industrial waste is transformed into composite fuel to generate electricity. The profit for each unit and the customer's demand for electricity depends on the circularity index. Linear demand versus linear and logistical cases of unit profit was considered. This study theoretically and numerically maximizes the profit of the system with optimal power consumption, circularity index of electricity, and green and waste minimization investment as per the carbon cap policy. To find the optimal strategies for maximum profit, an algorithm was developed. Sensitivity analysis is done to determine the fluctuations in the profit, emission cost, waste cost, circularity index, and power consumption due to the variations in parameters. The wise allocation of power generation from each unit and reduce energy loss by installing efficient storage devices will result in a higher profit. A system with the high efficacy of green techniques to reduce emissions, a smart grid to minimize waste, higher taxes to regulate emissions, and a rise in the amount of production of electricity from renewable sources will result in a greener power system that gains more profit than conventional systems. The key findings state that electric supply chain systems can obtain a good profit in a more sustainable manner than conventional systems.

Joint work with **Umakanta Mishra**

T85 **Neighborhood sum-based entropies of zeolite MER using Shannon's approach**

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Microporous aluminosilicate crystals consisting of silicon cations (Si_4^+) and aluminum cations (Al_3^+) arranged in tetrahedral shapes surrounded by four oxygen anions (O_2^-) are known to be zeolites. MER is a small pore zeolite with complex 3D framework and has a wide range of applications such as purification of water, storage of H-media, and the

removal of CO_2 because of their selective catalytic reaction. Neighborhood sum-based topological indices are scalar numerical values related to molecular constitutions involved in the process of correlating chemical structure with physical properties, chemical reactivity, or biological activity and they play a vital role in developing QSAR/QSPR models. Some of the well-known degree-based indices with high correlation factors are Zagreb, Randić, Atom Bond Connectivity, Harmonic and Geometric–Arithmetic index. Information complexity of 3D complex structured molecules is determined from graph entropies which are beneficial in determining the bond energies and stability of the compound. This manuscript focuses on determining neighborhood sum-based entropies of zeolite MER using Shannon's approch.

Joint work with **Joseph Clement**.

Computation of weighted Szeged type descriptors of titanium oxide nanosheets T86

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The weighted Szeged type descriptors are bond additive descriptors based on the closeness sets of the terminal vertices. These descriptors translate a molecular graph into a real number, focusing on the distances between vertices and edges, which forecast the physical, chemical, and structural characteristics of the molecules. The addition of weighted parameters to these descriptors produces findings that are more accurate and deliver closer outcomes. These descriptors play a vital role in QSAR, QSPR, and drug design models. This study explores the molecular graph of a titanium oxide nanosheet. Titanium oxide is a crystalline, divalent, covalent molecule that is non-toxic, simple to control in size, and has a highly organised structure. These nanosheets are employed in a variety of applications, including photocatalysis, solar radiation, medication delivery, water filtration, and bone implants. The molecular graph of this nanosheet is partitioned using Θ^*- relation and transformed into corresponding strength-weighted quotient graphs. By using the weighted parameters in strength weighted cut method technique, we compute the weighted Szeged type descriptors. Furthermore, we analyse weighted edge and weighted vertex variants of Szeged type descriptors and derive a more generalised formula for these descriptors.

Joint work with **Joseph Clement**

Sustainable circular supply chain with emission control and waste reduction from the healthcare industry using AI drone T87

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To establish a green and carbon-free world, it is essential to reduce carbon footprint. Under the carbon allowance and carbon tax scheme, several high-valued low-carbon technologies, like green technology, waste minimization technology are used to reduce carbon. This eco-friendly technology reduces two types of humanistic greenhouse gas emissions, such as the direct carbon emission and indirect carbon emissions generated by both parties in the supply chain. 3'R technology like recycle, reuse and rework aids to reduce waste. Among some cutting-edge technologies, artificial intelligence has considerable development in medical sector and transportation sector. Mostly, truck deliveries of medical products are hindered and emit more carbon dioxide. Also, the majority of waste are just dumped on the ground. As a result, AI drones help provide basic and urgent healthcare supplies. It delivers items like blood, IV bags, platelets, and organs and some other emergency products. Advance device like smart capsule is fitted inside drone to measure the temperature of the medical supplies. In this study, medical wastes and defective products that need to be re-manufactured are collected through return logistics. Therefore, the goal of this study is to reduce carbon emissions and reduce waste by investing in these technologies using AI medical drone transportation. Lead time is a function that includes loading time, in-transit time manufacturing time, unloading time and airborne time. Logistics time is a proportion of the distance travelled by drone, payload weight, and battery energy usage. This model demonstrates that when such successful technologies are deployed to maintain a sustainable environment, it increases the buyer's and vendor's total profit and supply chain's overall profit. Numerical analysis is being employed and sensitivity analysis has also been created to determine and analyse the best order quantity, and find the maximum integrated total profit of the vendor and buyer. Solution algorithm is being explained for procedure. Mathematica is used to calculate the profits and Adobe Photoshop is used to design the model as summary of the paper.

Joint work with **Umakanta Mishra**

T88 A sustainable three-layer circular economic models with controllable waste, emission and wastewater from textile and clothing industry

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The textile and clothing industries play a major role in greenhouse gas release, climate change, global warming, air pollution, water pollution, and soil damage due to land fill of clothes. Due to fast fashion evolution and the unnecessary lifestyles of humans, each year more than ninety-two million waste garments are produced. Only 14 percentage of it is recycled, and the remaining is dumped on land. So, by establishing a sustainable circular economy or circular business model, implementing zero waste concepts in the textile industry, and by removing the linear model of take, make, use, and throw away, at least thirty percent of the earth's damage can be mitigated. In this paper, a sustainable circular three-layer supply chain model consisting of a single supplier-manufacturer and many retailers is developed. That is, considering the textile industry has one fabric raw material supplier, one dress manufacturer, and many retailers. To create sustainability in this supply chain, water purification technology, green technology, and carbon emission

reduction concepts are introduced at the supplier stage, and zero waste techniques for the valorisation and utilization of pre-consumer textile waste, green technology, and carbon emission reduction concepts are implemented at the manufacturer stage. The integrated total profit maximisation model is derived, and solution finding algorithm. An optimal profit table for chain wide total profit function is given. The concavity of the chain-wide total profit function is shown by using a hessian matrix. The numerical examples, managerial implications, and sensitivity analysis are presented.

Joint work with **Umakanta Mishra**

Sustainable smart mobile phone model with product recovery, emission reduction and waste reduction by 3R technologies: A circular economy perspective T89

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E-waste is one of the fastest growing solid wastes, and mobile phones are a potential candidate for contributing to global e-waste. The extensive demand, short life span, limited repair options, and lack of effective recycling methods for mobile phones trigger e-waste generation. A circular sustainable inventory model that prioritises the conservation of the environment and promotes green industrial practises without compromising profitability is a need of this era. The present paper aims to develop an integrated sustainable model for a mobile manufacturing unit that incentivizes the end-of-life processing of used mobile phones while considering emission reduction, waste minimization, and carbon tax policy into account. The ultimate objective of this study is to determine the optimal integrated average total profit of the system with optimal order quantity and shortage quantity. The current model proposes that the mobile industry achieve maximum profit by introducing a product recoverymanagement for damaged mobile phones. The reuse, recycle, and rework concept of circularity is introduced to control waste and attain sustainability. A derivative test and hessian matrix analysis are performed to determine the optimum values of decision variables and an algorithm is designed to get the maximum expected average integrated total profit using Mathematica 9.0 software. Numerical and theoretical evidence is presented to support the recommended model's applicability in the mobile industry. To comprehend the variations in the expected integrated total profit, waste minimization technology investment cost, and emission reduction technology investment cost with the change of other parameters, sensitivity analysis and managerial insight were provided. A reutilisation score for mobile industry is defined to understand the potential of damaged mobiles for repurposing. It is found that the introduction of product recovery for waste mobile phones and the investment in green technology and waste minimisation technology to reduce emissions and waste results in attaining optimal profit.

Joint work with **Umakanta Mishra**

A biodiesel circular economic model using green and energy saving with zero emission and waste by Microwave 3R Technology: A case study in municipal solid waste management T90

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Waste concern is big challenges that today's growing cities are coping with is the deliv- ery of effective and sustainable waste management, together with a good sanitation,current challenge The ways is through advanced technologies such as microwave assisted internet of things (IoT) through sensor based alarm bins with green alternative for waste recycling. . Circular economy is enabled by the conversion of CO2 into gasoline, GHG gases into pharma- ceuticals, bio-waste into biofuels, plastic waste into building bricks, and concrete waste into building materials. The total energy payback for biodiesel, which is generated by microwave- assisted technology, is calculated and optimal solution were found for biodiesel production along with total profit by using Mathematica 9.0 software. The objective is to optimize total profit, energy and minimise waste in consideration of new vendor model application with the case study. The Kuhn-tucker solution approach was used to solve the model under the Stackelberg strategy.This study theoretically and numerically maximizes the profit of the system with optimize biodieselproduction with green and waste minimization investment as per the carbon cap policy. To find the optimal strategies for maximum profit, an algorithm was developed. Sensitivity analysis is done to determine the varations in the profit, emission cost, waste cost. a greener biofuelproduction system that gains more profit than conventional systems. The key findings state that energy production systems can obtain a good profit in a more sustainable manner than conventional systems.

Joint work with **Umakanta Mishra**

W91 Dissipative filter design for linear discrete-time interconnected system

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This paper describes the dissipative filter design for a class of discrete-time interconnected system. A linear discrete-time subsystems with coupling states which have disturbances and time-varying delays are considered. A effective filter is designed for the considered system. Then with the help of Lyapunov-Krasovski theory and linear matrix inequality (LMI) approach the stability of the designed systems are investigated. Sufficient conditions are developed to ensure the exponential stability of the augmented system involving system and error states. By using MATLAB LMI toolbox the filter parameters are easily determined. Finally, to ensure the effectiveness of the results obtained a numerical example is provided.

Joint work with **G. Arthi** (arthimath@gmail.com)

Order of rational and multiple rational Fourier coefficients of functions of Φ-bounded variation W92

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The order of magnitude of rational Fourier coefficients, for functions of Φ-bounded variation is estimated. The class of functions of Φ-bounded variation is extended for multiple variables and the order of multiple rational Fourier coefficients of functions in such class is estimated.

Joint work with **Rajendra G. Vyas** (email: drrgvyas@yahoo.com)

A Fractional Order Human Papillomavirus Model with Caputo Derivative T93

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In this article, a fractional order Human Papillomavirus (HPV) infection model with the impact of vaccination is presented with Caputo sense. The basic properties of the model are investigated. Using the fixed point theorem, the existence and uniqueness of the solution for the proposed Caputo fractional order HPV model have been proved. Theoretical results are validated by solving the proposed model using the Adams-Bashforth-Moulton Predictor corrector scheme. The numerical result reveals that HPV infection can be reduced by implementing vaccination as a control strategy. Moreover, simulation results indicated that the qualitative nature of the solutions of the classical integer order and the fractional-order model are the same.

Joint work with **Dr. K. Murugesan**.

The dynamics of the fractional-order SEIQR malware spread model on wireless sensor networks T94

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This study uses a mathematical model with fractional order derivative in the Caputo sense to design a fractional optimal control problem for malware spread in Wireless Sensor Networks (WSNs). We provide the state and co-state equations of the proposed model. The malware-free equilibrium and stability of the system is discussed. The basic reproduction number and communication radius of sensors are found. We introduce two

time-dependent control measures to be the most effective method for significantly reducing the spread of infection. One control parameter represents installing immune patches, whereas other indicates the removal of malware from the system. Numerical simulations are done to validate the theoretical results. Finally, it is shown experimentally that an ideal control technique can effectively suppress the spread of infected nodes.

W95 **A qualitative investigation on Caputo fractional neutral VF integro differential equation and its Uniform stability**

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In this article, we consider a Caputo fractional nonlinear functional neutral Volterra-Fredholm (VF) type Integro differential equation (IDE). Some fundamental criteria related to existence and uniqueness of solution have been derived with the help of Banach fixed point theorem, Krasnoselskii fixed point theorem. Next, we analyse the uniform stability of the considered type of neutral IDE's. Appropriate examples are used to validate the results.

Joint work with

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W96 **Extended Dissipative Performance of Fractional-order Neural Networks via LMI Approach**

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In this paper, the extended dissipativity performance is addressed for a class of fractional-order neural networks. The derivatives involving fractional-order has been considered in the sense of Caputo's derivative due to their significance over the other fractional derivatives. Unlike previous studies, the main objective of this paper is to answer the question regarding the extension of extended dissipativity criteria to the fractional-order neural networks. This purpose has been successfully achieved by providing an approach for analyzing the extended dissipativity performance for the fractional-order neural networks. By utilizing the theory of linear matrix inequality, a sufficient criterion has been derived to ensure the extended dissipativity performance for the considered class of fractional-order

neural networks. Lastly, the proposed theoretical results are verified through numerical examples along with simulation results.

Joint work with **G. Nagamani**, Department of Mathematics, The Gandhigram Rural Institute (Deemed to be University) (email: nagamanigru@gmail.com) and **D. Dafik**, Department of Mathematics Education, University of Jember, Jember, Indonesia (email: d.dafik@gmail.com)

A study on Ulam stability of fractional integro derivative impulsive Cohen-Grossberg neural network model W97

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This article deals with stability results for a class of impulsive fractional integro derivative Cohen–Grossberg neural network model. We discuss generalized Ulam-Hyers-Rassias stable. Next we prove that our problem is stable using Gronwall's inequality. Finally, we give example to demonstrate the validity of main results

Time-dependent magnetohydrodynamic (MHD) combined convection flow of an Eyring-Powell nanofluid across an impulsively rotating sphere, optimizing entropy under the influence of activation energy T98

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This investigation is illuminated by the widespread use of non-Newtonian fluids with impulsive motion in engineering. This investigation deals with the entropy optimization in the Eyring-Powell nanofluid flow over an impulsive rotating, moving sphere in an unsteady combined convection regime with the effect of magnetized field, activation energy and liquid hydrogen diffusion. The sphere's angular velocity and the free stream velocity combine to produce the impulsive motion seen here. The flow governing partial differential equations (PDEs) are formulated by incorporating the boundary layer concept in a higher dimensional form. Nonlinearity and coupling play significant roles in these PDEs. After subjecting to non-similar transformations, these PDEs are reinterpreted as dimensionless nonlinear PDEs. So obtained equations are linearized with the aid of the Quasilinearization method. The acquired set of linearized equations is subjected to an implicit finite difference scheme for discretization purposes. The results are represented via graphs that include different profiles and gradients. The friction between the fluid and sphere's surface and fluid velocity tend to decrease for Eyring-Powell nanofluid than the usual Newtonian nanofluid. The energy transfer strength is cut down by approximately 11% for rising values of magnetic field characteristics. A small change in the Brownian diffusion characteristics reinforces the mass transfer strength by 11% approximately. The entropy generation is pronounced more for linear combined convection, whereas it is less

for nonlinear combined convection. Adopting nonlinear combined convection, a magnetic field over a moving sphere can reduce the entropy generation

T99 Bioconvection in a nonlinear convective flow of Eyring-Powell nanoliquid with entropy analysis

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The focus of the study in this article is the Bioconvection in a nonlinear convective flow of Eyring–Powell nanoliquid over a vertical slender cylinder with entropy generation. The Brownian motion of nanoparticles and the phenomenon of thermophoresis in Eyring-Powell nanoliquid are represented by the two-phase Buongiorno's model. The Boussinesq approximation for the body force term in equations which govern the convection flow leads to nonlinear coupled partial differential equations (PDEs). Nonsimilar transformations are considered to handle the equations in the non-dimensional form. Further, the technique of Quasilinearization and the implicit finite difference scheme are used for numerical simulation of the mathematical solution of the problem. Graphs are used to depict the exciting findings for values of numerous flow and material parameters. The rising values of Bioconvection Peclet number intensify the fluid velocity and reduce the microorganism's density. The rate of heat transfer diminishes by about 75% when the Eckert number rises from- 0.5 to 0.5. The growth of microorganism's density number is observed as the Bioconvection Lewis number increases. The entropy generation intensifies due to higher nanoparticles diffusion and microorganism's density parameters, whereas the reverse behaviour is observed in the case of the Bejan number. An excellent agreement is noticed when the current solutions are compared with the corresponding outcomes reported in the existing literature.

T100 Numerical investigation of forced convection turbulent flow over a heated a microprocessor chip embedded with semi-circular fin

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Computers are capable of processing large amounts of data at incredible speeds which leads to increased heat due to increased microprocessor (CPU) temperatures. Resolving the issues pertaining to increased heat generation in the flow area requires suitable design of heat sinks. In this regard, a numerical investigation is carried out to enhance the cooling performance of a CPU integrated with several semi-circular fins. For this purpose, a three-dimensional model of a heated microprocessor chip (square channel) embedded with semicircular fins is created and a numerical simulation is carried out to investigate its cooling performance subjected to forced convection turbulent flow. The length and height of a square channel are 20 mm and 6.5 mm respectively whereas the height and diameter of semicircular fin are 2.5 mm and 1 mm respectively. The fins are arranged in rows and

columns with equal distance between them. An incompressible and steady flow of air at 300 K is used for cooling purpose. The K-epsilon realizable turbulent model is considered due to its suitability in industrial applications as it is robust and computationally strong. The governing equations (i.e., continuity, momentum, and energy) are solved numerically in Fluent. The grid independence test as well as code validation are also carried out prior to numerical investigation. The heat transfer rate is investigated by means of local Nusselt number and skin friction along the direction of flow. The average Nusselt number at different Reynolds number ranging from 4000 to 10000 is also evaluated. The effect of semi-circular fin is clearly visible as the local Nusselt number varies significantly near the fins. The velocity of air behind the fins is deteriorated due to which the mixing of hot and cold fluid takes place Due to the high mixing rate, the convective heat transfer rate increases at high Reynolds number. The effect of micro semi-circular fin area is clearly visible as the local skin friction number varies significantly near the fins. At the junction between the fins and cold fluid, more skin friction develops and then it gradually deteriorates until next semi-circular fin. The comparison is also made between the channels embedded with and without fins at different Reynolds number. The result shows lower skin friction near the fin area at high Reynolds number for the channel embedded with micro semi-circular fins.

Joint work with **Praveen James Sanga**, Department of Mechanical Engineering, Birla Institute of Technology, Mesra, Ranchi, India and **Prabal Datta**, Department of Mathematics, Birla Institute of Technology, Mesra, Ranchi, India

Darcy-Brinkman Model for Anisotropic Rotating Porous Channel Under the Influence of Magnetic Field W101

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This present article provides the study of the Darcy-Brinkman equation in an anisotropic porous channel rotating with constant angular velocity in the presence of a magnetic field. We have investigated the effect Hartman number (related to a magnetic field) on fluid velocities due to applied pressure gradient and rotation of channel for different values of Darcy numbers (related to permeability) and Taylor number (related to rotation). We have also discussed the effect of Hartman number on the volumetric flow rates and shear stresses concerning these parameters.

Joint work with **Vineet Kumar Verma** (Email: vinlkouniv@gmail.com)

Influence of MHD on hybrid nanofluid (SWCNT+MWCNT/ H2O) flow over an exponentially elongated sheet with slip conditions W102

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Slip condition deserves a lot of consideration since it plays a big role in heat transfer phenomena such as cleaning of micro heat exchangers, mechanical heart valve cleaning, and inner cavity polishing. This study focused on the numerical analysis of magnetohydrodynamic hybrid nanofluid slip flow in the presence of joule heating and viscous dissipation via an exponentially extending sheet. The governing coupled nonlinear equations of PDEs are transformed through exponential similarity variables into a system of coupled nonlinear ODEs, which is solved via MATLAB's bvp4c solver. The velocity profile is reduced as a result of the improvement in velocity slip and suction. Numerical findings are obtained for the skin friction coefficient and local Nusselt number. Hybrid nanofluid enhances the rate of heat transmission by 3.97%, according to the results of the thermal slip condition against the stretching sheet.

W103 **Magnetohydrodynamic effects on thermal radiation water-based hybrid nanofluid in a rotating system: Analytical Approach**

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This paper aims to analyze the MHD flow of a hybrid nanofluid in a porous media in the presence of thermal radiation and heat production over a vertical plate. For this investigation, the dimensionless governing equations are reduced to a system of linear differential equations using the regular perturbation method, and the equations are solved analytically. The impact of the flow field's numerous flow characteristics has been addressed and illustrated graphically. In the presence of Heat generation and thermal radiation parameter conditions, the Nusselt number in nanofluid is 9% lower than the hybrid nanofluid. The current work demonstrates that heat exchanger technology, geothermal energy storage, and other processes are significantly exaggerated by heat-enhancement approaches.

Joint work with **P V Satya Narayana** (email: pvsatya8@yahoo.co.in)

W104 **Algebraic mulitigrid method for virtual element discretization of the convection-diffusion equation**

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Consider the linear convection-diffusion equation,

$$\begin{cases} -\epsilon\Delta u + \mathbf{b}\cdot\nabla u = f & \text{in} \quad \Omega, \\ u = g & \text{on} \quad \partial\Omega \end{cases} \tag{1}$$

where $\Omega \subset \mathbb{R}^2$ is a bounded open set, with $\mathbf{b}$ and f are sufficiently smooth and $|\mathbf{b}| \gg \epsilon$ i.e., convection-dominated case.Virtual element method is widely studied due to its capability of handling general polygonal/polyhedral meshes. More recently, SUPG stabilization of VEM for convection-diffusion equation is discussed in Benedetto, M. F and Berrone, S

and Borio, A and Pieraccini, S and Scialo, S [Order preserving SUPG stabilization for the virtual element formulation of advection-diffusion problems,*Comput. Methods Appl. Mech. Engrg.*, 311, 18-40, 2016.] Design of efficient linear solvers are still computationally challenging for mesh-based numerical simulations. There are several direct or iterative solvers available, whose complexity is worse than linear. The multigrid method is an efficient iterative technique which is asymptotically optimal i.e. their overall cost is linear or close to linear in the number of unknowns. The Algebraic Multigrid (AMG) methods were designed to solve linear systems based on multigrid principles, but in a way that only depends on the coefficients in the underlying matrix. A new approach to the use of the AMG as a preconditioner for the CG method in ill-conditioned problems is presented in Henrique Pereira, F , Verardi, S, Silvio I.N [A fast algebraic multigrid preconditioned conjugate gradient solver, *Applied Mathematics and Computation* , 179, 344-351, 2006].

We investigate the performance of AMG when applied to VEM-SUPG discretization of convection-diffusion equation on different convex and nonconvex polygonal meshes. Since the linear system for this model problem is nonsymmetric, solvers such as generalized minimal residual method (GMRES) is preferable. In order to accelerate the convergence of these solvers we would like to use AMG as a preconditioner for GMRES.

Joint work with **E.Natarajan**, Indian Institute of Space Science and Technology, Thiruvananthapuram-695547, Kerala (email: ramanan8119@gmail.com) and **S. Natarajan**

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Speaker Index

In pic: Rockfort temple, Kallanai dam and Tanjore big temple