Research Spectrum

A Compendium of Graphical Abstracts Illustrating Research at IIT Indore

Volume 2 Issue 2

Editors:
Prof. Avinash Sonawane
Prof. Chelvam Venkatesh
Prof. I. A. Palani
Prof. Ram Bilas Pachori
Prof. Sanjeev Singh

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Director's Message

With great pride and honour, I write this foreword to the Second Issue of the Second Volume of 'Research Spectrum'. My heartiest congratulations to the team of Editors, and the executive team from R&D office, Prof. I.A. Palani, Dean R&D, Prof. Trapti Jain, Associate Dean R&D-I, Dr. Bodhisatwa Mazumdar, Associate Dean R&D-II for their consistent efforts in publishing it regularly.

With this issue, we are entering into the second year. The endeavor of 'Research Spectrum' aims to disseminate wonderful research carried out by the professors and students of IIT Indore, in the form of pictorial abstracts.

We sincerely wish that the readers will find Research Spectrum containing graphical abstracts, easy to understand we hope that it will further help disseminate the novel research ideas depicted therein amongst the avid researchers and lovers of technology.

With best wishes,

Prof. Suhas S Joshi
Director

TABLE OF CONTENTS

A machine learning approach for prediction of seasonal lightning density in different lightning regions of India

Chandrani Chatterjee[1], Joyjit Mandal[2], Saurabh Das[1]*

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[2]Department of Computer Science, Central University of Rajasthan, Ajmer, India

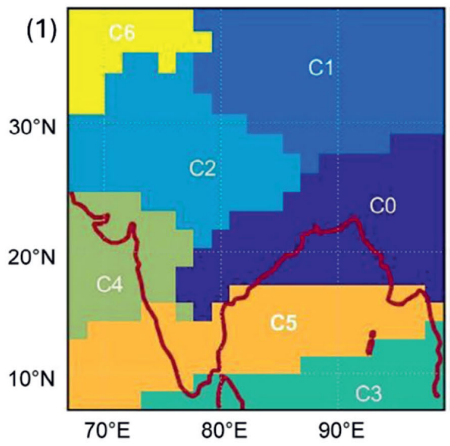


Fig.: 1. Clusters over Indian subcontinent based on the varied relationship among lightning activities and atmospheric parameters

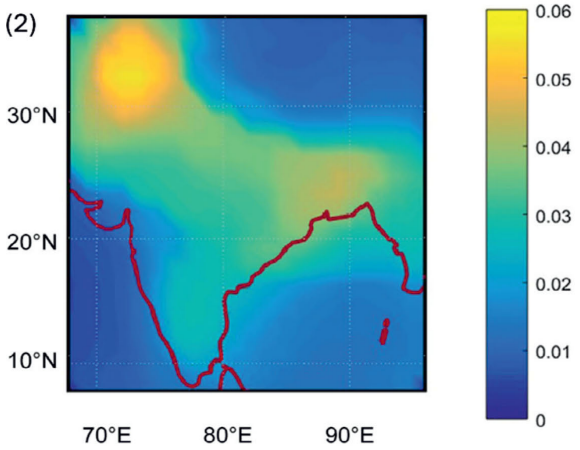


Fig.: 2. Spatial distribution of predicted annual lightning density (flash.km^{-2}.day^{-1}) over Indian region, indicating a very good match with actual observations

Lightning fatalities have become a growing concern, especially in India, due to climate change. However, the accurate prediction of the same is still inadequate due to complex relationship among different atmospheric variable. In this work, we harness the power of machine learning in seasonal prediction of the lightning activity over the Indian region. The region is initially categorized in different parts using a clustering technique based on multiple atmospheric features and then a ML based regression model is developed. The model is able to capture the seasonal behaviour and indicate the varying role of different atmospheric parameters in different topography in modulating the lightning occurrences.

The work has been published in the International Journal of Climatology: Chatterjee et al., Int J Climatol. (2023), 43, 2862–2878.

Activation-induced cytidine deaminase an antibody diversification enzyme interacts with chromatin modifier UBN1 in B-cells

Ankit Jaiswal, Rajarshi Roy, Anubhav Tamrakar, Amit Kumar Singh, Parimal Kar, Prashant Kodgire*

Department of Biosciences and Biomedical Engineering, Indian Institute of Technology Indore, India

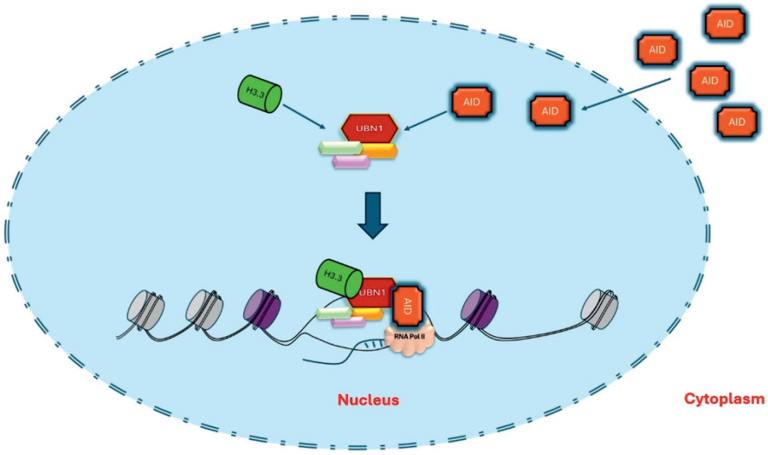


Fig.: UBN1 interacts with AID as well as H3.3. Due to this interaction, UBN1 may be able to load H3.3 and AID in complex forms to the variable region of the Ig locus

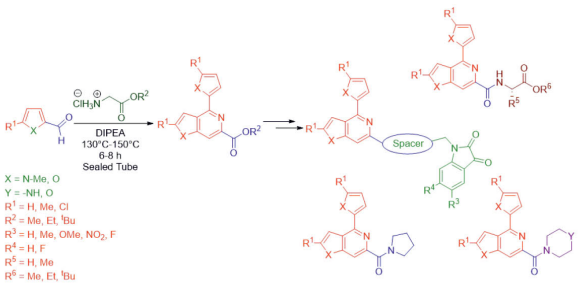
Activation-induced cytidine deaminase (AID) is the key mediator of antibody diversification in activated B-cells by the process of somatic hypermutation (SHM) and class switch recombination (CSR). Targeting AID to the Ig genes requires transcription, enhancers, and its interaction with numerous factors. We explored whether UBN1 (member of HIRA chaperon complex) interacts with AID using computational and in-vitro experiments. Our experiments established interactions between UBN1 and AID inside B-cells. Additionally, a double immunofluorescence assay confirmed that AID and UBN1 were co-localized in the B-cell lines. Moreover, proximity ligation assay studies validated that AID interacts with UBN1. Ours is the first report on the interaction of genome mutator enzyme AID with UBN1.

The work has been published in the Journal Scientific Reports: Jaiswal et al., Sci. Rep. (2023), 13(1):19615.

Delivery of new therapeutic tools for the treatment of tuberculosis and drug resistance tuberculosis

Premansh Dudhe[1], Mena A. Krishnan[2], Avinash Sonawane[2], Venkatesh Chelvam[1,2]*

[1]Department of Chemistry, Indian Institute of Technology Indore, India
[2]Department of Biosciences and Biomedical Engineering, Indian Institute of Technology Indore, India



Scheme: 1. General synthesis of anti-tuberculosis compounds **13e, 15d-h** *and* **24e**

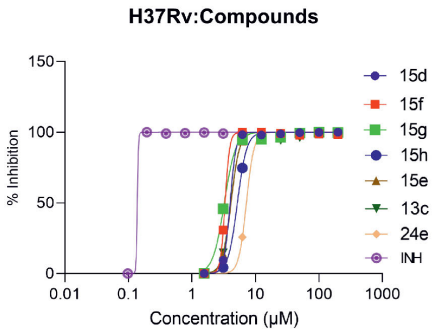


Fig.: Dose-response study (IC50) of most potent anti TB activity compounds in clinical isolates of MTB H37Rv in comparison with INH

Tuberculosis (TB) caused by Mycobacterium tuberculosis (Mtb) is one of the leading causes of death worldwide. We have developed more than 150 novel antibacterial pyridine ring fused heterocycles using a newly discovered reaction in our laboratory that are targeted at Pks13 enzyme inhibiting the formation of mycolic acid. Consequently identified several furo[3,2-c]pyridine and furo[3,2-c]pyridine isatin hybrids exhibiting potent antimycobacterial activity against virulent and non-virulent mycobacterial strains at low micromolar concentrations without causing cytotoxicity on macrophage cells. They are also active against clinical isolates of mycobacterium MTB H37Rv in 3-5 μM range of concentrations in comparison with standard antituberculosis drug isoniazid (INH, 0.31 μM).

The work has been granted Indian and USA patents: Method and system for metal-free solvent-free synthesis of fused-pyrido heterocycles and their biological activities against cancer and multi drug-resistant pathogens, Venkatesh C., Dudhe P., Krishnan M. A., Sonawane A., Indian Patent (2021), IN 366986, USA Patent (2022), US 11,427,596 B2.

A numerical study on nonlinear vibrations of laminated composite singly curved stiffened shells

Dr. Kaustav Bakshi

Department of Civil Engineering,
Indian Institute of Technology Indore, India

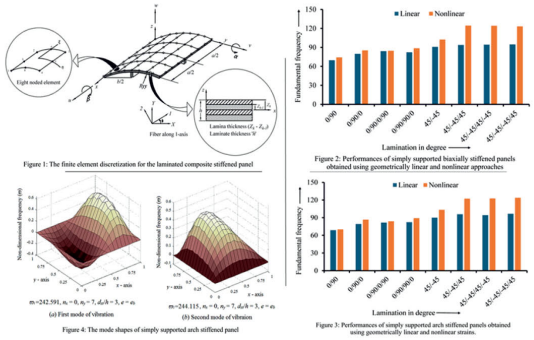


Fig.: 1. The nonlinear vibrations characteristics of simply supported stiffened shells

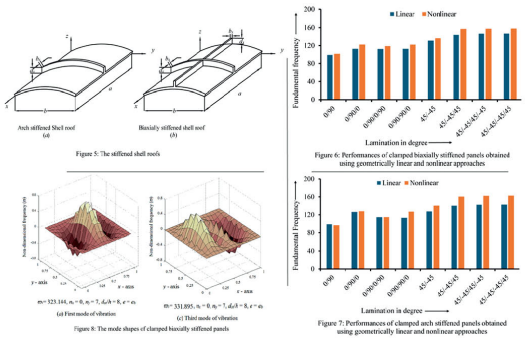


Fig.: 2. The nonlinear vibrations characteristics of clamped stiffened shells the QR code for the article is given below

The laminated composite cylindrical panels are used as roofs of stadiums, auditoriums and shopping malls. The moderately thin surfaces offer lower selfweight, seismic forces and foundation dimensions but exhibit large amplitudes of vibration which can be controlled by stiffeners. The free vibration characteristics provide valuable insight on rigidity and control of resonating frequency. This study formulated the curved surfaces by geometrically nonlinear strains only while stiffeners by linear and nonlinear strains. The conclusion was that the nonlinear approach is essential for shells with arch stiffeners to get correct predictions. The linear approach can be considered for shells having beam stiffener.

The work has been published in the Monthly issue of the Composite Structures: Bakshi, K. Compos. Struct (2021), 278, 114718.

eNCache: Improving content delivery with cooperative caching in Named Data Networking

Pankaj Chaudhary[1], Neminath Hubballi[1]*, Sameer G. Kulkarni[2]

[1]Department of Computer Science and Engineering, Indian Institute of Technology Indore, India
[2]Department of Computer Science and Engineering, Indian Institute of Technology Gandhinagar, India

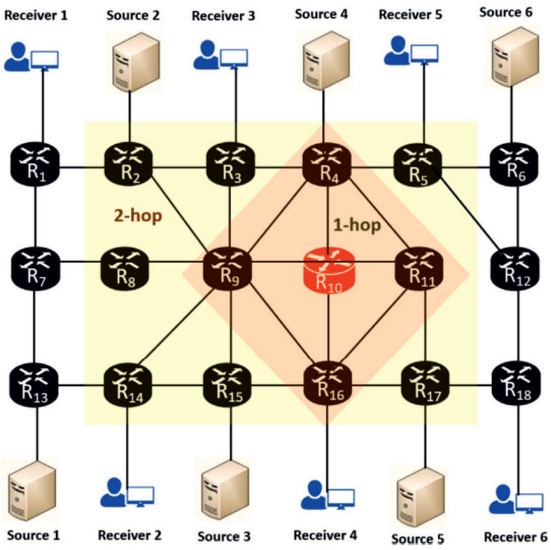


Fig.: eNCache Reference Architecture

Content-centric networks improve response times and resilience by caching content in routers. However, limited cache capacity challenges effective utilization, prompting the development of various interesting caching techniques. This paper presents eNCache, a cooperative caching method that enhances performance by enabling collaboration among neighboring routers. Unlike traditional on-path caching, eNCache retains simplicity while interacting with off-path routers for efficient caching and routing decisions. We detail algorithms for request handling and compare eNCache against existing strategies through simulations on RocketFuel ISP topologies. Results show that eNCache achieves reduced latency, improved cache hit ratios, and diversity in caching performance.

The work has been published in the Elsevier Computer Networks Journal: Chaudhary et al., COMNET (2023), 237, 110104.

AFibri-Net: A lightweight convolution neural network based atrial fibrillation detector

Nabasmita Phukan[1], M. Sabarimalai Manikandan[2], Ram Bilas Pachori[1]*

[1]Department of Electrical Engineering, Indian Institute of Technology Indore, India
[2]Department of Electrical Engineering, Indian Institute of Technology Palakkad, India

Fig.: 1. Implementation of the proposed optimal convolutional neural network models on resource constrained computing platform (Edge computing): Raspberry-Pi computing platform with Broadcom BCM2711 and 1.5 GHz Cortex-A72 quad-core CPU with 8 GB RAM

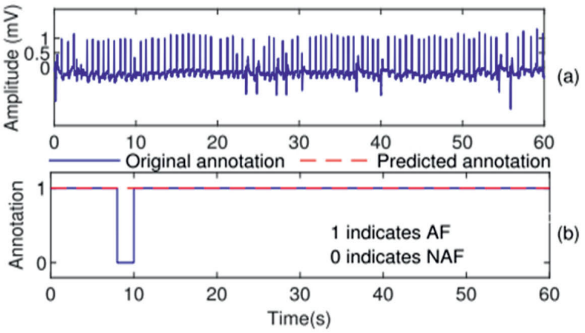


Fig.: 2. Detection result of the proposed optimal AFibri-Net model for (a) 60 s ECG signal taken from MIT-BIH arrhythmia database record 210; (b) Original event and the predicted event. Level 1 indicates AF event and level 0 indicates non-AF (NAF) event. Out of 1 AF event and 10 NAF events, all events are predicted correctly by the proposed optimal AFibri-Net model

Atrial fibrillation (AF) leads to life-threatening ischemic stroke. This paper presents a lightweight convolutional neural network-based AF detector (AFibri-Net), optimized for limited battery capacity in wearable devices. Extensive evaluations were performed using various combinations of convolutional layers (3, 4, 5), filters (8, 16, 32), activation functions, and kernel sizes (3×1, 4×1) across different electrocardiogram (ECG) segment durations (5, 10, 30-seconds). The best model, with 5 convolutional layers, exponential linear unit activation, and a 4×1 kernel, achieved 99.97% accuracy on 5-second ECG segments. A real-time implementation on Raspberry-Pi demonstrated efficient processing time with minimal accuracy reduction compared to a personal computer.

The work has been published in IEEE Transactions on Circuits and Systems I: Regular Papers (IEEE TCAS-I): Phukan et al., IEEE TCAS-I (2023), 70, 12, 4962-4974.

The value of Indian patents: An empirical analysis using citation

Mohammad Danish[1], Ruchi Sharma[2]*

Centre for Transformative Innovation, Swinburne University of Technology,
Hawthorn, Melbourne, Australia
School of Humanities and Social Sciences, Indian Institute of Technology Indore, India

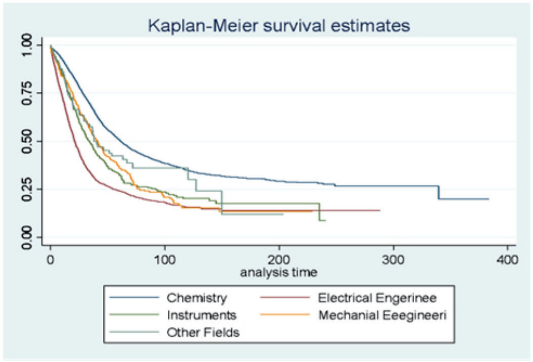


Fig.: 1. Kaplan- Meier survival estimates for different technology classifications

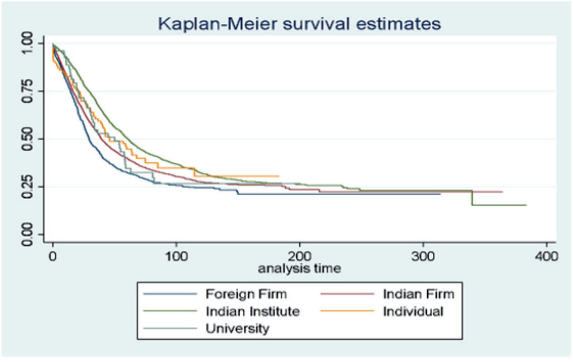


Fig.: 2. Kaplan- Meier survival estimates for different assignee types

Our study examines whether the growth in patenting activity in India, spurred by policy changes such as the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs), is reflected in a corresponding increase in the "quality" of Indian patents. To investigate this, we utilise 6,777 Indian patent data granted by the United States Patent and Trademark Office (USPTO) filed between 1984 and 2015. We find that patents in electrical engineering are more valuable than those in other categories, including chemistry, mechanical engineering, instruments, and other fields. Furthermore, our empirical findings support an overall increasing value of Indian patents in more recent filings, as the study demonstrates a declining citation lag trend of newly filed patents.

The work has been published in Economics of Innovation and New Technology (EINT): Danish, M., & Sharma, R. EINT, (2024), 33(5), 647-671.

On starlikeness of regular Coulomb wave functions

Árpád Baricz[1], Pranav Kumar[2], Sanjeev Singh[2]*

[1]Department of Economics, Babe -Bolyai University, Cluj-Napoca 400591, Romania; and Institute of Applied Mathematics, Óbuda University, 1034 Budapest, Hungary

[2]Department of Mathematics, Indian Institute of Technology Indore,

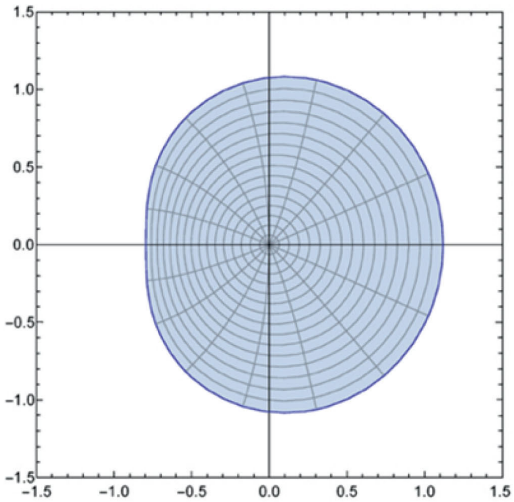


Fig.: 1. Image of the open unit disk unde $f_{L,\eta}(z)$ for $L = 1$ and $\eta = 2/3$

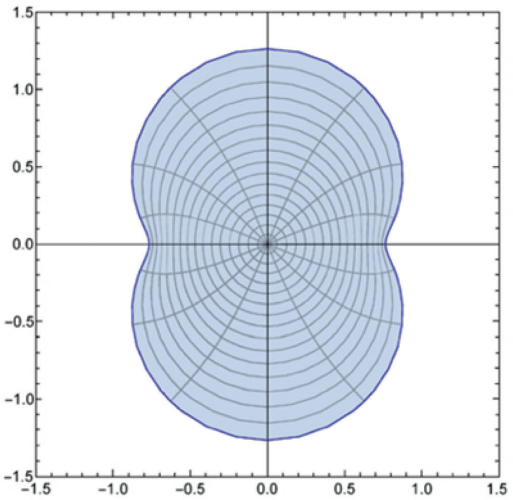


Fig.: 2. Image of the open unit disk under $f_\nu(z) = z^{1-\nu} J_\nu(z)$ for $\nu = 0.001$

In this paper, we study some geometric properties of a class of analytic functions which is defined from the J-fraction expansion of the ratio zf'(z)/f(z). We find the disk domain which is mapped into a starlike domain by these functions. Moreover, we study similar results for two different normalized forms of regular Coulomb wave functions and a normalized Bessel function of the first kind by using continued fractions expansions.

The work has been published in the Proceedings of the American Mathematical Society, (PAMS): Baricz et al. Proc. Amer. Math. Soc. 151 (2023), 2325-2338.

Highly selective ion transport by freestanding Zn-Imidazole complex intercalated graphene oxide membrane for enhanced blue energy harvesting

Khushwant Singh, Mayank K. Singh, Sarathkumar Krishnan, Suporna Bhowmik, Sheetal Gupta, Dhirendra K. Rai*

Sustainable Energy & Environmental Materials (SEEM) Lab, Department of Metallurgical Engineering and Materials Science, Indian Institute of Technology Indore

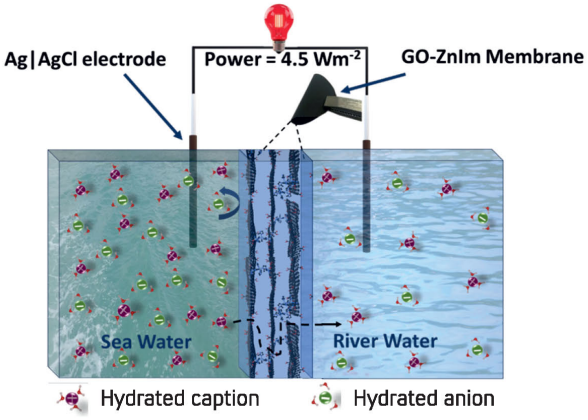


Fig.: Schematic depiction of power generation using GO-ZnIm membrane at the estuary

Generating electricity from seawater is a promising method for achieving our goal of zero-emission energy. This approach involves harnessing the free energy produced by mixing two different salt concentrations, such as at the junction of a river and the sea, to generate electricity. The process relies on separating two water bodies with membranes containing nanofluidic channels that selectively allow the passage of only one type of ion with a specific charge (either cation or anion). Our team has successfully developed a cost-effective, water-resistant membrane by intercalating zinc-imidazole complex into graphene oxide (GO-ZnIm), which exhibits highly selective cation transport and an improved flux rate. Under simulated estuary conditions, this membrane is capable of generating 4.5 W/m^2 of power, a performance that rivals the best commercial membranes available. Looking ahead, this innovative membrane holds potential for applications in water filtration, desalination, and harnessing energy from the ocean.

The work has been published in the Chemical Engineering Journal: 10.1016/j.cej.2024.150683.

Investigation of laser-assisted micromachining of NiTi SMA bimorph-based actuators toward developing optical shutters

Kaushal Gangwar[1], Kailaash Pandiyan[1], Palani Iyamperumal Anand[1]*

[1]Department of Mechanical Engineering, Indian Institute of Technology Indore, India

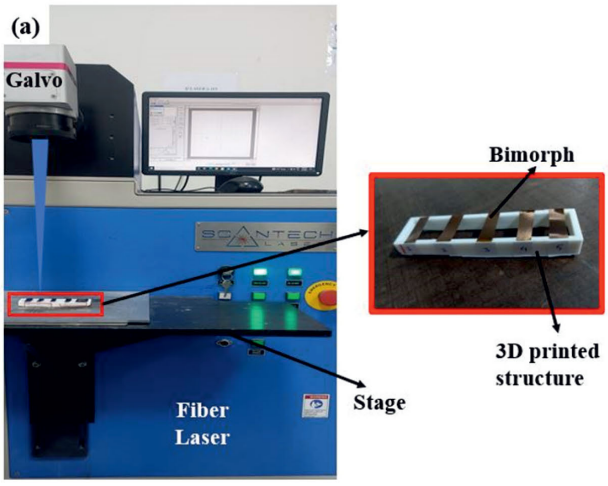


Fig.: 1. Setup for laser micromachining of bimorph

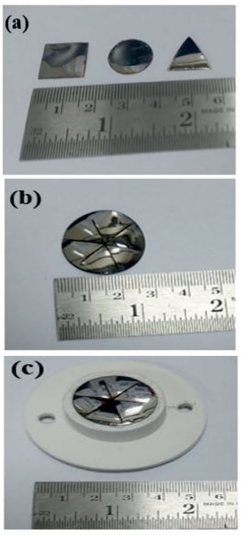


Fig.: 2. Various micromachined geometries out of bimorph structure with fiber laser

This work delves into precision cutting of NiTi shape memory alloy-based bimorph using laser assisted micromachining. NiTi SMA bimorph was fabricated using the e-beam evaporation technique followed by micromachining using a 1064 nm fiber laser. The influence of laser power, laser speed, spot diameter, and laser travel direction on kerf width and heat-affected zone after micromachining was studied. The optimized parameter for micromachining was at laser power 5 W with 5 mm s^{-1} laser speed and 50 µm spot diameter. Various shapes were cut at the optimized parameter, including an optical shutter of a diameter of 30 mm.

The work has been published in the Journal of Micromechanics and Microengineering: Kaushal Gangwar et al., J. Micromech. Microeng. 2024, 34 095002.

Floquet-engineered Valley-Topotronics in Kekule -Y bond textured graphene superlattice

Sushmita Saha, Alestin Mawrie*

Department of Physics, Indian Institute of Technology Indore, India

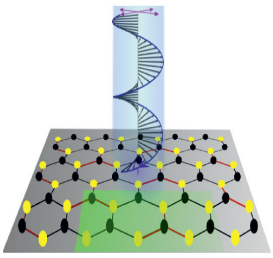


Fig.: 1. The schematic represents the interaction between Kek-Y bond ordered Graphene with the perpendicularly incident Circularly Polarized Light

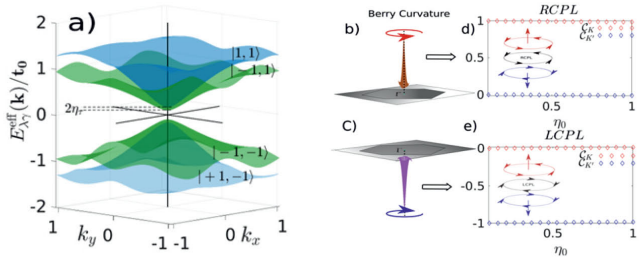


Fig.: 2. Low energy Dispersion of Photon-dressed KekY graphene with the gap opening at Γ-point and breaking the valley degeneracy. (b,c) Berry Curvature reveals the valley-selective Circular Dichroism corresponding to RCPL & LCPL influenced Floquet state |λ, γ⟩ respectively. (d,e) Valley resolved topological invariant No. with the variation in vector potential strength(η0) associated with RCPL & LCPL respectively. Here red and blue arrow decode the valley-pseudospin up(↑) and down(↓) respectively.

The exquisite distortion in a Kekule -Y (Kek-Y) superlattice merges the two inequivalent Dirac cones (from the K- and the K'- points) into the highest symmetric Γ-point in the hexagonal Brillouin zone. Here, we report that UV circularly polarised light not only opens up a topological gap at the Γ-point but also lifts the valley degeneracy at that point. Endowed with Floquet dynamics and by devising a scheme of high-frequency approximation, we have proposed that the handedness (left/right) in polarised light offers the possibility to realize the valley-selective circular dichroism in Kek-Y shaped graphene superlattice. Also, the non-vanishing Berry curvature and enumeration of valley resolved Chern number CK/CK'=+1/-1 enable us to assign two pseudospin flavors (up/down) with the two valleys. Thereby, the above observations confirm the topological transition, suggesting the ease of realizing the valley quantum anomalous Hall state within the photon-dressed Kek-Y. These findings further manifest a non-zero optical valley polarisation which is maximum at the Γ-point. This work thus proposes an optically switchable topological valley filter desirous in the evolving landscape of valleytronics.

The work has been published in the Journal of Physics D: Applied Physics, Sushmita Saha and Alestin Mawrie, J. Phys. D: Appl. Phys. (2024), 57 435301.

Workshop on Patentability Search

In order to strengthen intellectual property awareness and research capabilities, the Indian Institute of Technology (IIT) Indore organized an insightful workshop in collaboration with Xlscout, a leading provider of AI-driven patent analytics solutions on August 28th 2024. The event aimed to familiarize participants with advanced tools and techniques for conducting effective patentability searches, a critical step in the innovation and patent filing process.

The workshop brought together participants who are keen on enhancing their understanding of intellectual property rights (IPR) and innovation management. Expert from Xlscout demonstrated cutting-edge AI-powered platform, offering hands-on training to participants. Topics covered included the fundamentals of patentability, search strategies, and how to use artificial intelligence for precise and efficient patent searches.

Prof. Mirza S. Baig was honoured with Dr. G. P. Talwar Mid-Career Scientist Award 2024

In significant recognition of his outstanding contributions to the field of immunology, Prof. Mirza S. Baig, a distinguished faculty member at IIT Indore, has been awarded the prestigious Dr. G. P. Talwar Mid-Career Scientist Award 2024. The accolade was presented by the Indian Immunology Society (IIS) during the IMMUNOCON 2024 conference held at the Indian Institute of Science (IISc), Bangalore.

The award celebrates Prof. Baig's groundbreaking research in immunology, which has advanced the understanding of immune system mechanisms and their applications in combating chronic inflammatory diseases and cancer. His work has been pivotal in driving innovative approaches to immune-related disorders, earning him national and international acclaim.

Prof. Kapil Ahuja was honoured with 'National Teachers' Awards 2024'

Professor Kapil Ahuja, a renowned faculty member in the Department of Computer Science and Engineering at IIT Indore, has been honored with the prestigious National Teachers' Award 2024. The award was presented by the Honorable President of India on Teachers' Day, September 5, 2024. This recognition was conferred by the Department of Higher Education, Ministry of Education, Government of India, following a rigorous, transparent, and nationwide two-stage online selection process.

With fourteen years of exemplary teaching experience in India and the USA, Professor Ahuja leads the Mathematics, Data Science, and Simulation Research Laboratory at IIT Indore, making significant contributions to education and research in his field.

Prof. Palani I.A. was honoured by Defence Research and Development Organisation (DRDO)

Prof. Palani I.A., an esteemed faculty of the Department of Mechanical Engineering IIT Indore, has been awarded for his exceptional contributions to the development of TENG-based "Walk-to-Charge" Technology under a prestigious sponsored project by the Defence Research and Development Organisation (DRDO). This groundbreaking work was executed in collaboration with IIT Indore and ARDE Pune, showcasing a perfect blend of innovation and teamwork.

The "Walk-to-Charge" technology leverages Triboelectric Nanogenerator (TENG) principles to harness energy from human motion, revolutionizing portable energy solutions for defense applications. Prof. Palani's pivotal role in advancing this futuristic technology has earned him accolades in both academic and defense research circles.

This achievement underscores the potential of interdisciplinary collaboration to drive cutting-edge innovations that strengthen national defense capabilities.

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