# Research Highlights of Discipline of Mathematics, IIT Indore

**Dr. Safique Ahmad, Assistant Professor**

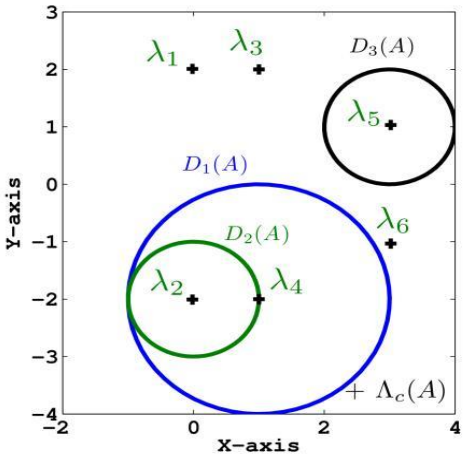
**Research Areas:**
a) Numerical Linear Algebra
b) Quaternionic Linear Algebra

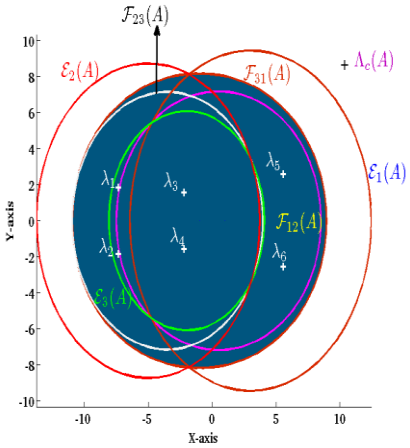
1. The matrix eigenvalue problems and matrix polynomial eigenvalue problems have tremendous applications in various fields of Science and Engineering, and the perturbation analysis on the above problems helps to understand the sensitivity analysis of the pertubed systems, so we always have to make sure that the perturbations have the right properties. There is always a good problems and we want the distance to the nearest bad problems for that we want the smallest perturbation that makes it a good problem. The perturbation and distance problem for matrix, matrix pencils, matrix polynomials and some special restricted problems to be proposed. Also we want the structured perturbation and structured distance problems as well.

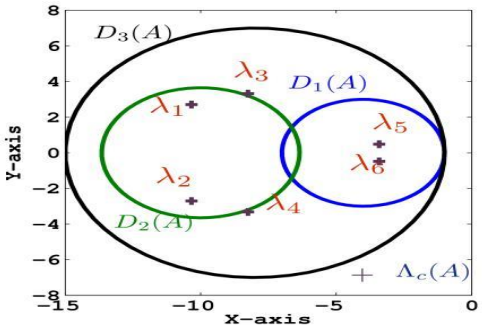
2. Multiparameter eigenvalue problem (MPEVP) arises in several applications. In many applications the coefficient matrices have further structure which reflects the properties of underlying physical model. The MPEVP arises from physical modelling and usually solved by numerical methods that are subject to roundoff errors, it is very importnat to study the perturbation analysis of these problems. This analysis is necessary to study the sensitivity of the eigenvalue/ eigenvectors. We are interested in the behaviour of backward error of MPEV, which are preserving various structures have been discussed. In particular, to present the backward error analysis for a given approximate eigenpair of MPEVP. We shall construct an appropriately structured minimal (in the Frobenius norm) perturbation such that the given approximate eigenpair becomes an exact for the perturbed one. Our main focus on multiparameter in which the cofficient matrices preserving the structures such as symmetric, skew symmetric, Hermitian, Skew Hermitian, circulent, skew circulent, and T even, T-odd, H-even H-Odd and Palnidromic parameter eigenvalue problems as well. To this end we shall discuss the structured condition number of the perturbed eigenvalues, which would measure the sensitivity of the perturbed eigenvalues.

3. Matrices over a skew field have brought the attention of many researchers in mathematics, physics, and engineering. Localization theorems of quaternionic matrices have been the focus of wider research for their large applications. Basically, we would work on the distribution theorems for the left and right eigenvalues of quaternionic matrices. We introduce the sufficient conditions for nonsingular quaternionic matrices. Moreover, we develop the sharper inclusion region to locate the right eigenvalues of quaternionic matrices. We present minimal Gerschgorin balls in 4D spaces which will contain all Gerschgorin balls of quaternionic matrix A. Finally, we introduce the estimation for the right eigenvalues of quaternionic matrices in a minimal ball in 4D spaces. The concept of perturbation bounds on the right eigenvalues of the quaternionic diagonalizable matrices is proposed. In particular, we present a Bauer-Fike type theorem for the right eigenvalues of the quaternionic diagonalizable matrices. In addition, localization theorems for the right eigenvalues of quaternionic matrices are discussed. Further, we state the Gerschgorin type theorem for the quaternionic matrices and show that the Gerschgorin type

theorem can be derived from Bauer- Fike type theorem when the eigenvalues are real. Moreover, we present a sufficient conditions for the stable quaternionic linear state space system $\dot{x}(t) = Ax(t)$, where A is a quaternionic square matrix. We shall extend the above work to matrix pencil and extension to matrix polynomial as well. Further, we would like to solve various distance problems on Quaternionic matrices and quaternionic matrix polynomials and, the bounds for the zeros/eigenvalues of the quaternionic polynomials/matrix polynomials will be derived.



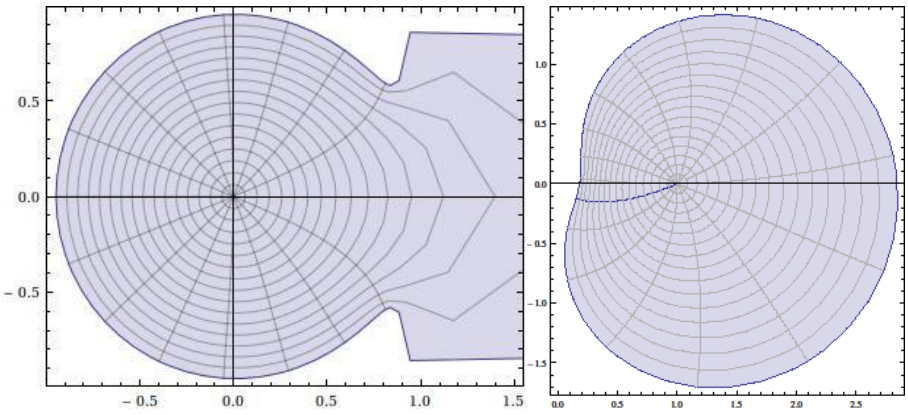

**Dr. Swadesh Kumar Sahoo, Assistant Professor**

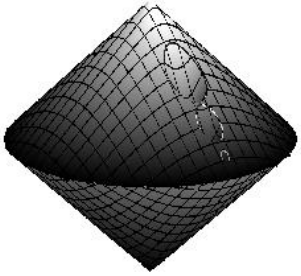
**Specialization:** Complex Analysis
**Research Interest:** Geometric Function Theory

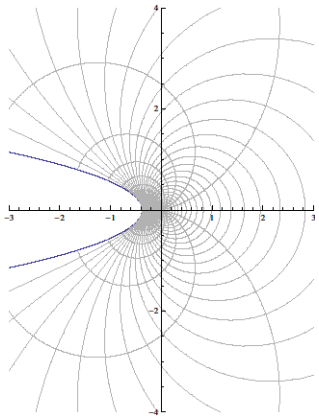
We work on problems in the theory of univalent functions, special functions, quasiconformal mappings, and hyperbolic-type geometry. In particular, we aim

- to extend theory of hyperbolic-type geometry associated with quasiconformal mappings and domains having geometric characterizations;
- to investigate properties of conformal mappings associated with metrics bilipschitz equivalent to the hyperbolic metric;
- to find necessary and sufficient conditions for certain analytic functions in terms of coefficient estimates, pre-Schwarzian and Schwarzian derivatives;
- to study analytic and geometric properties of partial sums, arc length, area, and radius problems for univalent functions;

- to visualize mapping properties of basic hypergeometric functions using techniques from geometric function theory.







**Dr. Antony Vijesh, Assistant Professor**

Research Interests

- Applied Functional Analysis

  Developing efficient numerical methods for various types of differential equations is one of the important problems in science and technology. Recently numerical methods for partial differential equation based on wavelets and finite difference method studied by many researchers. Dr. Vijesh and Mr. Harish Kumar developed a new numerical method based on wavelet for semi-linear parabolic differential equation with systematic convergence analysis. The proposed scheme produces higher accuracy with less number of grid points compared with methods available in the recent literature. [Ref: **APPL. MATH. COMP., 266, 1163—1176]**. Dr. Vijesh, Ms. Rupsha Roy and G. Chandhini proposed a modification in the quasilinearization iterative scheme for proving the existence and uniqueness result for fractional order differential equations. This modification reduces the computational complexity considerably for class of fractional order differential equations. **[Ref: APPL. MATH. COMP., 266, 687--697]**.

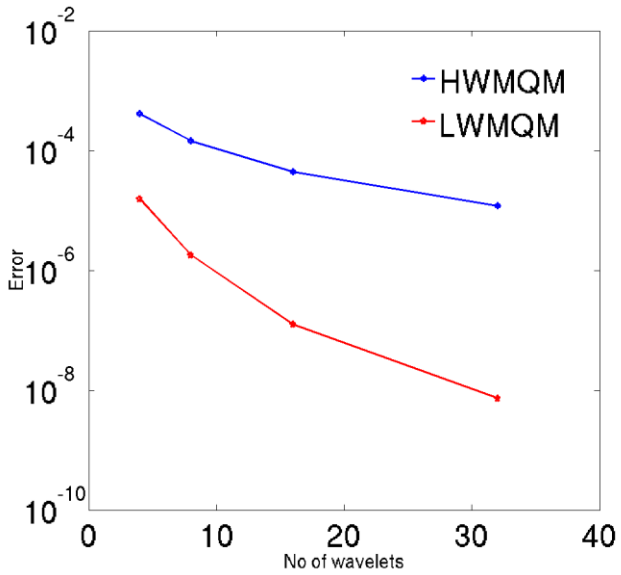



Fig1: Haar Wavelet Method Vs Legendre Wavelet Method

**Dr. Anand Parkash, Assistant Professor**

**Research Interests:** Algebra

Dr. Anand Parkash is working on Prime Submodules and Radical Formulae. For commutative rings with unity, intersection of all prime ideals is equal to the set of all nilpotent elements and it is called the radical formula for rings. Prime submodules are generalization of prime ideals and some radical formulae have been defined for modules. Recently, he has find a necessary and sufficient condition for a local domain of dimension one to satisfy the radical formula.

A. Parkash, One dimensional local domains and radical formula, *Beitrage zur Algebra und Geometrie*, 56(2) (2015), 729-733.

**Dr. Niraj Kumar Shukla, Assistant Professor**

**Research Interests**

- Wavelet Analysis
- Harmonic Analysis

The main research interest of Dr. Niraj Kumar Shukla is Frame and Wavelet analysis in different scenarios like locally compact abelian groups, local fields of positive characteristic, Euclidean space, etc. Wavelet theory is applicable to several subjects. All wavelet transforms may be considered forms of time-frequency representation for continuous-time signals and so are

related to Harmonic analysis. His work relates to Shift invariant spaces, Spectral theory, Time-Frequency analysis, topological properties of wavelet and scaling sets, etc.

**Dr. Md Aquil Khan, Assistant Professor**

## Research Interests

- Modal Logics
- Rough Set Theory and its Applications

Dr Md Aquil Khan works on modal logics, rough set theory (RST) and its applications. Since the inception of RST, it has seen applications in many areas viz. medicine, finance, information science, decision analysis, social science, pharmacy,
etc. To increase the applicability of the RST, it is important to extend the theory to relate it with some important issues in artificial intelligence such as multiple-source (agent) knowledge bases, temporal evolution of knowledge bases, information updates. In order to achieve this, one may needs to make necessary changes and extensions in the theory by bringing new ideas and results from other mathematical systems for uncertainties. This line of research comes under Dr. Khan's expertise. Currently, he is working on the extension of RST by bringing ideas and results from probability theory and co-algebra. This study, in one hand will increase the understanding of RST, and on the other hand, it will open the wider applications of the theory. Moreover, he also focuses on the logical systems which can be used for reasoning with rough sets.

**Dr. Ashisha Kumar, Assistant Professor**

**Research Interests**
Analysis

- d-plane transform (a generalization of X-ray and Radon transform)
- H-type Groups

Radon and X-ray transform is a very useful tool for tomography. Dr. Kumar works on some theoretical aspects of these transforms.