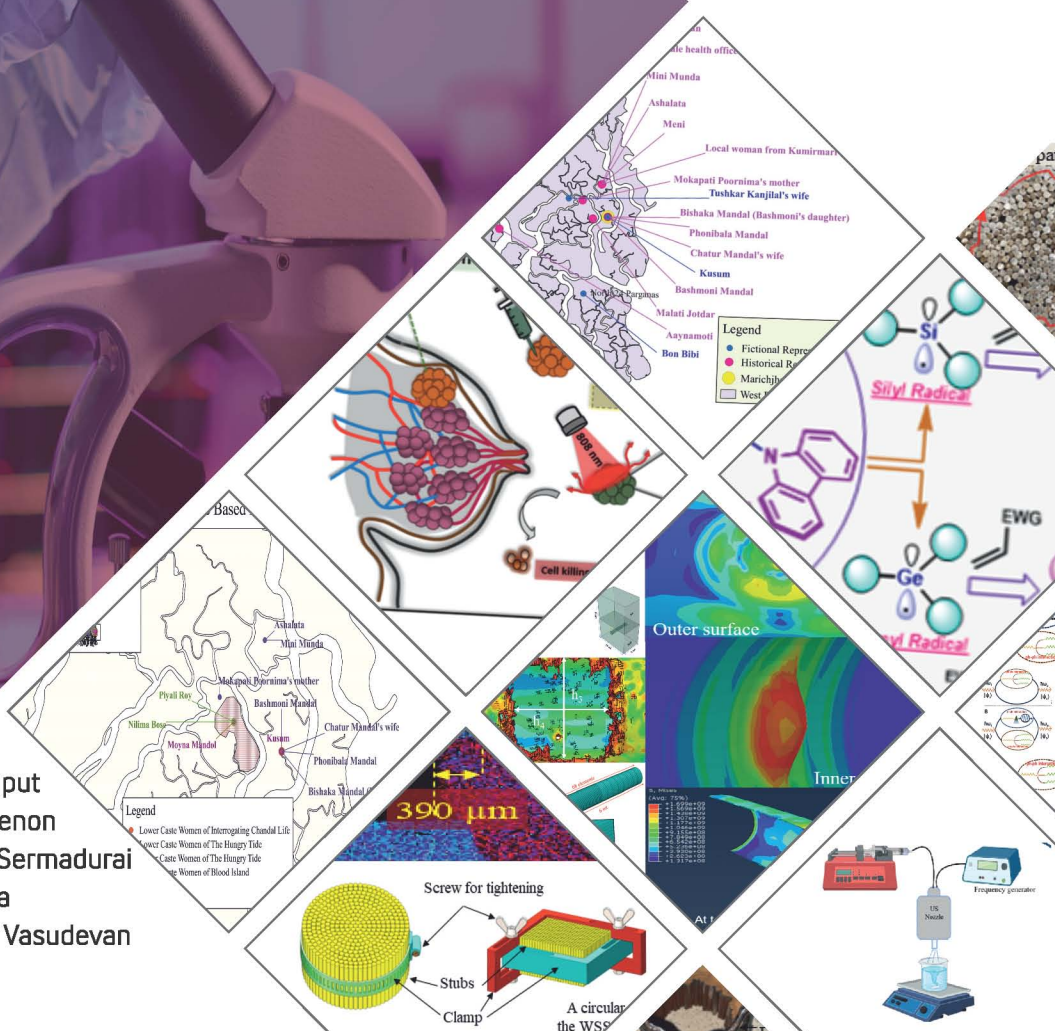




Research Spectrum

A Compendium of Graphical Abstracts Illustrating Research at IIT Indore

Volume 2 Issue 1



Editors:

Dr. Abhishek Rajput

Prof. Nirmala Menon

Dr. Selvakumar Sermadurai

Dr. Sharad Gupta

Prof. Srivathsan Vasudevan

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Director's Message



With great pride and honour, I write this foreword to the first 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

Editorial Message



What in the world is a “Spectrum”?

It is incumbent on the researcher to ask the big questions and explore possible answers. It is the mandate of the technocrat to translate research for our community, nation and the world. Technology- as both a product and catalyst of human ingenuity, has indelibly shaped the trajectory of human advancement. It acts as the medium through which humanity not only solves pressing challenges but also redefines the scope of what is possible. Today, more than ever before, research is intersectional and interdisciplinary. In this interconnected global economy, it is true that technology intersects with various dimensions of human life—ethics, society, environment—making it a critical force in both our understanding and our reshaping of the world. The synergy between technological innovation and human needs continues to drive advancements that not only solve immediate problems but also pre-emptively address those of the future. At IIT Indore, our approach to research and technology development has been interdisciplinary in the best sense of the term.

This issue of Research Spectrum highlights a range of interdisciplinary research that embodies this synergy. From the study of unique pulsar emission behaviours and the synthesis of silk fibroin nanoparticles for biomedical applications to innovative techniques for blast mitigation in underground pipelines and the development of human activity recognition frameworks, each work accentuates the convergence of theory and practice. The issue explores advancements in photoinduced HAT catalysis, compact laser diode case designs, and seismic meta surfaces. A cartographic digital analysis of Dalit massacres and the potential of biphasic cathodes in energy storage. The research presented in these pages come from diverse disciplines from Astronomy and Bio-Sciences, from Electrical engineering and Civil engineering, from Computer Science Engineering and Humanities and Social Sciences. What is common among all of these works is that each of them is directed at bettering human life, understanding societal challenges and finding thoughtful sustainable solutions to them all. The range of articles in this issue underlines that exciting research knows no disciplinary boundaries, that production of knowledge is its own reward.

These visual representations of research conducted in our different laboratories with our students and the faculty members is a glimpse into the work that happen every day in the Institute. These maybe broadly categorised as rigorous investigations into interdisciplinary research spanning sustainable technologies, computational advancements, biomedical innovations, and resource efficiency. Each study underscores the importance of bridging disciplines to generate solutions that are both innovative and impactful, reminding us that the pursuit of knowledge is inherently linked to the betterment of our collective existence. Curiosity and collaboration has to be combined with deep critical thinking to foster best research approaches- we hope that this diverse collection of works should of course inform the reader of the specific works, but collectively should foster and inspire interdisciplinary innovative thinking for students and faculty alike.

Professor Nirmala Menon

(For the Editorial Team)

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A Curious Case of Evolutionary Subpulse Drifting and Nulling

Parul Janagal¹, Samuel J. McSweeney²,
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²International Centre for Radio Astronomy Research, Curtin University, Australia.

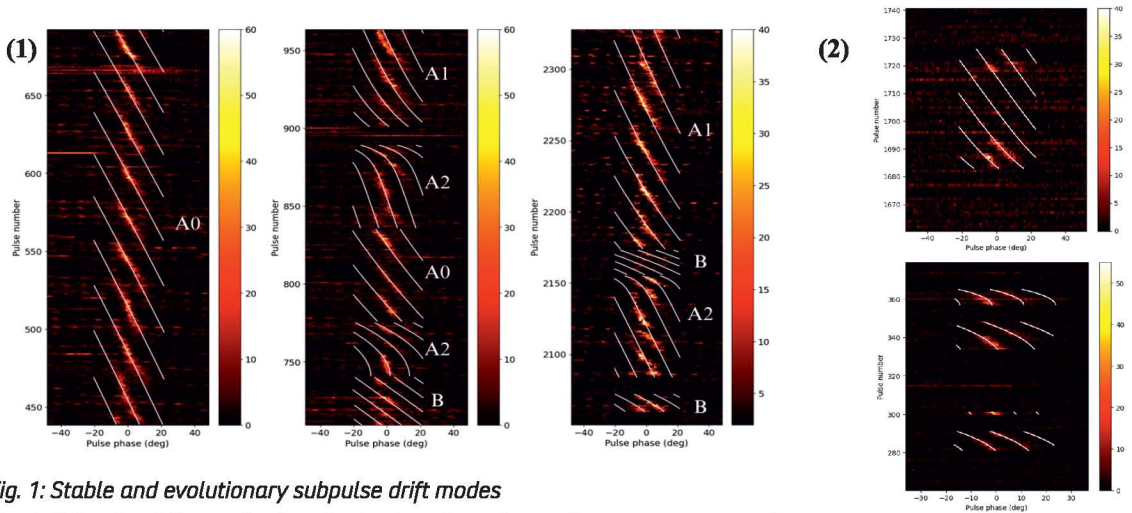


Fig. 1: Stable and evolutionary subpulse drift modes

Fig. 2: Subpulse drift rate (top) and subpulse phase (bottom) memory across nulls

The newly discovered pulsar PSR J0026–1955 exhibits unique behaviors, including subpulse drifting, where its radio emission drifts within the main pulse profile, and nulling, where emission ceases briefly. Observations with the upgraded Giant Metrewave Radio Telescope (Pune) at 300–500 MHz revealed rapid changes between drift modes and gradual drift rate evolution within a mode. We identified both stable and rare evolutionary drift modes, along with short and long nulls, and an overall nulling fraction of $\sim 58\%$. Our analysis suggests subpulse memory across nulls and a correlation between nulls and drift mode A2. To explain drift rate modulations, we propose two models: changes in polar gap screening or slow relaxation in the spark configuration. With its unique characteristics, this pulsar study serves as an excellent test bed for studying the intricacies of pulsar emission physics.

The work has been published in the Monthly Notices of the Royal Astronomical Society (MNRAS): Janagal et al. MNRAS (2023), 524, 2, 2684–2697.



Ultrasonic Atomizer based Fabrication of Silk Nanoparticle for Theranostics

Saumya Jaiswal, Abhijeet Joshi and Sharad Gupta*

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

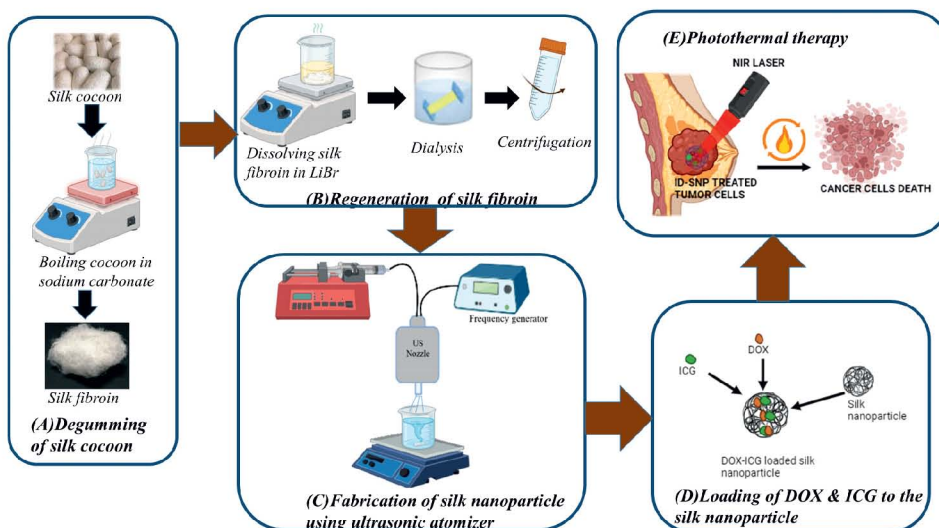


Fig.: Stable and evolutionary subpulse drift modes

This innovation presents a cost-effective method for synthesizing silk fibroin nanoparticles (SNPs) using an ultrasonic atomizer. This scalable technique produces ~50 nm monodisperse, unaggregated SNPs, suitable for large-scale industrial manufacturing. These biocompatible nanoparticles can encapsulate multiple diagnostic or therapeutic molecules, such as Indocyanine Green (ICG) and Doxorubicin (DOX). ICG is a near infrared chromophore, which could be used as a photothermal agent for tumor ablation and a near-infrared fluorophore for deep tissue imaging, while DOX is a widely used chemotherapeutic drug. These SNPs have a great potential for deep tissue imaging-based diagnostic and therapeutic applications.

The work has been published in the *ACS Biomaterials Science and Engineering*: Jaiswal et al. *ACS Biomater. Sci. Eng.* (2022), 8, 3054–3065.



Sulfonamide as Photoinduced Hydrogen Atom Transfer Catalyst for Organophotoredox Hydrosilylation and Hydrogermylation of Activated Alkenes

Kalu Ram Bajya¹, Manjeet Kumar², Azaj Ansari² and Selvakumar Sermadurai^{1*}

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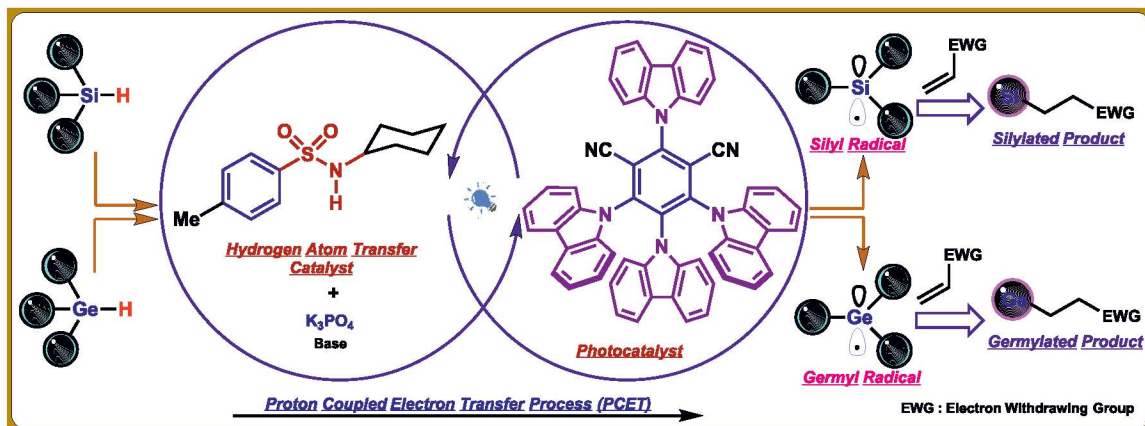


Fig.: Schematic representation of photocatalytic generation of silyl- and germyl radical using sulfonamide as hydrogen atom transfer catalyst via proton coupled electron transfer process under Blue LEDs Irradiation

Readily available, sterically, and electronically tunable sulfonamides have been developed as effective photoinduced hydrogen atom transfer (HAT) catalysts for selective Si-H/Ge-H bond functionalization of a broad range of silanes and germanes. Sulfamidyl radicals generated through photoinduced hydrogen atom transfer from sulfonamides is the key reactive species that enables an effective HAT process with hydrosilanes and hydrogermanes to generate the corresponding silyl and germyl radical respectively. This strategy was successfully executed in the metal-free synthesis of organosilanes and organogermanes via hydrosilylation and hydrogermylation of activated alkenes. Our developed protocol offers new avenue towards the sustainable synthesis of organosilicon and organogermanium compounds.

The work has been published in *Advanced Synthesis & Catalysis*: Bajya et al. *Adv. Synth. Catal.* (2023), 365, 976.



Safety Assessment of Underground Steel Pipelines with CFRP Protection against Subsurface Blast Loading

Gyanesh Patnaik and Abhishek Rajput*

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

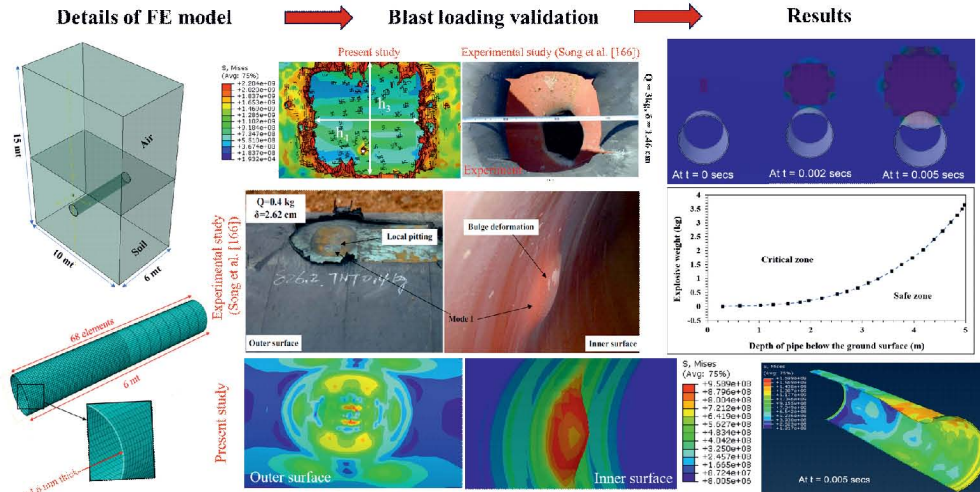


Fig.: FE modeling of underground pipeline under blast loading, results of strain & stress, and their validation with a real blast event

Underground steel pipelines transport water, oil, natural gas, and hazardous gases. Assessing their resilience to blasts is essential due to potential explosions. This study evaluates X70-grade steel pipelines against subsurface blasts using numerical methods. A finite element model is developed with the Coupled Eulerian-Lagrangian method in ABAQUS, incorporating Carbon Fiber Reinforced Polymer (CFRP) coverings for blast mitigation. The Jones-Wilkins-Lee EoS, Mohr-Coulomb plasticity, Hashin damage criteria, and Johnson-Cook model are used to simulate materials. Results show significant reductions in strain (up to 69.2%) and peak displacement (up to 55%) with CFRP coverings. Safety criteria for underground pipelines against subsurface blasts are proposed.

The work has been published in the Structures: Gyanesh et al., Structures, (2023), 54, 1541-1559.



Privacy Preserving Human Activity Recognition System for Assisted Living Environments

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¹Department of Computer Science and Engineering, Indian Institute of Technology Indore, India

²Western Norway Research Institute

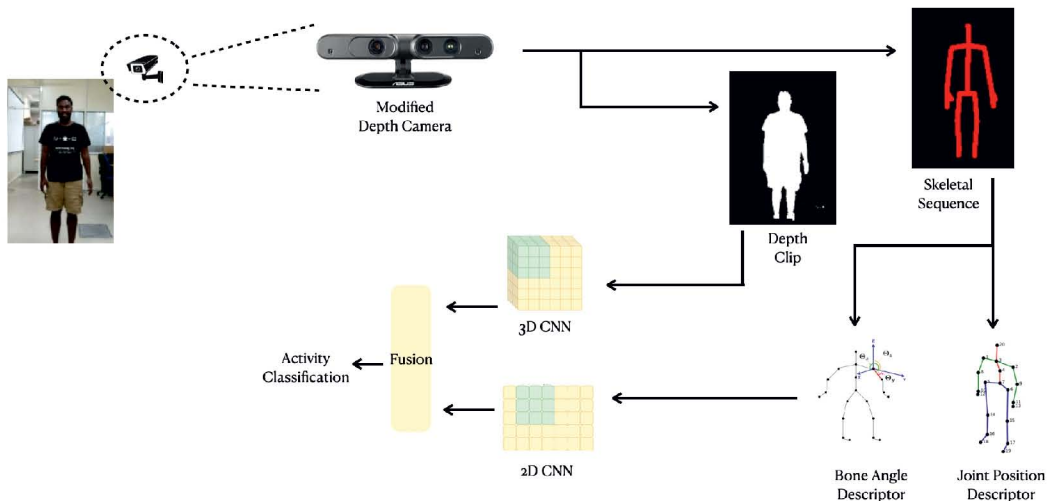


Fig.: High level depiction of the flow of the proposed approach

Automatic human activity recognition has numerous applications, especially in elderly support and healthcare. In this study, a robust framework for automatic human activity recognition is proposed that uses depth sensors that preserve privacy and are cost-effective. The depth sensors provide two data modalities, namely, depth maps and skeleton sequences, used together for activity recognition. Two novel descriptors, joint position descriptor based on the position of joints; and bone angle descriptor based on bone inclination, are generated from the skeleton sequence data. The data modalities and descriptors are fused using a two-level fusion strategy for a multichannel convolutional neural network (CNN) framework and accurate activity classification is achieved whilst preserving privacy.

The work has been published in the *IEEE Transactions on Artificial Intelligence*: Ankit et al., *IEEE Trans. Artif. Intell.* (2024), doi. 10.1109/TAI.2023.3323272



Fast Cancer Screening Device for Early-stage Cancer Diagnosis, using a Quantitative Photoacoustic Spectral Response Technique

Suhel Khan and Srivathsan Vasudevan*

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

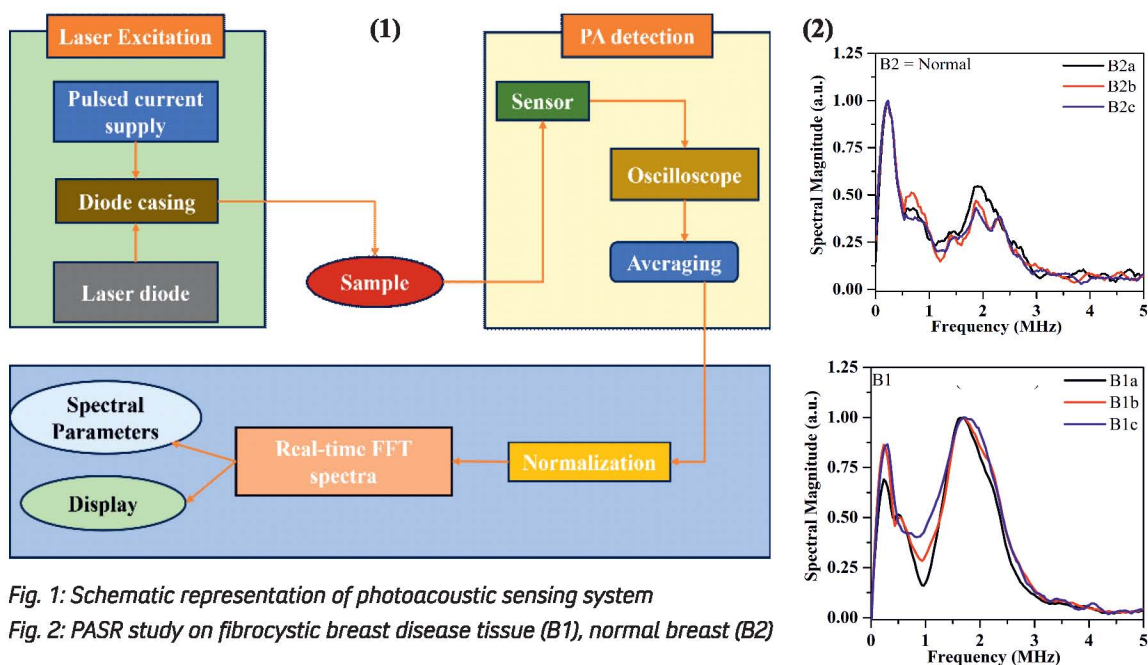


Fig. 1: Schematic representation of photoacoustic sensing system

Fig. 2: PASR study on fibrocystic breast disease tissue (B1), normal breast (B2)

In this study, a compact laser diode case design is developed to house several laser diodes for PA excitation, and a pulsed current supply unit is also developed in-house to power the laser diodes to generate a 25 ns current pulse at a frequency of 20 kHz. After PA experimental data acquisition, the signal's frequency spectra were calculated to characterize the tissue quantitatively and correlated with their mechanobiological properties. We experimented with an in vitro PASR study of fibrocystic human breast tissues and successfully differentiated different tissue types using quantitative spectral parameters peak frequency, mean frequency, and spectral energy. This gives the potential to take this technique further for cost-effective and quick clinical applications.

The work has been published in the *Journal of Biomedical Optics*: Suhel et al., *J. Biomed. Opt.* (2024), 29(1), 017002.



Digital Cartography and Feminist Geocriticism: A Case Study on Marichjhapi Massacre

Jyothi Justin and Nirmala Menon*

Digital Humanities and Publishing Studies Research Group,
School of Humanities and Social Sciences, Indian Institute of Technology Indore

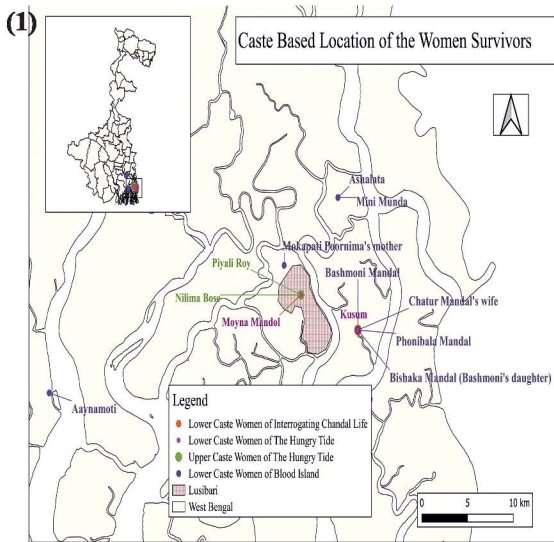


Fig.1: Caste Based Location of the Female Survivors of the Marichjhapi Massacre (1979)

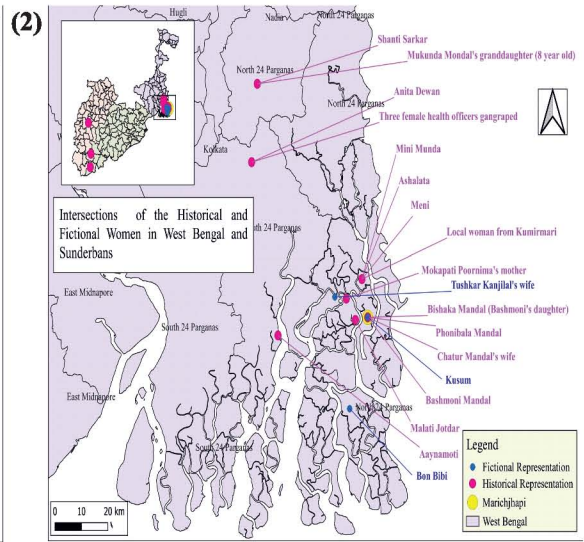


Fig.2: Intersections of the Historical Representations and Fictional Female Survivors of the Marichjhapi Massacre (1979)

The article explores the relations among space, caste and gender in Dalit massacres by locating the female survivors of the Marichjhapi massacre (1979). While foregrounding the absence of female narratives on the massacre, the paper applies a hybrid/mixed methodology which is a combination of feminist geocriticism (locates the narratives and survivors) and digital cartography (visualises and analyse) to study Dalit female experiences. Both fictional and nonfictional texts are closely read to create a database of the female survivors. QGIS software is used to map the survivor locations and to analyse the relations among caste, space, and gender in Dalit massacres.

The work has been published in Cartographica: The International Journal for Geographic Information and Geovisualization: Justin et al., Cartographica (2023) 58.3, 95-115.



Hybrid Rayleigh Wave Along A Nonlocal Nonlinear Metasurface With Two-degree-of-freedom Spring-mass Resonators

Manasa Bhat and Santanu Manna*

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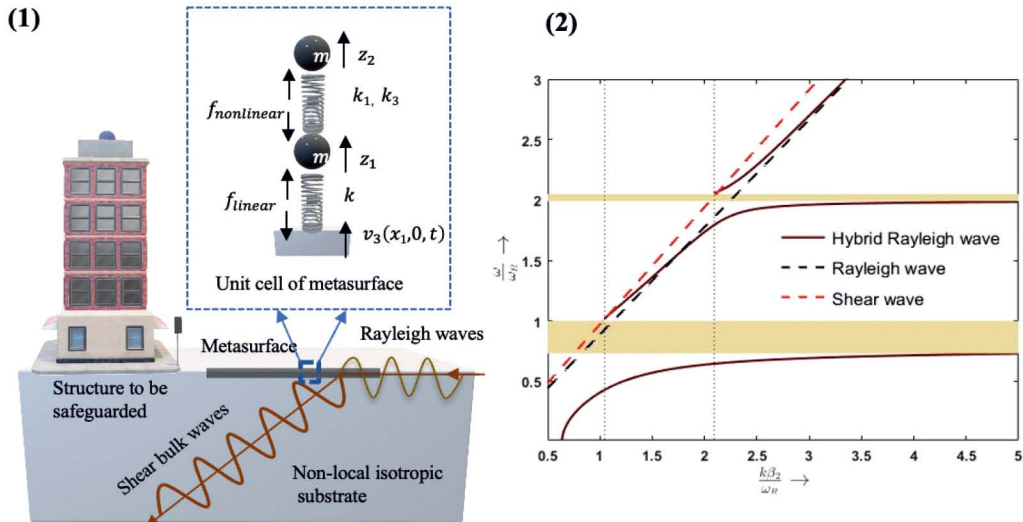


Fig.1: Schematics of the proposed model with the design of unit cell of metasurface

Fig.2: Dispersion curves for Rayleigh waves showing frequency bandgaps in case of hardening nonlinearity in springs

Seismic metasurface shows promising applications for the development of earthquake-resistant structures and improved seismic imaging and sensing capabilities. This paper presents a new design for a metasurface consisting of an array of 2-DOF nonlinear spring-mass systems attached via a linear elastic spring to a non-local elastic substrate. This study introduces a novel design leveraging nonlinearity and non-local elasticity to achieve multi-frequency bandgaps for hybrid Rayleigh waves. Numerous plots are plotted in MATLAB to demonstrate the effects of non-local elasticity and the velocity ratio of the host substrate, non-linearities, and relative amplitude inputs of the spring-mass system on the spectral bandgaps.

The work has been published in the *European Journal of Mechanics-A/ Solids: Bhat et al., Eur. J. Mech.-A/Solid (2024), 104, 105214.*



Unveiling the Potential of P3 Phase in Enhancing the Electrochemical Performance of a Layered Oxide Cathode

Hari Narayanan Vasavan¹, Manish Badole¹, Samridhi Saxena¹,
Velaga Srihari², Asish Kumar Das¹, Pratiksha Gami¹ and Sunil Kumar^{1*}

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²High Pressure and Synchrotron Radiation Physics Division, Bhabha Atomic Research Centre, Mumbai, India

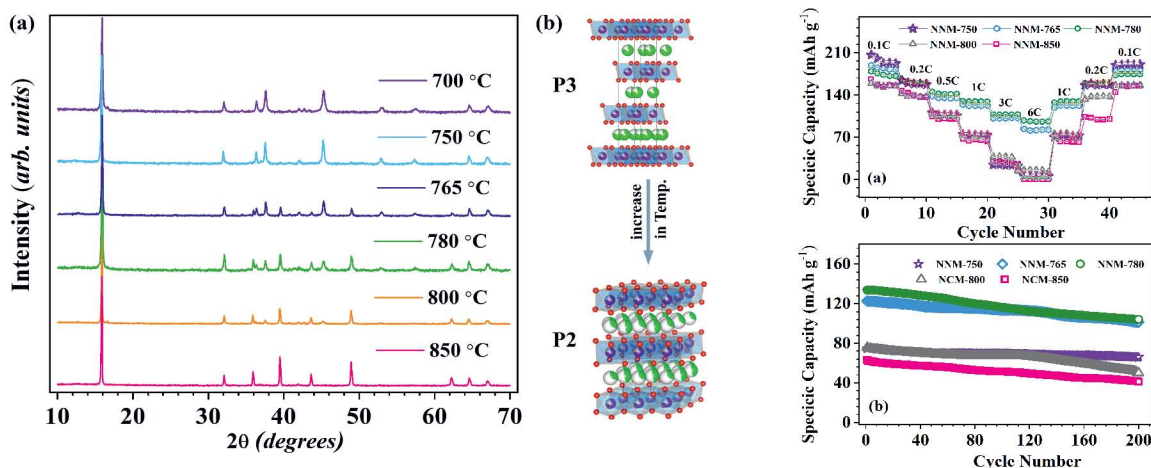


Fig.1: (a) Phase evolution of $\text{Na}_{0.75}\text{Mn}_{0.75}\text{Ni}_{0.25}\text{O}_2$ with calcination temperature.

(b) visualization of P2 and P3 structure

Fig.2: (a) Rate performance and (b) cyclic stability of NNM-x cathodes at a discharge rate of 1C

This study presents the synthesis and electrochemical behavior of a new monophasic P3 structure in $\text{Na}_{0.75}\text{Mn}_{0.75}\text{Ni}_{0.25}\text{O}_2$ (NNM) calcined at 750 °C. At 850 °C, it converts to a P2-type phase, with intermediate temperatures yielding P2/P3 biphasic structures. The monophasic P3 cathode exhibited a specific capacity of 190 mAh/g at 0.1C. The P3-dominant biphasic cathodes showed superior rate performance and stability. Operando Synchrotron XRD of the biphasic cathode data showed a suppression of the $\text{P3} \rightarrow \text{O}'3 + \text{O3}$ transformation observed in the monophasic P3-type material. Their excellent performance and stability make biphasic cathodes ideal for stationary and mobile energy storage.

The work has been published in *Material Today Energy*: Vasavan et al., *Mater. Today Energy* (2023), 37, 101380.



Repurposing Welding Waste Stubs and Wires as Substrate in Directed Energy Deposition Processes

Anas Ullah Khan and Yuvraj K. Madhukar*

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

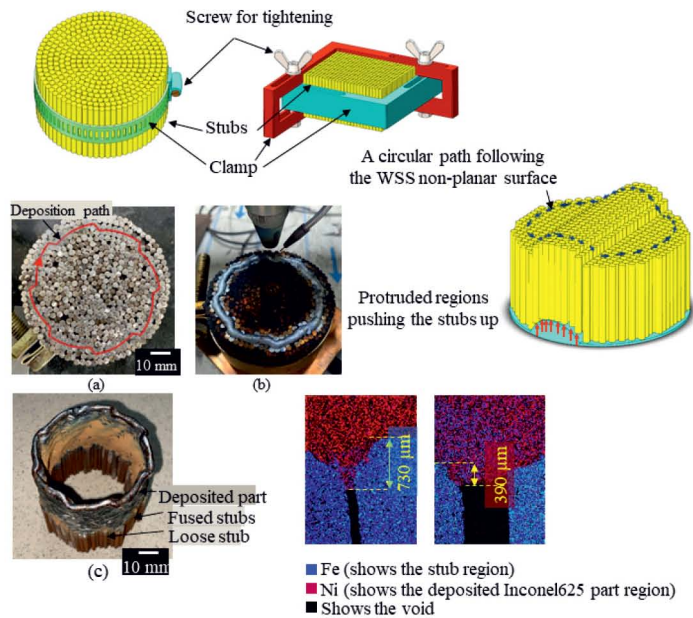


Fig.: Unused welding electrode utilisation as substrate for DED

The work aims to promote alternate substrate designs in directed energy deposition (DED) processes utilizing waste welding stubs obtained from shielded metal arc welding (SMAW). This is required for ease of part removal by overcoming strong fusion between conventional bulky substrate and deposited part. Reusing welding wastes is envisioned to reduce the environmental impact significantly. They can be disintegrated easily to release the part, ensuring the post-processing trouble-free. Experimental investigation shows the formed surfaces are viable for uniform and continuous deposition (material leakage 390–730 μm depth in voids).

The work has been published in the Journal of Cleaner Production: Madhukar et al., J. Clean. Prod. (2023), 16:139317.



Non-linear Temperature Dependent Raman Parametric Changes: An Identification of Fano Intervened Systems

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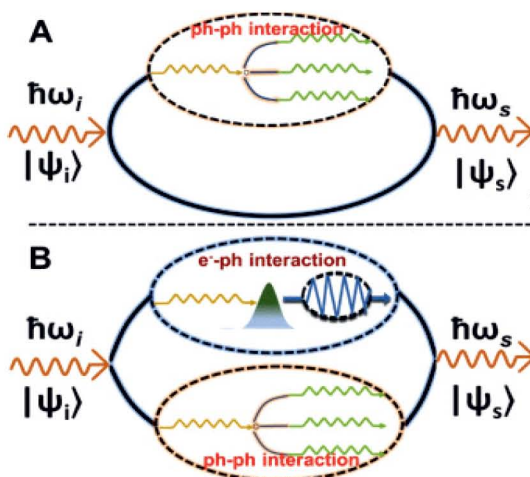


Fig.: Schematic diagram represents the different phonon decay processes in different systems

Raman spectroscopy, since its discovery in 1928, left millions of footprints touching almost all researchers coming from multidisciplinary research areas and has established itself as an extremely important analytical tool. In recent times, it also has exhibited capabilities to get information about non-traditional physical processes in a material at microscopic levels. A detailed review has been presented here so as to give an approach to analyze the effect of thermal perturbations on Raman line-shape. A compilation of temperature dependent Raman study from different range of materials has been presented and any observed deviation from the well-known anharmonic theory has been highlighted and possible reason for such deviation has been provided.

The work has been published in *Physics Reports: Chanchal et al., Phys. Rep., (2023), 1037,1-41*



Convocation at IIT Indore

Indian Institute of Technology Indore hosted the 12th convocation with Dr. Samir V Kamat, Secretary DDR&D and Chairman DRDO as Chief Guest on 13th July 2024. Dr. K Sivan, Chairperson, BoG presided the ceremony.

The convocation was followed by a series of events including Inauguration of the 'Centre for Narmada River Basin Management' Inauguration, Demonstration of technologies related to defence to the Chief guest etc.



International Conference on Energy and Environmental Materials (E2M-2024)

Department of Metallurgical Engineering and Materials Science organized an International Conference on Energy and Environmental Materials (E2M-2024) from July 11-13, 2024. Several Keynote and invited talks were scheduled during the conference. Oral and Poster Presentations were also organized in the event. Participants got an opportunity to excel their knowledge in the field of Energy and Environmental Materials.

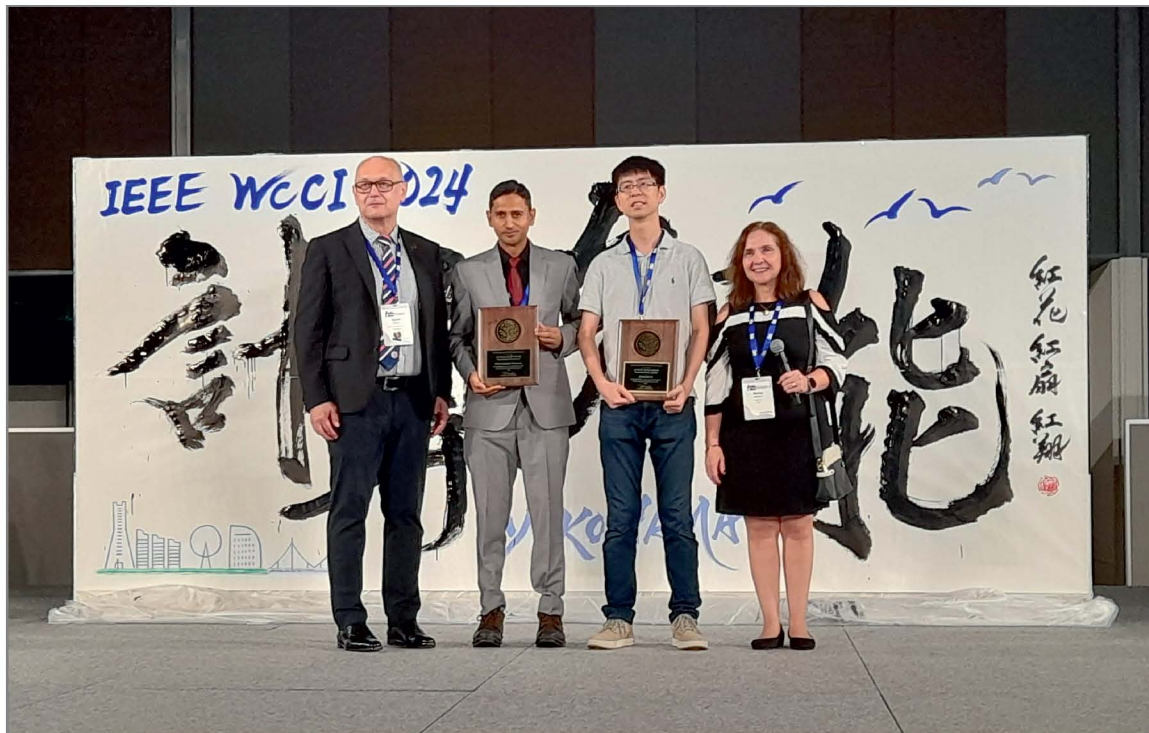


One-day Workshop on Narmada River Basin Management: Issues and Challenges

The "Narmada River Basin Management: Issues and Challenges" workshop, held at IIT Indore on 14th July 2024, brought together a diverse array of experts, policymakers, and stakeholders dedicated to addressing the complex management and conservation needs of the Narmada River Basin. This workshop served as a pivotal platform for fostering collaboration and innovation in sustainable river basin management practices. It aimed to delve into the intricate ecological, socio-economic, and cultural dimensions of the Narmada River Basin, emphasizing the importance of integrated approaches to ensure its long-term health and resilience.



Dr. M. Tanveer Honored with 2024 INNS Aharon Katzir Young Investigator Award



Dr. M. Tanveer, a prominent faculty member at the Indian Institute of Technology Indore, has been honored with the 2024 Aharon Katzir Young Investigator Award by the International Neural Network Society (INNS). The award was presented during IEEE WCCI 2024, the world's largest and most prestigious technical event on computational intelligence, held in Yokohama, Japan.

This esteemed award is presented annually to up to two exceptionally promising young researchers in the field of neural networks. Dr. Tanveer's achievement is particularly noteworthy as he becomes the sole Indian recipient in the history of the INNS awards, highlighting his significant contributions and leadership in the field.



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