IIT PALAKKAD

Research Scholars' Day

6th November 2021

RESEARCH SCHOLARS' DAY

RESEARCH SCHOLARS DAY

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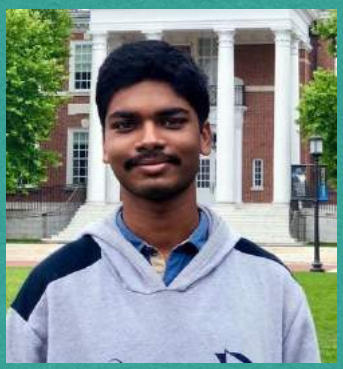

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Keynote Abstracts

RESEARCH SCHOLARS' DAY

Design of Fluid Dynamic experiments

Prof. Debopam Das

Department of Aerospace Engineering, Indian Institute of Technology Kanpur, India

e-mail: *das@iitk.ac.in*

In this talk I will discuss primarily how to design experimental setup for the state of art fluid dynamic research. Three examples will be considered: (i) Generation of clean vortex ring free of unwanted vortex and its interaction with an axisymmetric body, (ii) Instability of puffing plume and (iii) Stability of a round jet. Finally, how a simple design can lead to a successful flapping wing UAV will be discussed.

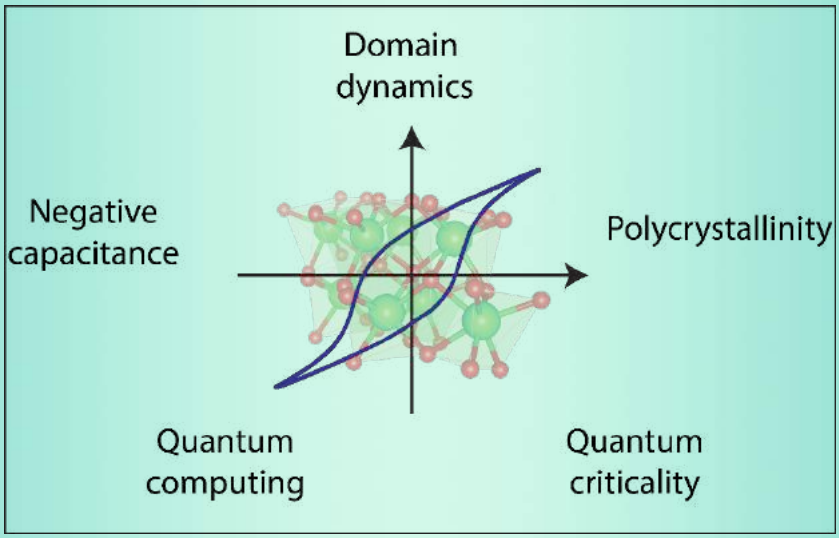
The exciting world of ferroelectronics - an overview

P. V. Ravindran,[1]

[1]*School of Electrical and Computer Engineering, Georgia Institute of Technology, Atlanta, USA 30332.*

e-mail: *rprasanna22@gatech.edu*

Ferroelectrics are a group of functional materials that are characterized by an electrically switchable spontaneous dielectric polarization. In the hundred years since the original discovery of ferroelectricity in Rochelle salt, several aspects of ferroelectricity have been explored with the phenomenon occurring in very wide range of material systems with diverse physical properties leading to remarkable fundamental discoveries and innovations. Over the last decade, the area of ferroelectrics has been undergoing a resurgence ignited by the discovery of ferroelectricity in CMOS-compatible binary oxides and the proposal to exploit the phenomenon of negative capacitance in these materials to keep the Moore's law going. In this talk, we will go over a wide range of challenges and opportunities surrounding ferroelectric materials and its rich physics ranging from quantum effects to high-speed electrical characterization of negative capacitance.



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Research Scholars' Talk Abstracts

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Design, Synthesis and Biological Evaluation of A Lipophilic Derivative of EGCG As Potent and Selective EGFR Inhibitor

Revathy Sahadevan[1], Satyam Singh[2], Rajarshi Roy[2], Sushabhan Sadhukhan[1]*

[1]Department of Chemistry, IIT Palakkad

[2]Department of Biosciences and Biomedical Engineering, IIT Indore

e-mail: 202004003@smail.iitpkd.ac.in

Natural compounds have been bedrock for the drug discovery for many decades. *(–)*-Epigallo catechin-*3*-gallate (EGCG) is one such natural compound derived from green tea.[1] EGCG has shown anticancer activities such as inhibition of cancer cell proliferation, activation of apoptotic pathways, inhibition of angiogenesis, invasion, and metastasis in various types of cancer. EGCG has been shown to inhibit Epidermal Growth Factor Receptor (EGFR)[2], which is a transmembrane protein involved in the downstream signalling process leading to cell growth and development. Overexpression of EGFR is often found to be involved in the progression of many types of cancer such as breast cancer, lung cancer, and colon cancer.[3-5] Despite EGCG possessing great therapeutic and chemopreventive properties, its use in clinical trials has been rather limited because of poor bioavailability and chemical instability. To overcome these shortcomings, herein we employed the structural modification of EGCG, substitution of alkyl chains at 4″ position via ethereal linkage. Seven lipophilic 4″-alkyl EGCG derivatives have been synthesised and tested for their antiproliferative activities. Among these seven derivatives, **4″-C_{14} EGCG** was found to be a **selective EGFR inhibitor** and a potent **anticancerous** agent. In this talk, I will be discussing about the story behind this discovery.

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A Simplified Approach to Exclude Suction Induced Resistance from Pile Load Test Results

Alpha Lukose, Sudheesh Thiyyakkandi
Department of Civil Engineering, IIT Palakkad
e-mail: 101704002@smail.iitpkd.ac.in

Bored piles are widely used in various infrastructure projects and have the advantage of being suitable for a wide range of soil conditions and urban environments. The estimated axial resistance of bored piles from pile load tests may be inclusive of the resistance contributed by matric suction if the ground water table at the time of testing is deep, which is however non-existent when soil gets saturated by rainfall infiltration or the rise in water table. This study presents a simplified method to estimate the suction induced additional resistance reflected in the measured pile resistance, which can be subsequently excluded to obtain the corrected pile resistance. The constrained dilation of shear band during the pile loading is modelled as a cavity expansion scenario and suction effect is incorporated by considering change in shear modulus due to suction. The predictive capability of the proposed approach was substantiated using the results of model-scale study on axial load response of piles in unsaturated sands.

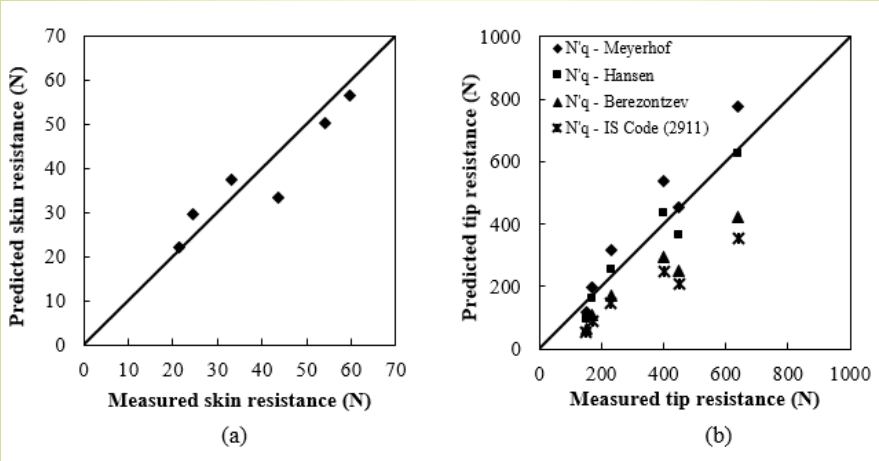

Figure. Predicted vs. measured: (a) side shear; and (b) tip resistance due to suction

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Hardware Based Loop Optimization for CGRA Architectures

C. Sunny[1], S. Das[1], K. J. M. Martin[2], P. Coussy[2]
[1]Department of Computer Science, IIT Palakkad,
[2]Univ. Bretagne-Sud, UMR 6285, Lab-STICC, 56100 Lorient, France
e-mail: 112004004@smail.iitpkd.ac.in

With the increasing demand for high performance computing in application domains with stringent power budgets, coarse-grained reconfigurable array (CGRA) architectures have become a popular choice among researchers and manufacturers. Compute-intensive loops are the hot-spots usually offloaded to CGRAs. Several techniques have been devised to optimize the loop acceleration for CGRAs. However, works in this direction are predominantly software-based solutions (i.e. software pipelining, loop unrolling). This work addresses the optimization opportunities at a deeper level and presents a hardware based loop control mechanism that can support arbitrarily nested loops. Major contributions of this work are, a lightweight Hardware Loop Block (HLB) for CGRAs that eliminates control instruction overhead of loops and an acyclic graph transformation that removes loop branches from the application CDFG. When tested on a set of kernels chosen from various application domains, the design could achieve a maximum of 1.9× and an average of 1.5× speed-up against the conventional software based approach. The total number of instructions executed is reduced to half for almost all the benchmarking kernels with an area and power consumption overhead of 1.02× and 1.01× respectively.

Publication

Sunny, C., Das, S., Martin, K. J., & Coussy, P. (2021, June). Hardware Based Loop Optimization for CGRA Architectures. In *International Symposium on Applied Reconfigurable Computing* (pp. 65-80). Springer, Cham

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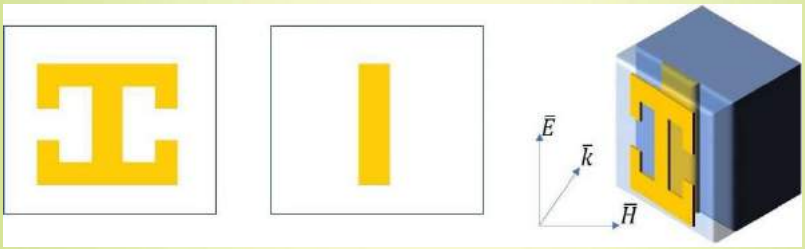
Metamaterial Enabled Electromagnetic Structures for Microwave to Millimeter-wave Applications

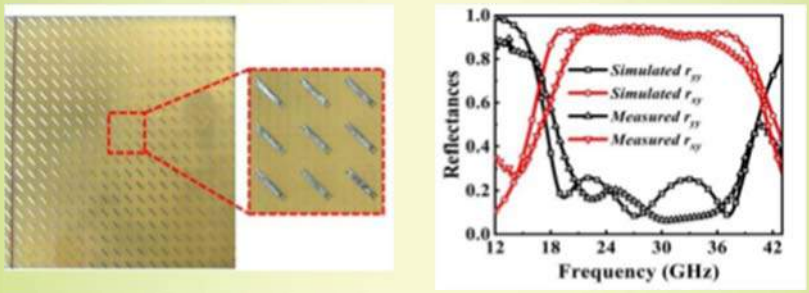
Mohammad Abdul Shukoor*[1], Sukomal Dey[2]
Department of Electrical Engineering, IIT Palakkad
e-mail: 121814002@smail.iitpkd.ac.in

The number of wireless devices operating at different frequencies across the usable spectrum has increased dramatically in recent years worldwide. Frequency Selective Surfaces (FSS) can play an important role in this topic, contributing to interference mitigation and wireless security in indoor radio environments. Metamaterials often derive their extremely high characteristics from surface plasmons, constituting a collective oscillation of free electrons. The entire new generation of metamaterials is developed simply by harnessing the properties of surface plasmonic waves. Metamaterial-enabled absorbers (MMA) have been proposed for the near-unity absorption of EM waves. When an EM wave impinges on the metasurface, it induces a surface current on the top unit cell and bottom ground. These are anti-parallel, equivalent to the circulating loop of current resembling the magnetic dipole. The tangential electric field excites electrical resonance on the top FSS. Wave Polarization is the locus traced by the tip of the electric field vector in a plane perpendicular to the direction of propagation with time. Dividing the electric field as the vector sum of two orthogonal components to generate relative phase difference between them is the basis of the birefringence effect in naturally available crystals. These devices are large in volume and have restricted bandwidth, high loss, and incidence angle-dependent response, limiting their practical application. Following the introduction of FSS technology, it has been used in polarisation conversions such as linear to cross, linear to circular, and multi conversion at once from microwave to optical regimes.



(a) (b) (c)

Fig 1. I - shaped perfect metamaterial absorber. (a) Top view (b) bottom view. (c) 3D view



(a) (b)

Fig. 2. Fabricated prototype (20 x 20) (a) H-shaped Polarization Converter, (b) Simulated and Measured reflectances.

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Normative Violence on the Body

A. Pradeepkumar, A. George
Department of Humanities, IIT Palakkad
e-mail: 231914001@smail.iitpkd.ac.in

Judith Butler is an American philosopher and a gender theorist. In her seminal text Undoing Gender, Butler discusses normative viólenle and how it applies to the body. Normative violence implies that the norms have the power to guide the life of a human. These norms turn out to be violent when it restricts the desires of people. Butler suggests that these norms present a standardization criteria in the society. These norms take the form of violence when it is inflicted upon people in their intimate levels of life. Contrary to physical violence, normative violence is not imposed in the form of tangible bodily violence but as something that can restrict the conditions of human life. Furthermore, these norms are not written laws; instead, it is produced, reproduced, re-idealized, and reinstituted through social practices. The presentation is based on the theoretical framework of Butler's notion of normative violence and discusses the normative violence that operates behind the social issues of rape and body shaming. My study is an inquiry on how normative violence takes the body as an instrument in the social issues of rape and body shaming.

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Retracts of Domains in $\mathbb{C}^N$

J. Mammen, G. P. Balakumar
Department of Mathematics, IIT Palakkad
e-mail: 211914001@smail.iitpkd.ac.in

A fundamental question in complex analysis in both one and higher dimensions is about determining those subsets S of a given domain D in $\mathbb{C}^N$, which arise as fixed-point sets of some holomorphic self-map of D. This being a broad and rather general challenging problem, we consider the following sub-problem in this short talk: determine those subsets of D which can be realized as holomorphic retracts. Specifically, we shall present theorems about fundamental examples such as the Euclidean ball in $\mathbb{C}^N$ and conclude with a few concrete goals for the PhD thesis.

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2-D Axisymmetric Modelling of $CH_4/O_2/N_2$ Counterflow Diffusion Flames

P. Navaneethakrishnan*, Krishna Sesha Giri

Combustion Diagnostics Lab, Department of Mechanical Engineering, IIT Palakkad

e-mail: 131704001@smail.iitpkd.ac.in

Two-dimensional axisymmetric modelling was done on the OpenFOAM platform to predict the extinction strain rate (K_{ext}) and major species concentrations in methane/oxygen/nitrogen counterflow diffusion flames. The model was validated with experimental measurements for various nozzle diameters(D), fuel-oxidizer combinations, and nozzle separation distances (L) [1] [2]. The model predicts the K_{ext} as well as the trend with L/D accurately. Such extensive validations on 2D axisymmetric geometry are not reported in the literature prior to this work. The unity Schmidt number assumption and the use of realistic boundary conditions are the highlights of the model for K_{ext} prediction. The model was compared with other 1D models [3] that use potential flow assumptions and also validated with temperature & species measurements for various strain rates in the off-extinction limits [4] with the predictions closely agreeing with experiments. This effort brings out the advantages of a 2D axisymmetric model and the flexibility of the OpenFOAM platform in modelling counterflow flames.

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Thermal Conductivity Measurements in Gold Nanoparticle Decorated Graphene

M. K. Ranjuna, B. Jayakumar*
Department of Physics, IIT Palakkad
e-mail: 221804101@smail.iitpkd.ac.in

We present a systematic study on the thermal conductivity of gold nanoparticles (Au NPs) decorated graphene on a SiO_2/Si substrate by the Optothermal Raman technique. Our results, with moderate Au NPs coverage of <10%, demonstrate an enhancement of the thermal conductivity in graphene by ~ 44% and a decrement in the interface conductance by a factor of 1.5 from its pristine values. A detailed analysis of our results shows the importance of the photo-thermal conversion efficiency of Au NPs, plasmon-phonon coupling and the lattice deformation due to local strain developed after gold nanoparticles deposition in enhancing the thermal conductivity of the system. Moreover, the decrease in the interface thermal conductance can be attributed to the presence of the stabilizing ligands between the graphene and Au NPs. Our study paves way for a better understanding of the thermal management in such hybrid systems, which are envisioned as excellent candidates for optoelectronics and photonics applications.

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Poster Abstracts
Chemistry

RESEARCH SCHOLARS' DAY

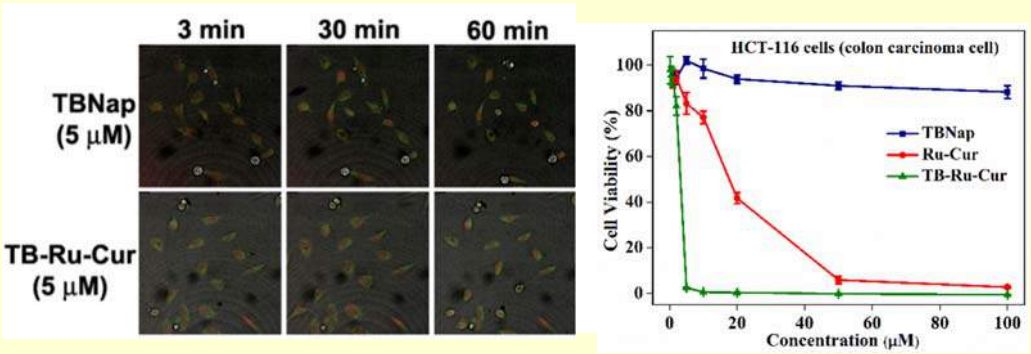
Synthesis and cytotoxicity evaluation of a 'V-shaped' fluorescent 4-Amino-1,8-naphthalimide Tröger's base derived Ru(II)-curcumin organometallic conjugate

Binduja Mohan, Sankarasekaran Shanmugaraju

Indian Institute of Technology Palakkad

e-mail: *201914001@smail.iitpkd.ac.in*

The design, synthesis, and application of luminescent metal complexes as efficient theragnostic agents have great significance in the field of medicinal chemistry [1]. Luminescent *d*-metal ion complexes are well-known for their therapeutic activities because of the unique photochemical and photophysical characteristics [2]. 4-amino-1,8-naphthalimide derived Tröger's base (**TBNap)** derivatives are novel organic scaffolds that are famous for their robust DNA binding affinity, quick cellular uptake, and can also act as apoptosis inducers in cancer cells [3-5]. We have developed a novel luminescent *N*-4-pyridyl-4-amino-1,8-naphthalimide Tröger's base (**TB Nap**) with unique chiral cleft shape geometry using N-4-pyridyl-4-amino-1,8-naphthalimide as the precursor through facile synthetic strategy. Knowing the significance of ruthenium metal complexes, naturally available therapeutic agent "curcumin" and **TBNap** in the field of cancer therapy, we designed a novel **TBNap**-containing Ru(II) curcumin organometallic conjugate **(TB-Ru-Cur)** by the self-assembly of **TBNap** with previously reported arene-Ru(II)-curcuminato complex, **Ru-Cur**. **TB-Ru-Cur** displayed a fast cellular uptake, highly luminescent characteristics, and cytotoxicity against various cancer cell lines such as HeLa cells, HCT-116, and HepG2 cancer cells with an efficiency much higher than clinically used cisplatin. In summary, the work herein demonstrates that the **TB-Ru-Cur** can act as a potent anticancer theragnostic agent thereby bridging the gap between therapeutic and diagnosis properties.



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Factors Determining the Extra Stability of β–hairpin from B1 Domain of Protein G

Nayana E C, Padmesh Anjukandi, Gokul Govind

Indian Institute of Technology Palakkad

e-mail: *201914002@smail.iitpkd.ac.in*

Proteins are biomolecules that have evolved to carry out specific functions in our body. Their functions in turn are dependent upon their three-dimensional structure to a great extent[1]. Hence it is of prime importance to study the protein structure and the factors affecting their stability.

β–hairpin of B1 domain of protein G is a special case of interest as it is a secondary structural motif that is highly stable even in μs time scale. Molecular dynamics simulations were carried on out in the presence and absence of urea with and without mutations of side chains to study the stability factors. The unique fold of GB1 hairpin is due to the strong backbone H-bond framework. Additional stability for this protein is provided by the strong side chain interaction networks and specific arrangement of certain hydrophobic group side chains.

The major finding is that the key factor which holds the β–hairpin is the hydrophobic group side chain without which the protein crumples altogether [2]. We have found that the denaturing process for the protein with backbone H-bonds, hydrophobic interactions, and side chain H-bonds was indeed slower in the presence of urea when compared to the protein that lacks these interactions.

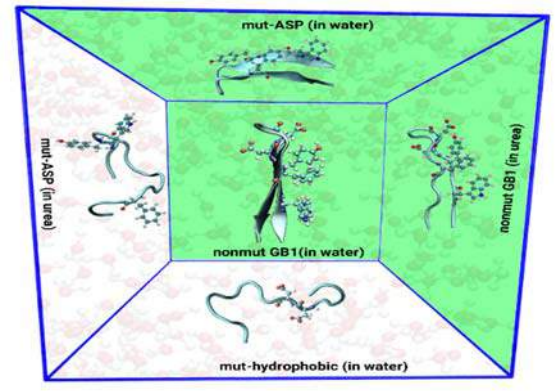

Figure 1: Representation of different conformations of GB1 hairpin with and without mutation in the presence and absence of urea

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Design, Synthesis and Antibiotics Sensing properties of Tröger's base Containing Amino-1,8-Naphthalimide Scaffold and Organic Fluorene Polymer

Ananthu Shanmughan, Pandi Raja Lakshmi and Sankarasekara Shanmugaraju

Indian Institute of Technology Palakkad

e-mail: *202004001@smail.iitpkd.ac.in, prj21@iitpkd.ac.in*

Overuse and improper disposal of antibiotics have led to them being an emerging class of organic contaminants in the environment [1]. The finding of a suitable chemical sensor for selective and sensitive detection of antibiotics in solution has been a hot topic in recent years. In light of this, we have recently developed a Trogers base containing a luminescent supramolecular V-shaped scaffold,bis-[N-(3-pyridyl)methyl)]-9,18-methano-1,8-naphthalimide-[b,f][1,5]diazocine (TBNap), and successfully employed as a potential fluorescence probe for the discriminative sensing of structurally assorted antibiotics in DMSO solution [2]. A strong fluorescence quenching and preferential binding affinity were realized for nitro-containing antibiotics such as Furazolidone, Nitrofurantoin and Nitrofurazone. In continuation to this, we designed a Tröger's base functionalized organic fluorene polymer (TB-FL-COP) from 4,4'-(9H-fluorene-9,9-diyl)dianiline monomer unit [3-4]. TB-FL-COP gave sensitive and selective fluorescence quenching responses to sulfa-containing antibiotics such as sulfadiazine and sulfamethazine in DMSO. Competitive fluorescence studies also confirmed the preferential binding affinity of the polymer for sulfa-containing antibiotics even in the coexistence of other potential competing analytes. It is evident from these studies that Tröger's base containing structures and polymers can be viewed as potential sensor systems for antibiotics detection. We will be highlighting the outcomes from these two studies in this poster presentation.

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Optimizing the reaction conditions on CVD to obtain N-doped Graphene

M. Roshni, D. Jagadeesan

Indian Institute of Technology Palakkad.

e-mail: *202014003@smail.iitpkd.ac.in*

2D materials are well known for their unique properties and graphene is one among them. However synthesizing graphene in desired configuration in higher yields remains a challenge. CVD is one among the bottom-up synthesis of graphene where hydrocarbon precursors will be decomposing at higher temperatures over transition metal surfaces. Temperature, pressure, substrate and precursor can be varied to adjust the number and size of layers, percentage of defects in graphene.[1] For example solubility of carbon is different among transition metals which results in single layer graphene growth over copper substrate and multilayer formation on nickel substrate. Properties of graphene can be improved by doping heteroatoms such as nitrogen by replacing carbon into the structure in any of the three forms such as pyridinic, pyrrolic and graphitic nitrogen which can be later used to anchor metal atoms to create single atom catalyst. N2 or NH3 gases were used initially to introduce N-doping. Controlling the doping configuration was difficult with gaseous precursors.[2, 3, 4] The major motive behind this study is to find out the experimental conditions at which nitrogen can be doped into graphene in a specific configuration with a higher yield using CVD from liquid precursors mixed with N-containing molecules.

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A modular synthetic platform based on sequence-defined oligo-dithiocarbamate for material and biomedical applications

A.Jose, M. Porel

Indian Institute of Technology Palakkad

e-mail: *201814001@smail.iitpkd.ac.in*

Structural control at macromolecular level via the incorporation of unique and defined monomers at preordained positions, as seen in natural sequence-defined macromolecules (SDMs) like DNA and protein is a challenging process. Diverse backbone and pendant group functionality, desirable chain length and defined monomeric sequence are the hallmarks of an SDM that imparts structural diversity and tunability. Motivated by this, we have developed a support free, iterative strategy to synthesise SDMs possessing dithiocarbamate (DTC) functionality. The SDMs were post synthetically modified to attach a fluorophore to explore its metal sensing and removal capabilities. The systematic increase in the number of DTC units facilitated selective sensing of Hg2+ ions even in sub-picomolar concentrations (Limit of detection or LOD is 3 x 10-13M) and removal efficiency of >95% (figure). Maintaining amphiphilic balance, an imperative necessity for the synthesis of antibacterial drugs can also be attained with this modular SDM platform. We are also extending our work to incorporate different functionalities in the backbone as well as in the side chain in an attempt to explore the structure activity relationship of these SDMs for varied applications in the material and biomedical fields.

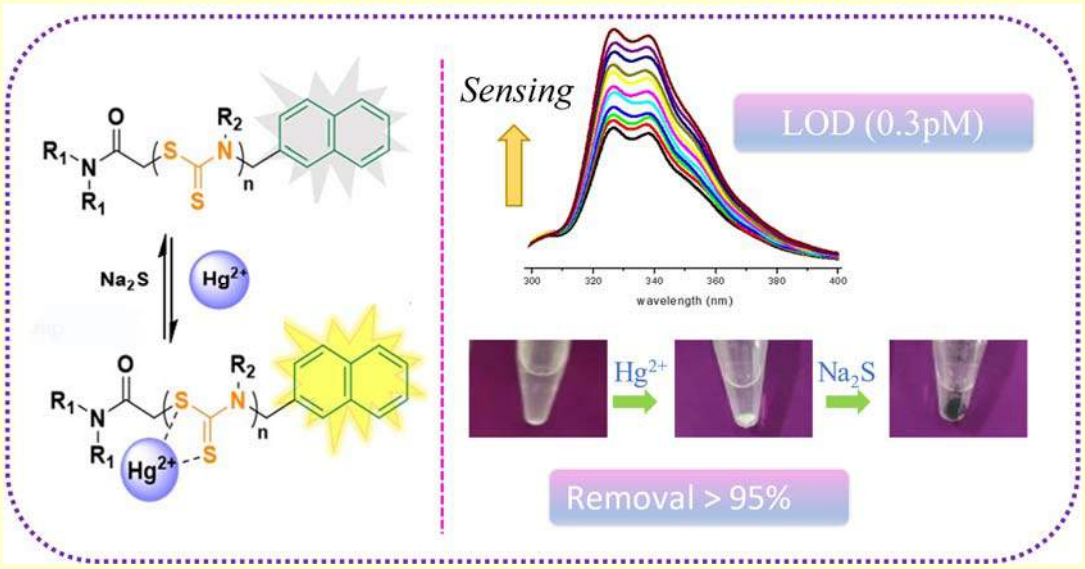

Figure: Schematic representation of sequence defined DTC system applied for selective sensing and removal of Hg2+ ions

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Optimizing Stability of Cu Nanocluster Using Protein Templates, and Its Photoluminescent (PL) Characteristics and Applications

A. Sebastian, S. Mojumdar

Indian Institute of Technology Palakkad

e-mail: *202004002@smail.iitpkd.ac.in*

Being nontoxic, synthetically flexible and cost- effective, Cu nanocluster (NC) assays can bloom in various scientific investigations. But they have been relatively less explored due to their low stability. Here we describe an efficient protocol in order to optimize the stability and photoluminescent (PL) characteristics of Cu NCs. We developed a green emitting PL Cu NCs (Cu/Lys) which has superior optical properties and robust photostability. We also corroborated that Cu/Lys NCs can efficiently exhibit FRET within the system. The uniqueness of these temperature-dependent PL reversibility of these nontoxic Cu/Lys enables them to be used as a nanothermometer and a PL marker for sensitive biological samples. The experimental techniques, working and advantages of this work will be presented here.

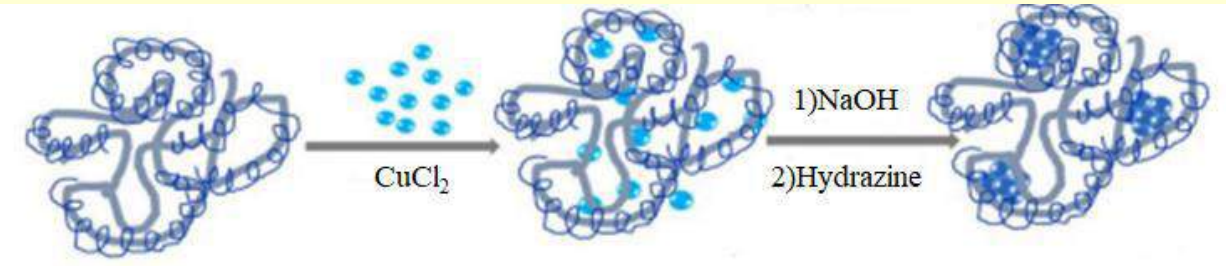

Figure: Schematic representation for the synthesis of stable Cu/Lys nanoclusters

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IIT PALAKKAD

Poster Abstracts
Civil Engineering

RESEARCH SCHOLARS' DAY

Frequency adaptive control design and comparative assessment on structural control

S Abhishek, Dr. Sanjukta Chakraborty

Indian Institute of Technology Palakkad

e-mail: *101914004@smail.iitpkd.ac.in*

Structures are always subjected to uncertain excitations like wind, blast and seismic forces. These excitations can cause high structural responses which are undesirable and these are to be controlled. Some of the common control strategies used to control structures includes (a) passive control (b) active control and (c) semi-active control. The performance of the structure deteriorates when the structural properties degrades. Hence the passive devices designed will not be able to reduce the structural responses as they have been designed. This necessitates the use of feedback control mechanism in which the structural properties of interested parameters are continuously monitored and control actions are applied adaptively to the system in order to reduce the response. The most common feedback control algorithm used in civil structures is Linear Quadratic Gaussian (LQG) algorithm. It has been observed that in the case of LQG control excess control force is being applied to the system even when structural response is minimum. This may cause adverse effects by amplifying the response and lose the importance of controlling the system. Hence a frequency adaptive control algorithm is to be developed to reuse the excess control force developed without causing any adverse effects to the system. Our study focuses on developing a new frequency adaptive control algorithm which can be used for all frequency regions of structural vibration

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Desalination coupled with wastewater treatment and energy production using Microbial Desalination Cell

A.M Sabarija, P. Gangadharan

Indian Institute of Technology Palakkad

e-mail: *101914005@smail.iitpkd.ac.in*

In this study, a microbial desalination cell (MDC) was employed to achieve desalination of brine solution, wastewater treatment, and power production. Brine solutions with concentrations of 0.5 M, 1 M, and 2 M were desalinated with an anion exchange membrane at the anode and a cation exchange membrane near the cathode of the MDC. Under long term operation (48 days), the performance of MDC was monitored for desalination efficiency, bioelectricity generation, substrate utilization. The maximum desalination efficiencies and power densities of 38%, 37% and 33% and 45.41 mW/m2, 30.34mW/m2and 17.19mW/m2, were obtained with 2 M, 1M and 0.5 M solutions, respectively. Desalination was accountable to the microbial induced bioelectricity generation. The ohmic resistance of the system was found to vary inversely with the conductivity of the brine solution and this leads to increased power production with higher brine concentration in the middle chamber. Simultaneously, the anode chamber of the MDC exhibited a maximum of 83.4% for substrate degradation using 1 M brine solution in the middle chamber. The findings suggest that MDC is a viable technique for producing energy from desalination, however, the desalination efficiency can be enhance further by integrating it with capacitive deionization and reverse osmosis.

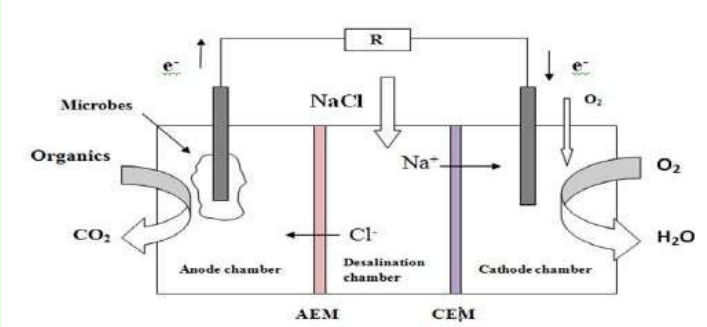

Fig 1: Schematic diagram of a microbial desalination cell for water desalination. AEM: anion exchange membrane, CEM: cation exchange membrane.

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Spatio-temporal distribution of Indian Summer Monsoon Rainfall extremes in the context of climatic variability

Athira K[1], Sarmistha Singh[1], Ash Abebe[2]

Indian Institute of Technology Palakkad [1], Auburn University USA [2]

e-mail: *102004001@smail.iitpkd.ac.in*

The occurrence of extreme precipitation events during Indian Summer Monsoon Rainfall (ISMR) has increased significantly in recent decades. Natural variability of extreme precipitation events in India in Spatio-temporal scales has been linked to various climatic variables like El Niño Southern Oscillation (ENSO), Equatorial Indian Ocean Oscillation (EQUINOO), Pacific Decadal Oscillation (PDO), and Atlantic Multidecadal Oscillation (AMO). In this study, extreme precipitation indices are used to characterize the ISMR extremes and coupled association with climatic variables identified using wavelet analysis. It has been found that the climate variables together cause variability in the ISMR extremes. An increase in the number of climate variables did not improve the coherence, since these climatic variables influence each other. Further, the decomposition of wavelets at different scales has shown that more than half of the grid points considered were significant at interdecadal and multidecadal scales even though they are designated with different scales. This indicates that the non-stationary behavior of the ISMR extremes is directly linked to the climatic variables at higher scales.

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Resilient Reinforced Soil Structures to Mitigate Rainfall Induced Slope Failures

K.A. Dhanya, P.V. Divya

Indian Institute of Technology Palakkad

e-mail: *101804101@smail.iitpkd.ac.in*

Rainfall induced slope failures are becoming a major threat in unsaturated residual soil slopes worldwide. Major part of Kerala state in India, especially the hilly regions are covered with residual lateritic soils. Matric suction contributes to its stability in the unsaturated state as it increases the shear strength. Many rainfall induced slope failures were reported in lateritic soil slopes in Kerala, during monsoon seasons of 2018, 2019 and 2020. Application of geosynthetic reinforced composites in mitigating rainfall induced slope failures is investigated in the present study. The reinforced composites used in the present study was a knitted polypropylene non-woven geotextile, reinforced with high tenacity polyester yarns in both machine and cross machine directions. Rainfall infiltration analysis was conducted in order to check the adaptation of the geosynthetics reinforced soil slopes to a changing climate. Factor of safety of the unreinforced soil slope was reduced at the onset of rainfall infiltration and failed at 10 hrs of continuous rainfall. Reinforced composites was found to be very effective in maintaining the integrity of slopes, even during extreme rainfall events and increased the factor of safety by 2.5 times compared to that of unreinforced soil slopes.

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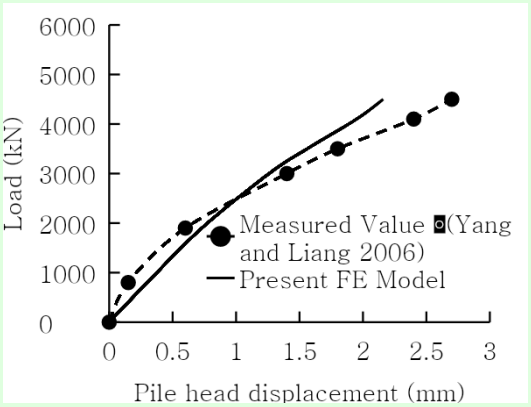
Influence of Soil Cover on Lateral Response of Rock-Socketed Piles

C. R. Neeraj, Sudheesh T. K
Indian Institute of Technology Palakkad
e-mail: *102004006@smail.iitpkd.ac.in*

The rock-socketed piles are large diameter bored piles socketed to bed rock that are widely adopted foundation practice to carry heavy axial and lateral loads. It is a usual practice to neglect the effect of soil cover during the design of axially loaded rock-socketed piles. Unlike, the axial load case, the depth and nature of soil cover is found to have significant role in the behaviour of rock-socketed piles when subjected to lateral loading. The poster presents a detailed parametric study carried out to investigate the influence of depth and shear strength parameters of the soil cover on the lateral load response of rock-socketed pile. A numerical analysis conducted in finite element tool, ABAQUS, which was validated using an experimental study found in literature is used for the parametric study. For short and moderate length piles considered in this study, the geometric parameters such as soil cover depth, socket length, and ratio of soil cover depth to socket length were found to have profound effect on the lateral load response of rock-socketed piles. The effect soil cover depth was also found to be relatively independent of the shear strength characteristics of soil.

Figure



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Assessment of Short to Medium Range Precipitation Forecast in India

Sakila Saminathan[1*], Subhasis Mitra[2]

[1,2] *Department of Civil Engineering, Indian Institute of Technology Palakkad, Kerala*

e-mail: *101814002@smail.iitpkd.ac.in*

Abstract

Reliable and accurate precipitation forecast information is needed for various disaster mitigation and management purposes. Forecast information is generated by various Numerical Weather Prediction (NWP) models around the world. Spatio-temporal variability of forecast and uncertainty in the NWP models reduces the skill and reliability of the forecasts, hampering greater uptake for various purposes. So, this study aims to check the performance of short to medium range (1 to 7 days) Precipitation forecast information in India. The Climate Forecast System version 2 (CFSv2), European Centre for Medium Range Weather Forecasts (ECMWF), Global Ensemble Forecast System (GEFS) and Indian Institute of Tropical Meteorology (IITM) precipitation forecast has been assessed by using different precipitation indices. The evaluation of these models is done by using Heidke Skill Scores (HSS). HSS stated that the European Centre for Medium Range Weather Forecasts performed well followed by Global Ensemble Forecast System and Climate Forecast System version 2. Thus the models which perform well in Indian region can be used as an input to hydrological models and in various decision making purposes.

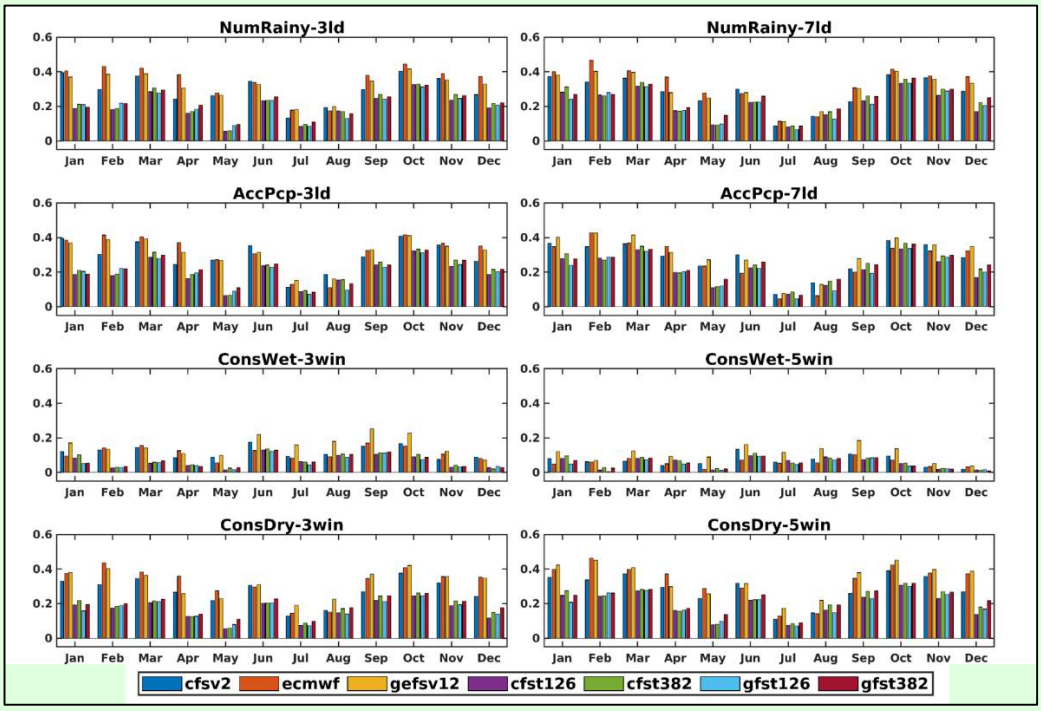

Figure 1. HSS values of different indices and models over the Indian region

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Flexural Fatigue Behaviour of Steel Fibre Reinforced Concrete Pavements: A Comparative Study

Ajeesh Koorikkattil, Sunitha K Nayar, Veena Venudharan

Indian Institute of Technology Palakkad

e-mail: *101914001@smail.iitpkd.ac.in*

Though various material models to represent the fatigue response for steel fibre reinforced concrete (SFRC) are available, the adequacy of these models for design of pavements have not been well established. Present study compares the suitability of the fatigue-based S-N models, with generalized fatigue models including various significant parameters in design of SFRC pavements. These generalised models, developed by the authors using statistical analysis, includes uncracked and pre-cracked stress conditions of material so as to be suitably incorporated in the inelastic design methods used for SFRC pavement design. The study mainly focusses on two design methods, the IRC SP46:2013 method and the mechanistic-empirical design method developed at IIT Madras (MEFRC). From the design solutions, it was found that incorporation of the generalized models improves the design efficiency of both IRC SP46:2013 and MEFRC method. From the parametric study it was concluded that the MEFRC method is more sensitive to variation in fibre dosage and subgrade modulus irrespective of the fatigue models used. This study is relevant as the use of the generalized models enable a rational design of SFRC pavements using inelastic analysis, avoiding a separate fatigue damage analysis.

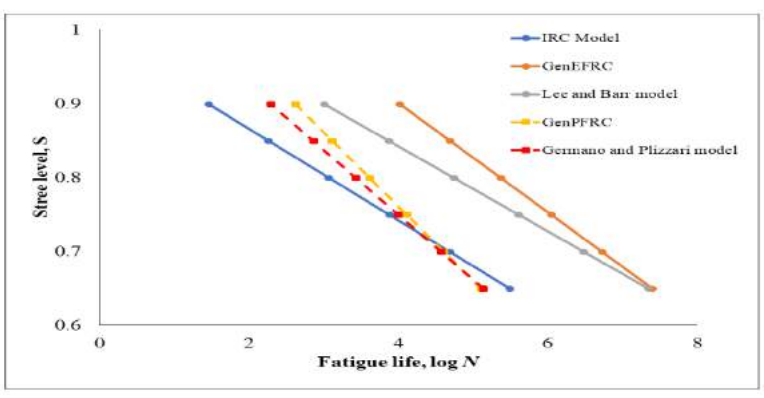

Figure 1 Comparison of S-N models relevant to this study

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Sensitivity changes of water deficit droughts on evapotranspiration methods in the Indian subcontinent

Femin C Varghese, Subhasis Mitra
Indian Institute of Technology Palakkad
e-mail: *101914002@smail.iitpkd.ac.in*

The choice of general circulation model (GCM) and reference evapotranspiration (ETo) estimation methods are crucial in projecting water deficit. Standardized Precipitation Evapotranspiration Index (SPEI) which is derived from water deficit also depends on choice of GCM and ETo estimation methods. In this study variance-based global sensitivity analysis is used to evaluate relative sensitivity of projected changes in future water deficit (P-ETo) and SPEI to the choice of GCM and ETo estimation methods across the Indian subcontinent. Two distinct periods are considered i.e., 2030-2060 and 2070-2100 for analysing the change in water deficit and droughts. To quantify the range and estimate the relative sensitivity of future projections to both factors, 7 GCMs and 11 ETo estimation methods are used. The 11 ETo methods are categorized into 4 major ETo methods based on temperature, radiation, mass transfer and combination. Results show that changes in future water deficit and droughts properties varies with regions and seasons. Overall, changes in water deficit droughts are more influenced by the choice of ETo, while GCM effects are more prominent for different regions. Result of this study indicate, the role of proper ensemble formation of GCMs and ETo estimation methods based on seasons and regions, to develop a robust range of future conditions for water resources planning.

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A method to select shelter locations that maximizes post-disaster connectivity reliability

K. Nitheesh, B. K. Bhavathrathan
Indian Institute of Technology Palakkad
e-mail: *102004004@smail.iitpkd.ac.in*

Disasters degrade road networks and disrupt traffic flow. Post-disaster state of the surrounding road network has to be accounted for, while planning for disaster management, and it plays a significant role in the evacuation of a disaster affected population to safe shelter locations. We employ a combination of degradation state and traffic state of the road network to define the post-disaster network state, and employ it in the selection of shelter locations.

Based on the network's expected post-disaster state, the problem is so formulated that at the solution, the aggregate connectivity reliability between a shelter location and the neighbourhood to which it serves will be maximum when aggregated across all shelter locations. The resulting optimization formulation can be seen similar to the general class of Reliable Facility Location Problems (RFLPs) in literature. Our work differs from the conventional RFLPs in that, the uncertainty associated with the state of the road network is being considered, and thereby the connectivity of each facility location is also accounted for. We describe the general methodology that could be followed for feasible road networks, and this would aid in equitable distribution of emergency shelter locations, and in the resilience-building against disasters.

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Development of a Framework Towards Structural Damage Prediction Using LiDAR

Nikunj Dhanani, Senthilkumar Venkatachalam

Indian Institute of Technology Palakkad

e-mail: *102013002@smail.iitpkd.ac.in*

Non-contact measurement technology such as Light Detection and Ranging (LiDAR) has been used to measure the geometric features at a macro level through its point cloud data. However, its potential use in precision centric applications such as damage deduction in structural members is limited due to various factors leading to inconsistencies in its accuracy. The factors influencing accuracy include atmospheric conditions, the scanning surface properties, and the scanner's angular resolution. Among all the influencing factors, the location of the scanner from the target surface is the only factor that has active control feasibility by the operator. Further, it has a significant influence on the interpoint spacing between point cloud points, which significantly influence the measurement accuracy. Therefore, an appropriate selection of scanner location and its effective scan area of the target beforehand helps to collect useful point cloud data on evaluating structural damages accurately without an invasive way. In this research, a set of mathematical equations and interactive graphs are proposed to decide TLS coverage areas while capturing the damages on structural components with differing accuracy levels.

Extraction of the damages from collected point clouds

To extract information from the collected point clouds, such as the area of damages, crack depth, etc, a semi-automated approach is demonstrated. The plan fitting algorithm RANdom Sampling and Consensus (RANSAC) is proposed to distinguish structural damages and outliers. Following that, Poisson Surface Reconstruction algorithm is implemented to generate a 3D surface from the segmented damages, and the accurate damage information is measured.

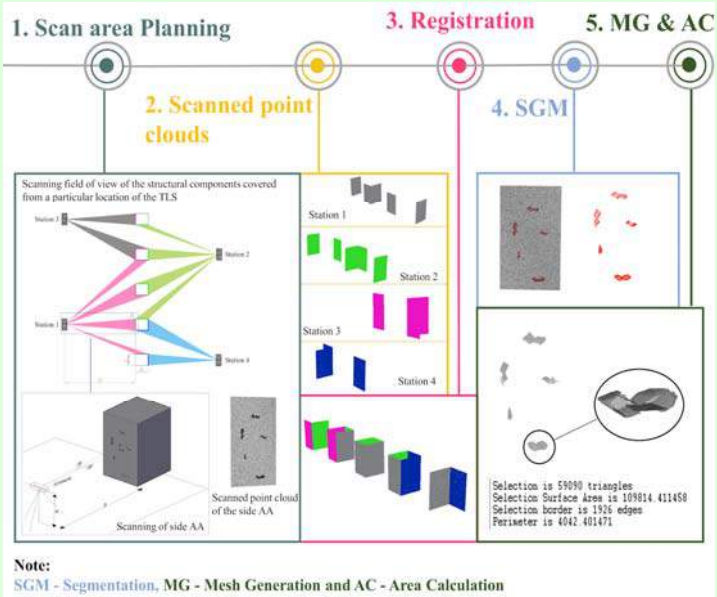

Fig : The process for extraction of damages on the structural members using LiDAR

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Poster Abstracts
Computer Science

RESEARCH SCHOLARS' DAY

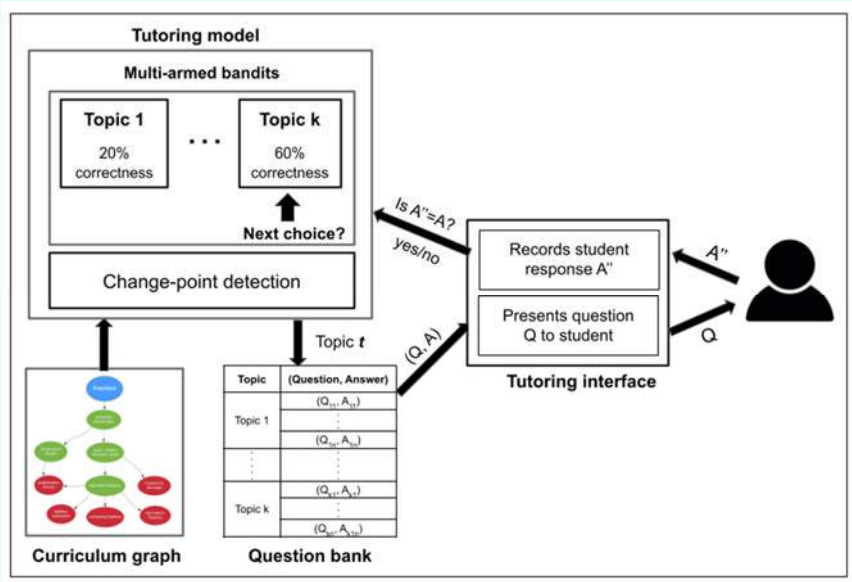
Generating personalized sequence of learning content based on a curriculum graph

S.K. Meethian[1], C. Lakshminarayanan[2]

Indian Institute of Technology Palakkad [1], Indian Institute of Technology Madras [2]

e-mail: *111914007@smail.iitpkd.ac.in*

One of the significant drawbacks of the current mode of teaching is the lack of personalization - the same course material is delivered to a large population of students regardless of their abilities and learning speed. This 'one-size-fits-all' strategy of content delivery does not cater to the learners' individual learning needs and the quality of education thus takes a hit. In this work we propose a reinforcement learning based tutoring model that helps a student to master a curriculum by adaptively sequencing learning content based on the student's learning curve. The model uses a curriculum graph, that represents the prerequisite relationships between various topics, to determine the next best topic to be offered to the student for practice. The topic selection is formulated as a multi-armed bandit problem where the arms correspond to the topics and the reward is the correctness of the student response to a problem associated with that topic. A change point detection algorithm is used to determine whether a topic has been mastered by the student. Our model has demonstrated better performance than some of the existing tutoring algorithms in simulations. The model performs very well in scenarios where a student struggles to learn a topic.



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DGraphNTP: Conditional De Novo Generation of Drug Graphs for Novel Target Proteins

S. Mallick, S. Bhadra

Indian Institute of Technology Palakkad

e-mail: *111913002@smail.iitpkd.ac.in*

De novo drug design, particularly for specific target proteins, is a crucial part of the drug discovery pipeline, however, it is time-consuming and expensive [1]. In recent years, there has been a surge of machine learning and deep learning methods which automate this task. However, only a few such methods tackle the problem of designing novel drugs for novel target proteins. We studied two popular deep learning methods for de novo drug design, one which utilizes the SMILES string representation of drug molecules, and the other which utilizes the graph structure representation of drug molecules. We propose a method that combines a conditional graph generative model along with an appropriate target protein representation for the task of de novo drug design for novel target proteins. We compare the proposed method with the existing SMILES string-based baseline method [1] and show the effectiveness of the proposed method through various metrics and utilizing docking for interpretable results.

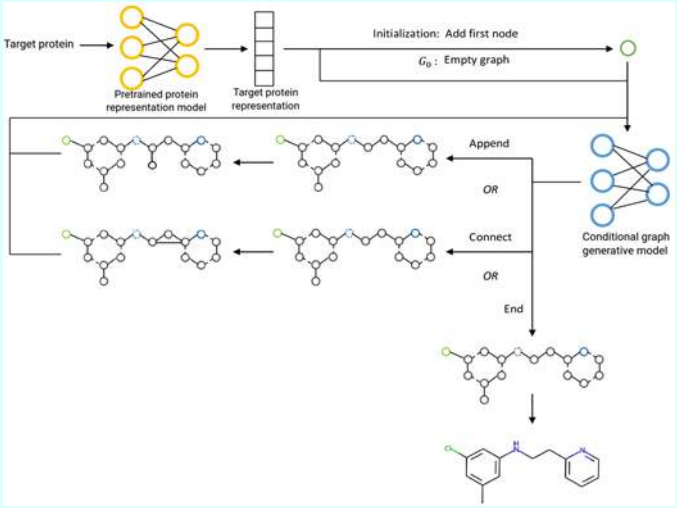

Figure 1: High level view of the proposed method for de novo drug graph generation for novel target proteins.

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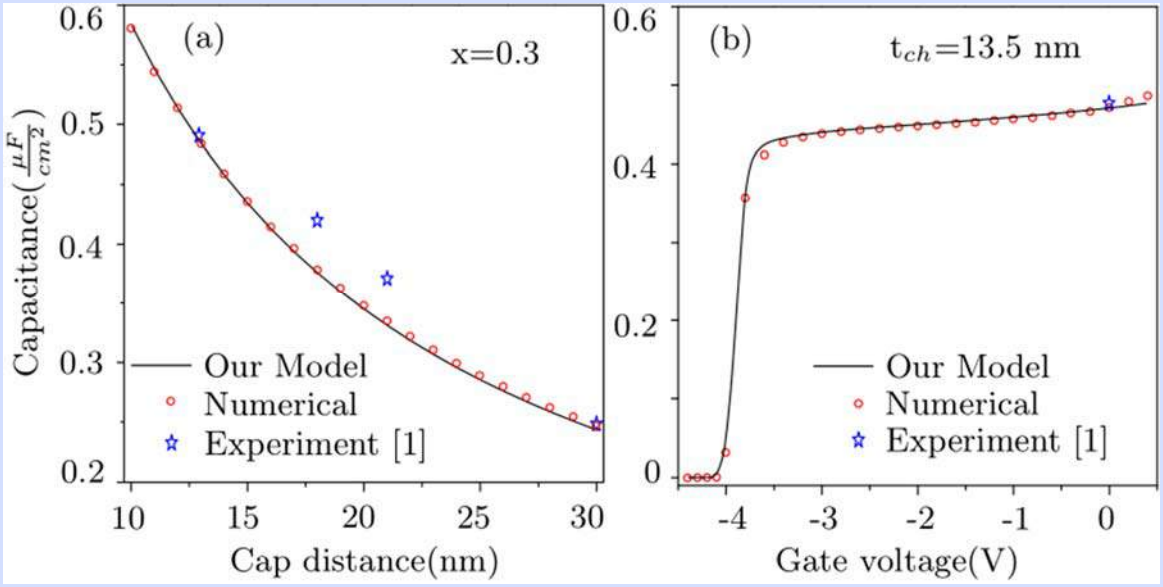
Poster Abstracts
Electrical Engineering

RESEARCH SCHOLARS' DAY

Analysis and Modeling of ultra thin channel N-Polar GaN/AlGaN MIS-HEMTs

Anuja Menokey M, Arvind Ajoy
Indian Institute of Technology Palakkad
e-mail: *121704001@smail.iitpkd.ac.in*

The GaN MIS-HEMTs are well known in high breakdown voltage, high sheet carrier density, and high saturation velocity due to its advantage over microwave power amplification and high frequency applications. The research in GaN MIS-HEMTs has focused on Ga polar and N polar directions, have different growth kinetics and surface properties. However, the Ga polar MIS-HEMTs have a trade-off exists between carrier density and barrier thickness. This trade-off is alleviated in N polar devices, since the barrier layer is located below channel layer. Also, it will allow the aggressive scaling of transistors while maintaining high carrier density. Therefore, N polar MIS-HEMTs are popular in ultra thin channel and enhancement mode devices. In this work, we introduce an analytical model for N polar MIS-HEMTs. The proposed model is based on the solution of Schrodinger and Poisson equations for a finite triangular potential well under first-order perturbation theory, and avoids the use of fitting parameters. The results are validated with numerical data at different gate bias conditions. In addition, we have derived gate capacitance model which is in close agreement with experimental data over different gate to channel distance and gate bias [1].



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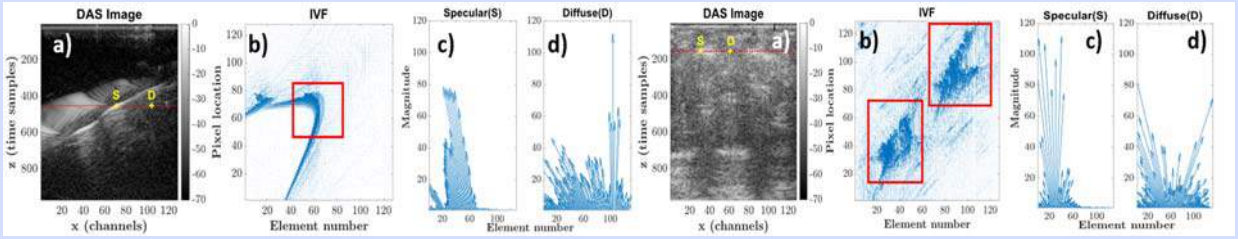
Intensity Vector Field: A Tool for Visualization and Characterization of Tissue Reflections in High Frame Rate Ultrasound imaging

Gayathri M, Mahesh Raveendranatha Panicker

Indian Institute of Technology Palakkad

e-mail: *121814001@smail.iitpkd.ac.in*

In ultrasound (US) imaging, the reflections from the tissue interfaces are low directional diffuse scattering or high directional specular reflections based on their relative sizes with respect to the signal wavelength and acoustic impedance mismatches[1]. The directivity of specular reflections depends on the angle of US wave incidence and the tissue interface orientation. This impacts the visualization of various structures in the US image, if the apodization in beamforming (conventionally delay and sum (DAS)) inappropriately weighs the reflections arriving at the transducer resulting in misdiagnosis. This puts forth the necessity to consider both the magnitude and direction of the reflected intensity and this work proposes an intensity vector field (IVF)[2][3] representation for the spatial distribution of acoustic intensity of each pixel to supplement visualization and, aid in transducer probe adjustment/selection of the right set of transmit angles. Experimental results for a 0º plane-wave (PW) transmission from 1) gelatin phantom with a 0.8mm Copper wire inserted at an angle and 2) back palm of a healthy volunteer are presented. It is seen from Case.1, 2 b) that IVF becomes dense and converges in specular regions (red rectangle regions in b)) with the convergence direction governed by the PW transmit angle and reflector orientation (Case. 1, 2 c)). On the other hand, it is spatially diverging in diffuse regions (Case. 1, 2 b), d)).



Case 1: Wire phantom **Case 2: Back palm**

Case 1, 2 : a) DAS image b) IVF along the red dotted line in a) c) Magnified IVF of specular pixel 'S' d) Magnified IVF of diffuse pixel 'D' respectively for gelatin wire phantom and back palm. The red rectangle in Case 1b) corresponds to the wire region and in Case 2b) corresponds to the two metacarpal bones.

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Electromagnetic Metamaterial Enabled Structure for Microwave and Millimetre-wave Applications

Mohammad Abdul Shukoor, Sukomal Dey
Indian Institute of Technology Palakkad
e-mail: *121814002@smail.iitpkd.ac.in*

Artificial periodic constructs with unique electrodynamic properties not found in nature, such as negative refraction index (NRI) and inverse Doppler effect, are called Metamaterials (MMs). Metasurfaces (MMs) are called planar metamaterials with sub-wavelength thickness, and they can be easily fabricated using lithography and nano printing techniques. The ultra-thin construction of MSs can significantly reduce loss in the wave propagation direction by carefully selecting materials and designing the device. Several metasurfaces can be classified based on their polarisation response, including frequency selective surfaces (FSS), high impedance surfaces, ideal absorbers, polarization converters and reflecting surfaces. Frequency selective surfaces (FSS) are two-dimensional periodic structures containing planar metallic array elements (patch or apertures) on a dielectric substrate, which show transmission and reflection at a specific resonant frequency [1]. The orientation of the electric field vector in a plane perpendicular to wave propgation direction is referred to as EM wave polarization. Asymmetric metasurface's unitcell can perform polarization conversion phenomena by controlling and manipulating the amplitude and phase parameters of the EM wave. This occurs when the plane wave frequency matches the FSS element resonance frequency. As a result, an FSS has the potential to pass or block electromagnetic waves of particular frequencies in free space. The prototype of the linear-cross polarization converters of the reflective type is shown in Fig. 1 as proof of concept.

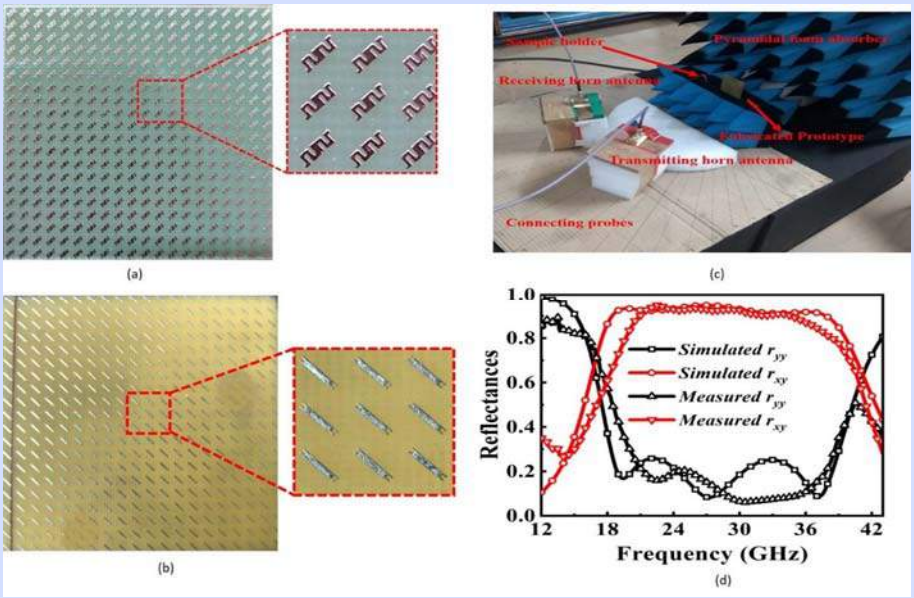

Fig. 1. Fabricated prototype (20 x 20) (a) Meanderline Polarization Converter, (b) H-shaped Polarization Converter, (c) Experimental setup for free-space measurement, (d) Measured reflectances.

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Extending the Capability of Linear Array Ultrasound Probe to Concave Array using Low-Cost Acoustic Lens for High Frame Rate Focused Imaging

Pisharody Harikrishnan Gopalakrishnan, Mahesh Raveendranatha Panicker

Indian Institute of Technology Palakkad

e-mail: *hgpisharody@itpkd.ac.in*

In the current scenario medical practitioners use different types of transducer probes for imaging organs at different depths and with varying field of view. Normally linear arrays are used for near-field imaging while convex probes are used for far-field imaging. In both the cases, focusing is achieved through electronics delays, which will reduce the frame rate to maximum of 50 fps. In this work, an approach towards a low-cost setup using gel based acoustic lens for converting a linear array transducer probe with plane wave transmission to a concave array to induce focused ultrasound (US) B-Mode imaging is attempted as shown in Fig.1(c). By employing acoustic lens instead of a dedicated concave array, the integration complexity, space requirement of interconnects and power consumption of driving the hardware units could be saved [1-3]. The simulated beam pattern employing k-wave toolbox [4] for linear array and the linear array with concave acoustic lens mask, both with zero angle planewave transmission is as shown in Fig. 1(b-c), which clearly shows the significance of the proposed approach. The experimental results yielded an improvement in the lateral and axial resolution of 36.67 % and 28.57 % respectively which were pre-validated using simulation results yielding similar outcomes of 47.50 % lateral and 33.33 % axial resolution.

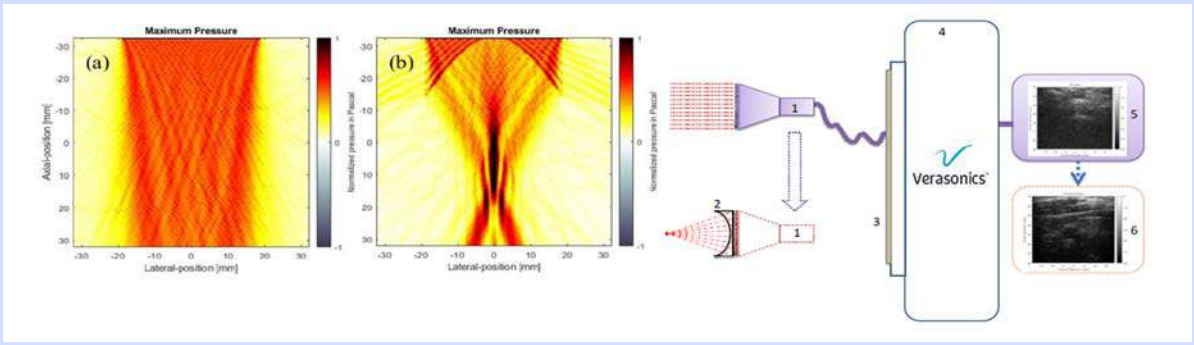

Figure 1. (a) Beam pattern for the linear array with zero angle planewave transmit, (b) Beam pattern for the linear array with concave lens mask and zero angle planewave transmit. (c) System Block diagram 1-linear probe, 2-concave lens, 3-UAT, 4-Verasoncis 128 channel system, 5-B-Mode image with no lens, 6-B-Mode image with concave lens.

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A Switched-Capacitor CVC and CFC for Capacitive Sensors Representable using π-Model

P. Sebastian, P.P. Narayanan, S. Vijayakumar
Indian Institute of Technology Palakkad
e-mail: *122003003@smail.iitpkd.ac.in*

In this paper, a new Capacitance-to-Voltage Converter (CVC) and Capacitance-to-Frequency Converter (CFC) for capacitive π-model are presented. A simple and effective closed-loop mechanism is proposed that provides the output voltage and frequency proportional to the sensor capacitances in the π-model. The proposed feedback mechanism ensures that the linearity performance of the converter is not affected by the non-linearity of the elements in the forward path. A π-model capacitor comprises of three capacitances, Cx2: the capacitance formed between the electrodes and Cx1 and Cx3: capacitance between each electrode and ground. Such π-model representation is very effective in sensing the relative position of the measurand (by measuring Cx1 and Cx3) in addition to the measurand detection (from capacitance Cx2). The proposed switched-capacitor based converter uses only DC source for excitation and hence achieve high accuracy measurements. A prototype has been developed and verified the practicality of the converter for sensor capacitance ranges from 20 pF to 200 pF. The worst-case linearity error of 3.5% was observed when operated in open-loop configuration, and the error reduced to 0.28% when operated in the proposed feedback configuration. The developed prototype exhibited negligible cross-sensitivity between the capacitance measurement in the π-model and can provide the best measurement rate compared to the existing architectures of capacitive π-models.

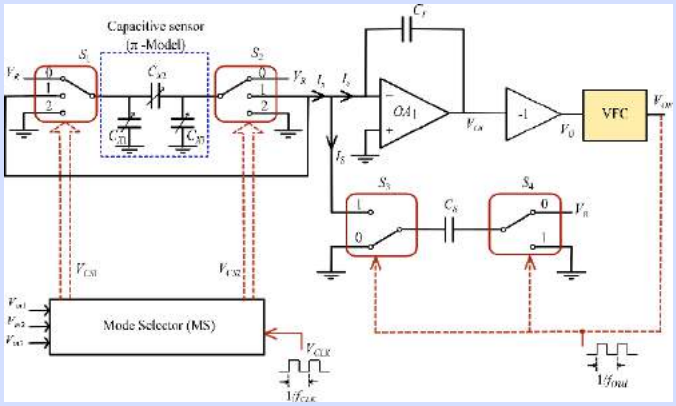

Fig: Block Diagram of CFC

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A Novel Single-Element Inductance-to-Digital Converter with Automatic Offset Eliminator

Narayanan P. P., Sreenath Vijayakumar
Indian Institute of Technology Palakkad
e-mail: *122004005@iitpkd.ac.in*

Single element inductive sensors have a large area of applications and are preferred over other sensors due to their immunity to harsh and polluted environments. The sensor output corresponding to the measurand is measured by using inductance to digital converters. In most cases, the offset inductance L0 offered by the sensor will be large as compared to ΔL (due to the measurand). Thus, the existing architectures that measure the sensor inductance LX (=L0 ± ΔL) lead to underutilization of the output range and hence such systems cannot focus on sensing the measurand alone. The proposed LDC, automatically eliminates the offset inductance in the final output and utilizes the entire digital scale only for representing ΔL. Also, the digital output of the proposed LDC is made independent of the coil resistance RC of the inductive sensor. The proposed LDC employs DC source for digitization, thereby eliminates the need for AC excitation sources that demands repeatable sinusoidal amplitude for high accuracy measurements. The direct digital conversion is performed by modifying the dual-slope conversion technique. The block diagram representing the proposed LDC is shown in Fig. 1. A prototype of the LDC was developed and verified the automatic offset elimination operation of the proposed converter. The prototype exhibited better performance as compared to the existing architecturs [1-4] with a worst-case linearity error of 0.5% for ΔL ranging from -9 mH to +9 mH [5].

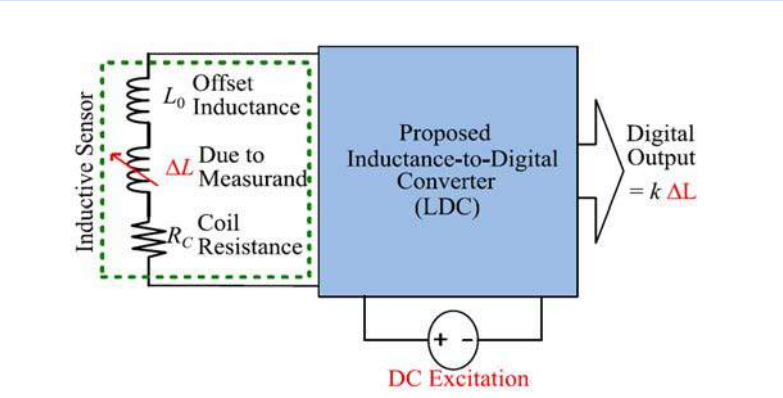

Fig. 1 Block diagram of proposed LDC. The digital output is proportional to change in inductance ΔL independent of L0 and RC, where k is a constant

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Synchronous Detection To Reduce Offsets In Focus Error Of An Optical Pickup Unit

Rekha S S, Arvind Ajoy

Indian Institute of Technology Palakkad

e-mail: *122014008@smail.iitpkd.ac.in*

The Optical Pickup Unit (OPU) is an optical assembly which is used for reading and writing digital optical disks. It consists of a laser diode, quadrant photodetector, and other optical components to maintain focus. This arrangement of the laser and photodetector is very similar to those in expensive equipment, such as atomic force microscopes, used for nanoscale metrology. Many researchers have hence investigated the use of an OPU to design low-cost alternatives. However, these non-standard uses of an OPU are challenging, since the OPU has originally been optimized to sense reflections from the highly reflecting surface of an optical disk.

In our previous work [1], we presented a new synchronous detection based method that improves the performance of the OPU in measuring the reflection from poorly reflecting substrates. In this method we excited the laser with a pulsed input, and looked for a signal at the pulsing frequency in the output from the OPU. This signal was further processed through a phase-sensitive detector. We have shown that this method reduces the offsets in the measurement, and allows us to make effective use of a higher gain to measure the reflection from substrates with poor reflectivity.

This poster shows the scope of using the OPU with synchronous detection for different applications.

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Poster No: 26

4th Research Scholar's Day, November 6th, 2021

An Angle Independent Depth Aware Fusion Beamforming Approach for Ultrafast Ultrasound Flow Imaging

Madhavanunni A N, Mahesh Raveendranatha Panicker

Indian Institute of Technology Palakkad

e-mail: *121813001@smail.iitpkd.ac.in*

In the case of ultrasound flow imaging systems, the most employed flow estimation techniques are the directional beamforming based cross correlation and the triangulation-based autocorrelation. However, the directional beamforming-based techniques require an additional angle estimator [1] and are not reliable if the flow angle is not constant throughout the region of interest. On the other hand, estimates with triangulation-based techniques are prone to large bias and variance at low imaging depths due to limited angle for left and right apertures [2]. In view of this, a novel angle independent depth aware fusion beamforming approach is proposed and evaluated in this paper. The hypothesis behind the proposed approach is that the peripheral flows are transverse in nature, where directional beamforming can be employed without the need of an angle estimator and the deeper flows being non-transverse and directional, triangulation-based vector flow imaging can be employed. In the simulation study, an overall 67.62% and 74.71% reduction in magnitude bias along with a slight reduction in the standard deviation are observed with the proposed fusion beamforming approach when compared to the triangulation-based beamforming and directional beamforming, when implemented individually as shown in Fig. 1. The efficacy of the proposed approach is demonstrated with in-vivo experiments as well.

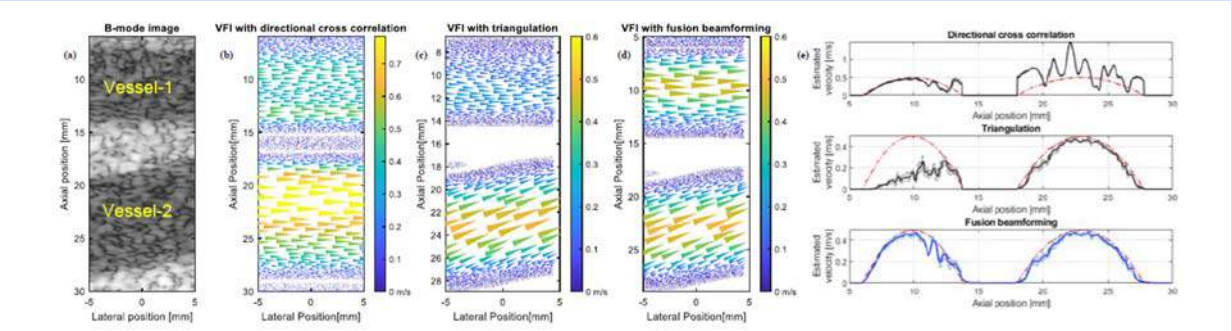

Figure 1. Simulation results [3]: (a) B-mode image of the region of interest, (b) Vector flow images (VFI) obtained with directional cross correlation [1], (c) VFI obtained with triangulation based VFI scheme [4], (d) VFI obtained with the proposed depth aware fusion beamforming method, (e) Comparison of mean estimated velocity plots. Shaded region shows one standard deviation.

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Double E-Shaped Reflection Type Polarisation Converter For Radar Cross Section Reduction

Shyam Sundar Pati, Soumik Dey, Swaroop Sahoo, Sukomal Dey

Indian Institute of Technology Palakkad

e-mail: *122114005@smail.iitpkd.ac.in*

Recently, Metamaterial (MMs) based planar polarisation converters are gaining attention as a tool of manipulating polarisation and surface wave characteristics of electromagnetic waves. It founds various applications as RCS reduction in stealth technology, polarisation beam splitters and other defense applications. In this work, a new compact unit cell for reflection-type linear co-pol to cross-polarization conversion is presented. The metasurface is printed on a perfect conductor-backed dielectric substrate. The unit cell consists of double E-shaped resonators. The structure exhibits a broadband linear cross conversion from 6.46− 14.07 GHz (7.61 GHz or 74.2 %) with a polarization conversion ratio (PCR) > 90 %. This converter response is found to be stable at a high incidence angle of > 30°. Periodicity of the unit cell is 0.38 λ0, where λ0 is the free space wavelength at the center frequency of the operating range. This proposed converter can be used in stealth technology for radar cross-section (RCS) reduction. At frequency 9.8 GHz, the 4 × 4 array of the converter reduces the RCS by more than 21 dB for both monostatic and bistatic conditions.

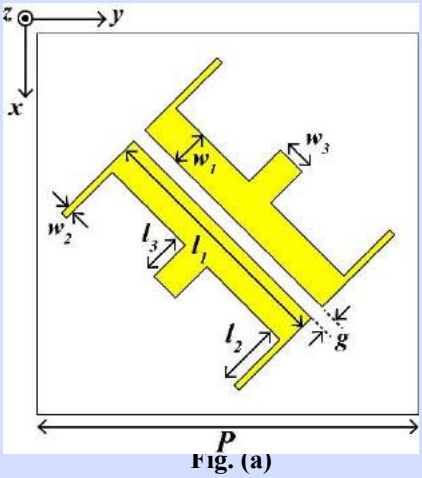

Fig. (a)

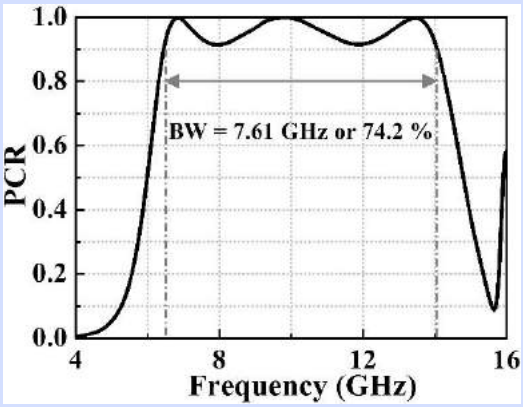

Fig. (b)

Fig. (a) Schematic of the proposed linear cross converter (b) simulated polarization conversión ratio (PCR)

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IIT PALAKKAD

Poster Abstracts
Humanities

RESEARCH SCHOLARS' DAY

WOMEN AT LEISURE: FINDINGS FROM NSSO TIME USE SURVEY 2019

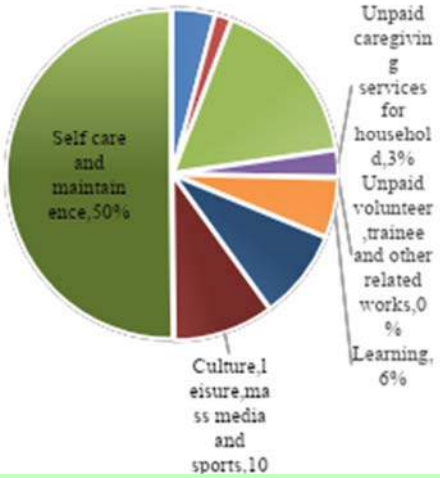
A. Jacob

Indian Institute of Technology Palakkad

e-mail: *232014001@smail.iitpkd.ac.in*

One of the major objectives of feminist economists is to remove invisibility of women's work from every aspect of life. While disentangling the paid and unpaid work of women, little focus is given to the domain of leisure activities which is an important aspect of assessing the quality of life. It is seen that leisure is a 'gendered'activity, creating privileged and underprivileged classes where women are relegated the deprived status in availing leisure opportunities. The study analyses the leisure time dispositions of both urban and rural women, deriving the findings from NSSO Time Use Survey 2019. It is revealed that age, income, social class and activity status of women considerably affects the time spend by women in leisure and related activities.

Figure 1 : Proportion of time spend in different activities by women in a normal day



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Determinants of Inflation in India in a Dynamic Setup

Masudul Hasan Adil
Indian Institute of Technology Palakkad
e-mail: *masudul@iitpkd.ac.in*

The present study empirically examines the factors accounting for inflation in India in an open economy framework by utilizing the bounds testing approach to cointegration for the 2006: Q3-2019: Q4 period. The findings reveal the existence of a long-run relationship with the household survey-based inflation expectation, real output, narrow money aggregate and interest rate as important determinants of inflation. The study concludes that inflation is well explained by a combination of structural and monetary factors. Notably, the significance of inflation expectation as an important explanatory variable corroborates the utilization of inflation forecast by the RBI as an intermediate target in the flexible inflation targeting framework. In this backdrop, it is imperative for RBI to conduct a high frequency inflation expectations survey of households to account for frequent information updation on the part of certain groups of households.

Keywords: Inflation forecast; flexible inflation targeting; bounds test; India

JEL Classification: E47, E52, E58, E5, E4

IIT PALAKKAD

Poster Abstract Mathematics

RESEARCH SCHOLARS' DAY

Sufficient and efficient estimators for Student-t models under Basu et al. likelihood maximization

Atin Gayen, M. Ashok Kumar
Indian Institute of Technology Palakkad
e-mail: *211814002@smail.iitpkd.ac.in*

In parameter estimation problems, sufficient statistics summarizes all relevant information about the unknown parameters available in the entire sample. Fisher introduced the notion of sufficiency based on the usual likelihood function. This is useful particularly when the underlying model is exponential. We propose a generalized notion of principle of sufficiency based on a generalized likelihood function, namely Basu et al. likelihood function that arises in robust inference. Euclidean squared distance is closely related to this likelihood function. We find the specific form of the family of probability distributions that have a fixed number of sufficient statistics (independent of sample size) with respect to this likelihood function. These distributions are of power-law form and are a generalization of the exponential family. Student distributions are a special case of this family. We also extend the concept of minimal sufficiency with respect to this generalized notion and find a minimal sufficient statistic for Student distributions. We observe that the generalized estimators of parameters of Student distributions are functions of the minimal sufficient statistics derived from this generalized notion. We finally show that these estimators are also efficient in the sense that variance of each of these estimators equals the variance given by the asymptotic normality result.

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IIT PALAKKAD

Poster Abstracts
Mechanical Engineering

RESEARCH SCHOLARS' DAY

Contact of thin elastic shells with flat rigid substrates

Aiswarya M Kasarla, Sovan Lal Das
Indian Institute of Technology Palakkad
e-mail: *131913001@smail.iitpkd.ac.in*

In this research, a very interesting and little discussed contact problem of a thin shell with a rigid substrate is studied. Out of all the available shell theories, we have selected the linear Cosserat shell theory to have a more generalized analysis. The problem is that of a plane strain type with cylindrical shell in contact with a smooth planar rigid substrate, the shell is subjected to uniform line load F N/m applied at the top edge as shown in Figure.1. Due to symmetry, one half of the Shell will be considered as in Figure 2.The results obtained are compared with two more shell theories and finite element simulation using ABAQUS

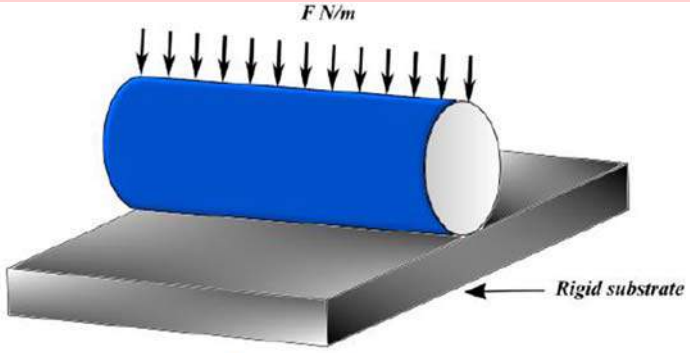

Fig 1: Cylindrical shell resting on a rigid substrate.

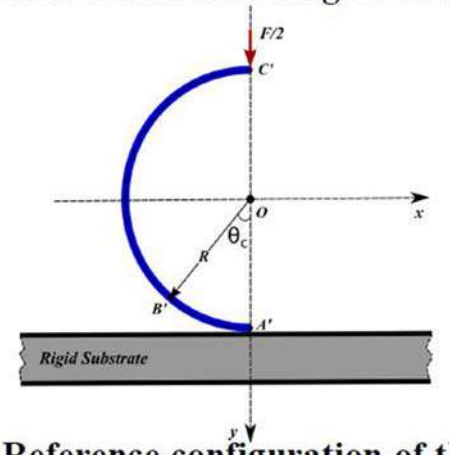

Fig 2: Reference configuration of the shell.

PREDICTION OF THERMAL CONTACT CONDUCTANCE IN CONFORMING ROUGH METAL CONTACTS THROUGH REGENERATION OF MEASURED SURFACE PROFILE

E.Ajul, Samarjeet Chanda

Indian Institute of Technology Palakkad

e-mail: *131914001@smail.iitpkd.ac.in*

In this work the effect of asperity height and the number of discrete contact points on TCC is studied. The contact between a conforming smooth-flat and rough surface is considered to evaluate TCC at the interface. A Gaussian distribution with zero mean and standard deviation equals to the root mean square (RMS) value of the surface roughness is considered for generating the asperity height distribution of the required rough surface. Two surfaces with RMS values of 5 μm and 3 μm roughness are considered. To study the effect of the number of contacting asperities, the roughness is kept constant at 5 μm and the number of contacting asperities is varied between 11 to 51. Effect of air conduction on heat transfer across the interface is also studied for all the cases. A steady state heat diffusion equation is solved along with the appropriate boundary conditions to achieve the same. A qualitative analysis of the effect of TCC is presented by comparing the top surface temperature of the considered physical domain for different cases of contact. It is found that TCC increases with the number of contacting asperities and decreases with increase in surface roughness.

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ELECTROCHEMICAL THERMAL MODELLING OF Li-ION BATTERY CELL AT DIFFERENT DISCHARGE RATES

Arundas Odungat, Samarjeet Chanda
Indian Institute of Technology Palakkad
e-mail: *132104001@smail.iitpkd.ac.in*

Li-ion batteries are widely used in energy storage systems (ESSs) due to their high energy density. Prolonged usage of Li-ion battery packs often results in elevated temperatures within the cells which give rise to safety concerns. Efficient thermal management of battery packs using Battery Thermal Management Systems (BTMS) is the key to mitigating safety issues. Different electro-chemical-thermal (ECT) models are available in the literature that can predict the heat generation in Li-ion batteries, a key input for the design of efficient BTMS. This work is focused on using the NTGK(Newman, Tiedemann, Gu, and Kim) model for predicting the temperature and heat generation of a pouch type li-ion cell when it is discharged at different C-rates. A naturally cooled pouch type Li(NiCoMn)O2 cell is numerically simulated. Simulations are performed for constant ambient air temperatures and different but constant rates of discharge. The model predictions show that with increase of C-rate average surface temperature increases and higher temperature region is observed near to the tabs necessitating the development of efficient thermal management systems for battery packs.

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Stress Distribution in Infinitely Long Plate with Circular Hole Loaded by Concentrated Loads

M. Shafeeque K K, KVN. Surendra
Indian Institute of Technology Palakkad
e-mail: *131814002@smail.iitpkd.ac.in*

An infinite plate with a circular hole loaded by concentrated forces is a 2-D exterior problem which is solved here by superposing Flamant problems followed by annihilating far-field and boundary tractions using limiting case of Lame's problem. This method being identical to that used for classical problem of disk under diametral compression (corresponding interior problem), leads to closed-form solution for the exterior problem. Series solution is applicable for distributed loads, which in the limit approaches solution for the title problem. FEM which can model only finite geometries, approximates the infinite domain in the limit. The latter two methods are adopted here for validation of the analytical method by comparison. The analytical method is extended to solve three-point, four-point and n-point loading cases on the circular hole boundary

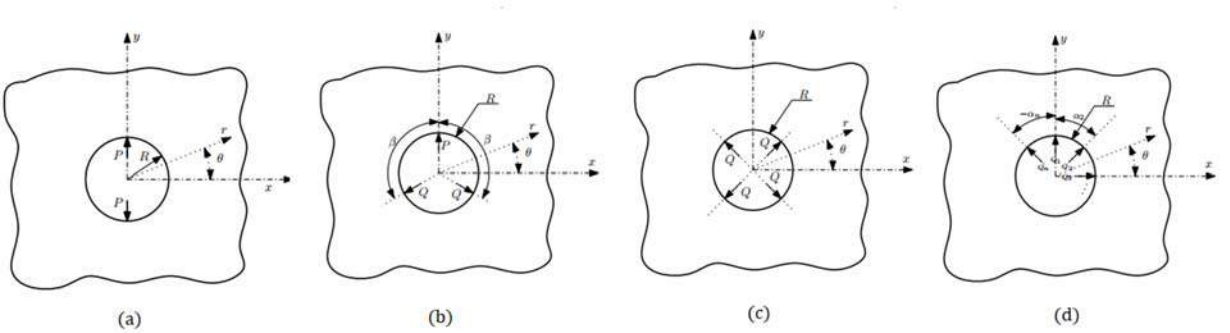

Fig. 1. The exterior problems: Infinite plate with a circular hole subjected to (a) diametrical compression, (b) 3-point load, (c) 4-point load and (d) n-point load on the hole boundary.

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Classical kinetic theory based model of collisional flows through an axisymmetric pipe

Mudasir Ul Islam, Sovan Lal Das

Indian Institute of Technology Palakkad

e-mail: *132004002@smail.iitpkd.ac.in*

The flow of granular materials such as sand, snow, and coal is a common occurrence in nature and industries. In nature, they occur as avalanches of granular snow and rock debris slides. And in industries, they occur in the pharmaceutical, mining and polymer processing areas. The continuum modeling of granular media is motivated by the pioneering experimental work of Bagnold [1], which suggests the transfer of momentum is mainly due to collisions between grains. Later, Jenkins [2] extended the kinetic theory of dense gases [3] to describe the rapid flow of identical, smooth, nearly elastic, spherical particles. In this work, we study flows of inelastic grains driven by gravity in an axisymmetric pipe using the balance equations, constitutive relations, and boundary conditions that result from kinetic theory [4]; [5]. We find two qualitatively different steady flow regimes for the given particle parameters and pipe radius within a volume flow range. The one with a low mean velocity and high volume fraction is denoted as the dense slow flow, while the other with high mean velocity and low volume fraction is called as dilute fast flow regime .

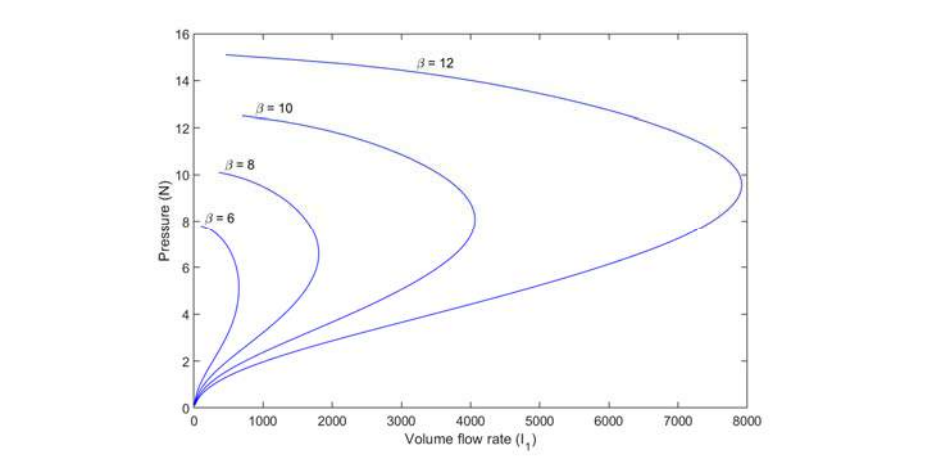

Figure: Variation of the pressure with the volume flow rate for different dimensionless pipe diameter β.

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Investigation on the effect of graphene nanocutting fluid minimum quantity lubrication on the machining performance of Inconel 625

P. R. Rakesh, D. Chakradhar
Indian Institute of Technology Palakkad
e-mail: *131704002@smail.iitpkd.ac.in*

Inconel 625 is nickel-based superalloy that found widespread usage in aerospace, marine and nuclear applications due to its outstanding mechanical properties. However, the poor thermal conductivity and high temperature strength of these alloys makes machining more difficult. In this study, the machining performance of Inconel 625 under nano-minimum quantity lubrication environment was investigated. Coconut oil was selected as base fluid and graphene nanoparticles were dispersed to enrich the physicochemical properties of cutting fluid. Experiments were conducted according to Taguchi's L16 orthogonal design under various concentrations of nanocutting fluid, and at different levels of cutting speed, feed, and depth of cut. Surface roughness, tool flank wear and material removal were selected as responses and turning performance was optimized by the grey relational multi-objective optimization method. Cutting speed of 80 m/min, feed of 0.05 mm/rev, depth of cut of 0.8 mm and 0.50 wt. % graphene nanofluid were obtained as the optimal machining conditions. Analysis of variance was performed to identify the influence of input parameters. The tool wear mechanisms and chip morphology were analyzed using SEM and EDS to understand the cutting tool performance under each cooling condition.

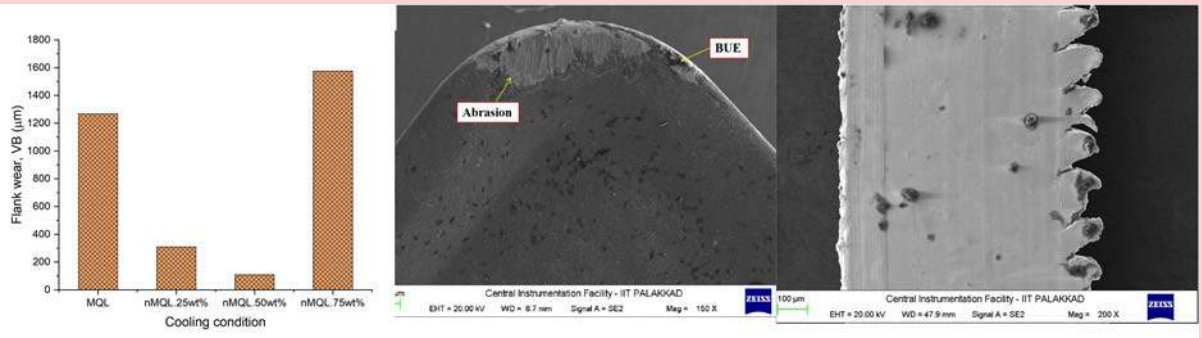

Figure 1: (a) Variation of tool flank wear under various cooling environments, (b) SEM image of tool flank wear under 0.50 wt % nMQL, (c) SEM image of chip under 0.50 wt % nMQL

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Rolling Contact Fatigue (RCF) Studies On Surface Hardened And Through Hardened AISI 4140 Alloy Steel

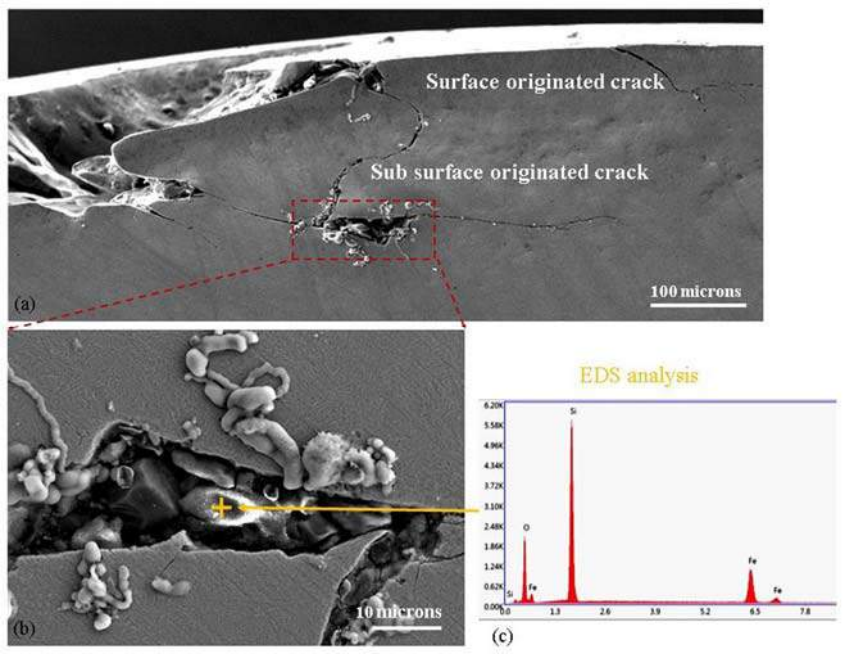
Ranju M R, Kesavan D

Indian Institute of Technology Palakkad

e-mail: *131814003@smail.iitpkd.ac.in*

Surface pitting is the primary type of failure that occurs in the bearings due to the rolling contact fatigue (RCF) phenomena. A twin disc-on-cylinder benchtop test rig is used to reproduce the same Hertzian elliptical contact met in bearings to study the effect of surface treatment on rolling contact fatigue life of the AISI4140 steel. Through hardened and induction hardened specimens are subjected to the experimental analysis with boundary lubricant condition. The RCF life cycles obtained from the experiment are used to plot the failure analysis diagram to compare the L10 life of specimens. It is observed that the surface hardened specimen shows significant improvement almost three-fold in life compared to through hardened specimen.

A 3-dimensional elastic finite element model is developed to estimate the maximum contact pressure and maximum sub- surface shear stress on the specimen under various loading conditions. The obtained maximum shear stress region from the FEA is in good agreement with the crack initiation region observed in experimental studies.



Poster No: 38

4th Research Scholar's Day, November 6th,2021

Numerical Investigation on the Effect of Reinforcement on the Properties of AA6063-Silicon Carbide Composites

Shanmuga Priyan V.G.[1]*, Kanmani Subbu S.[2]

[1,2]*Indian Institute of Technology Palakkad, Palakkad*

*e-mail: *131814004@smail.iitpkd.ac.in*

Aluminium matrix composites have found widespread applications due to its desirable properties like high specific strength and stiffness, good electrical conductivity etc. AA6063-Silicon Carbide composites with different volume fractions were fabricated using Ultrasonic assisted stir casting. It is a variant of conventional stir casting to avoid agglomerations of fine reinforcement particles and distribute them evenly in the melt. The tensile strength and hardness of the composites were evaluated experimentally. To understand the influence of the reinforcement particles on the resultant properties, the composite was modelled as a representational volume element (RVE) using Digimat – a multi-scale material modeling software and the mechanical and thermal simulation was carried out using Abaqus. Since Aluminium-SiC composites are also employed in cooling of high power circuits and electronic packaging, the thermal behavior of it needs to be studied. The predicted ultimate tensile strength and effective thermal conductivity were an overestimate as the model does not consider porosity present in the real scenario. However, there was overall good accordance with the experimental results and the data available in literature. Thus the model developed can be utilised for further analysis.

a) b) c)

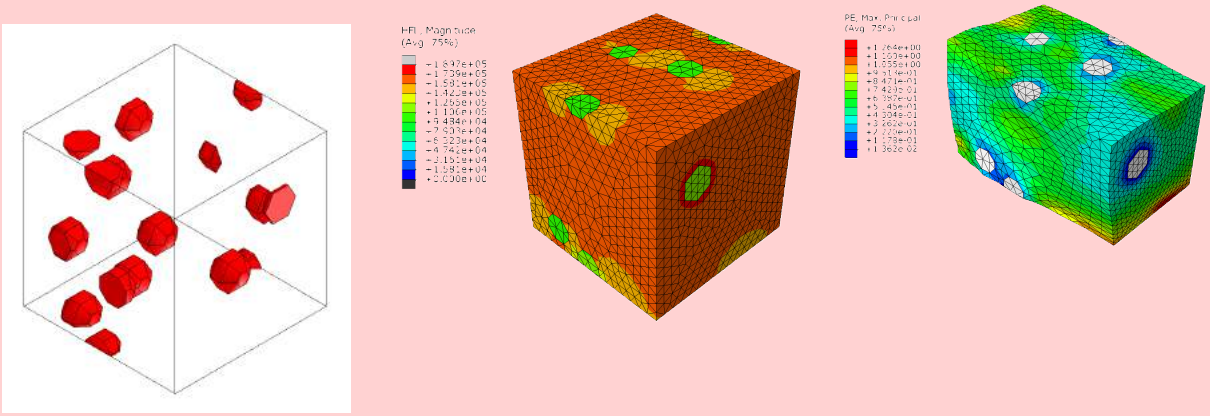


Figure 1: a) Geometrical model - RVE b) Heat flux distribution and c) Plastic strain of 3 volume percentage of Silicon Carbide in AA6063-SiC composite

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Study on the Geometrical Variation of Contour for Different Angle Between the Edges of Part

D. Simson, S. Kanmani Subbu
Indian Institute of Technology Palakkad
e-mail: *131914002@smail.iitpkd.ac.in*

Laser powder bed fusion (LPBF) is an emerging manufacturing process to fabricate complex geometries ranging from bulk to micro size components. Even though the complex geometries could be fabricated by LPBF, the fabricating component with sharp corners is a great challenge in this process. The corners of the parts are affected by numerous process parameters like laser spot diameter, laser power, scanning speed, scanning strategy, powder size distribution, etc. In scanning strategy the contour plays an important role in the dimensional accuracy of a part as compared to infill. Hence in this study the only contour is considered, and analysed the geometrical variation of the contour on various corner designs (α=60°, 90°, and 120°) as shown in Fig. 1(a). The laser power and scanning speed were optimized for continuous deposition and uniform width for the Ti-6Al-4V single track experiment. Same laser power and scanning speed is used for all three corner designs. The geometric analysis of corners was carried out using a scanning electron microscope followed by image analysis software. From the results it is confirmed that there is a variation in the track width at the corners and it increases as the angle between the edges reduces which is shown in Fig. 1(b).

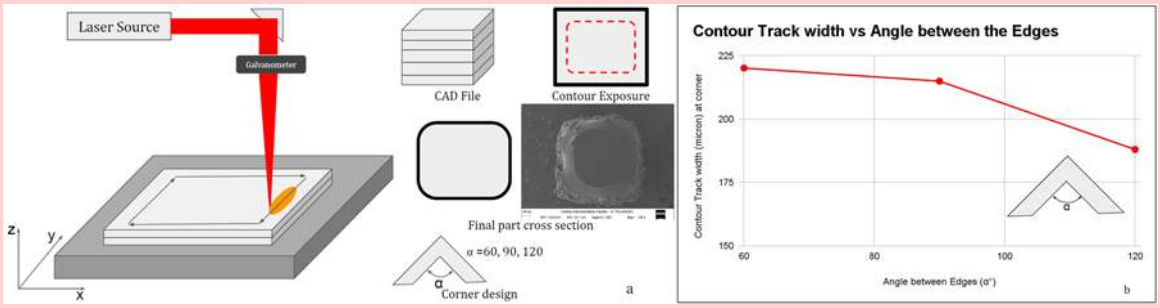

Figure.1 *Schematic of LPBF process and Variation of part fabricated from CAD design (a), Track width variation for different angles between the edges (b).*

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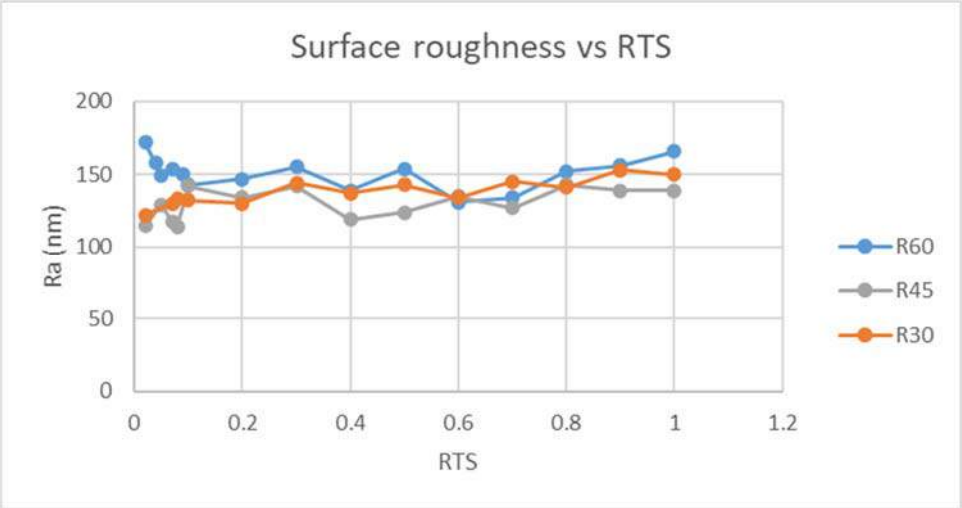
Edge radius effect on the surface roughness in orthogonal turning of Al6082 alloy

Suresh Ellappan, Afzaal Ahmed
Indian Institute of Technology Palakkad
e-mail: *131914003@smail.iitpkd.ac.in*

In mechanical micromachining, the uncut chip thickness is comparable to the edge radius of the tool. In the present study, the effect of relative tool sharpness on the surface roughness has been investigated. Orthogonal turning is carried on Al6082 with carbide inserts of edge radius 30, 45 and 60 µm. The surface finish is characterized using contact surface profilometer and optical microscope. Results indicates that the edge radius significantly influences the surface roughness.



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Poster Abstracts
Physics

RESEARCH SCHOLARS' DAY

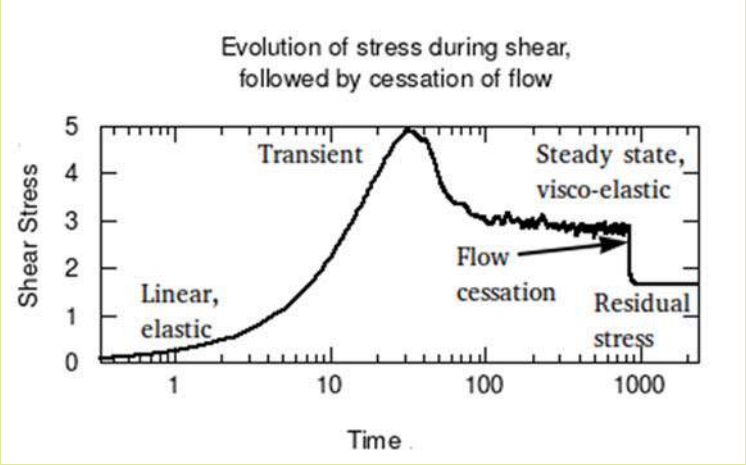
Residual stress in dense disordered materials - Competition between thermal and mechanical noise

Suganthan

Indian Institute of Technology Palakkad

e-mail: *222114001@smail.iitpkd.ac.in*

Soft amorphous materials are ubiquitous in nature, constituting many materials around us, including toothpaste, paints, wet cement, shampoo, bitumen etc. Upon external force, they show visco-elastic behaviour. The yielding mechanism in these disordered systems is a topic of immense interest. Even in the steady state flow, where one expects a simple viscous liquid behaviour, these materials show flow inhomogeneities. Upon flow cessation, these systems show a non-trivial decay of stress to a finite value - residual stress - even after a long time relaxation. Previous works, in thermal systems, show a multi-step stress relaxation behaviour. In the athermal systems the stress relaxation, even though is an exponential decay, the residual stress values are dictated by not only the initial mechanical noise in the system but also correlations that develop at later times. In this work we study residual stresses in both thermal and athermal systems and in steady state flow as well as in transient flow state, where flow inhomogeneities are observed. We have tried to understand the effects of thermal (controlled by applied temperature) and mechanical noise (controlled by applied shear rate and strain) on the residual stress state by tuning the magnitude of both noises.



Unconventional Spin-Orbit Mott Insulating States of 4d/5d TMOs with Perovskite structures

A. A. Abraham

Indian Institute of Technology Palakkad

e-mail: *222004001@smail.iitpkd.ac.in*

'Spin orbit Interaction' (SOI) is a key factor that alters the electronic properties of materials which possess elements with large atomic numbers. The interplay among large crystal field splitting, strong SOI and a weak on-site electron- electron Coulomb repulsion results in the formation of unconventional Spin - Orbit Mott Insulating States in 4d/5d Transition Metal Oxides (TMOs) with perovskite structures rather than the much expected metallic behaviour in these materials. Detailed investigations on the unexplored 4d/5d TMOs with perovskite structures may result in the discovery of various other exotic quantum phases of matter.

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Origin of Carbon in the Early Galaxy and Carbon Enhanced Metal Poor Stars

Jeena S K, Projjwal Banerjee
Indian Institute of Technology Palakkad
e-mail: *222004002@smail.iitpkd.ac.in*

Very metal-poor (VMP) stars that have factor of $\lesssim$100 less Fe relative to the Sun are thought to be the fossil records of the nucleosynthesis of the earliest generation of massive stars that were present on the early Galaxy. A large fraction of VMP stars are found to be enhanced in C relative to Fe and are referred to as carbon enhanced metal-poor (CEMP) stars. A subclass of CEMP stars that have low abundance of heavy elements called CEMP-no stars are thought to be produced from ISM polluted by the very first generation of (PopIII) stars. However, the high values of C measured in some of the CEMP-no stars are difficult to match with existing models of massive Pop III stars particularly when reasonable levels of dilution is taken into account. We find that rapidly rotating stars can produce high levels of C in the wind which can account for the high levels of C enhancement seen in some of the CEMP-no stars. We find that the C yields depend on the parameters such as mass of the progenitor, rotation rate, as well as the mass loss prescription.

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Electrical manipulation of non-collinear antiferromagnet.

Reshna Elsa Philip
Indian Institute of Technology Palakkad
e-mail: *222004005@smail.iitpkd.ac.in*

Antiferromagnetic materials can complement ferromagnetic (FM) components in spintronic devices with improved properties due to their enhanced stability against the perturbation via external magnetic fields. Non-collinear antiferromagnets, possessing non-collinear spin configurations due to geometrical frustrations, compose an important class of antiferromagnets. Despite their vanishingly small net magnetization, in the order of a few milli–Tesla, these material systems exhibit a large anomalous Hall effect (AHE) due to a non-vanishing Berry curvature. Spin transfer torque switching of magnetization has been observed in different ferromagnetic systems, which is the rotation of magnetization of the ferromagnetic layer by spin polarized currents. The spin–orbit torque (SOT), which emerges through relativistic effects such as the spin Hall effect and the Rashba–Edelstein effect, allows one to control not only the magnetization in ferromagnets but also the Néel vector in collinear antiferromagnets. A recent work by Takeuchi et al. has explained rotation of the chiral-spin structure (non-collinear) of Mn3Sn driven by spin–orbit torque. They have observed fluctuation in the anomalous Hall resistance caused by electric current injection above a certain threshold in heterostructures consisting of well-defined epitaxial Mn3Sn thin-film stacks. The observed fluctuation is due to SOT–driven continuous rotation of the chiral-spin structure. The study offers a family of materials for electrical manipulation of collective spin structures in spintronics research. The observed behaviour of materials gives hope for new-concept spintronics devices with unconventional functionalities and low-power consumption.

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Water Vapour Triggered Actuation of Chitosan Free Standing Film

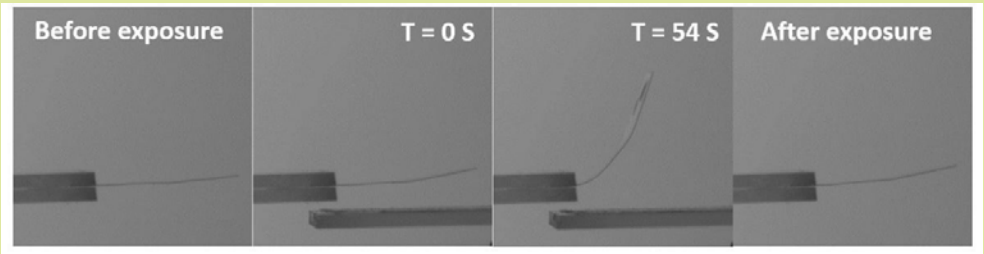
Aathira Murali[1], P. B. Sunil Kumar[1],. Dillip K. Satapathy[2]

Indian Institute of Technology Palakkad[1], Indian Institute of Technology Madras[2]

e-mail: *221704001@smail.iitpkd.ac.in*

Our topic of interest: "Stimuli-responsive materials," is gaining much research attention in recent years. It is a rapidly growing field with many applications, such as soft grippers1 and soft robots2, and our present study focuses on the actuation of chitosan in response to water vapour. We have successfully tuned the fabrication process for making homogeneous free-standing films of chitosan with the ability to exhibit fully reversible and repeatable actuation cycles. Figure 1 represents the snapshots showing the actuation pathway of a chitosan film at different stages of actuation. Our materials of choice have the added advantage of being biodegradable, renewable, and sustainable biopolymers. Our choice of stimuli is also very environmentally friendly as well as widespread in nature. Even a small amount of water vapour as a trigger is enough to manifest a large macroscopic response. The actuation characteristics of chitosan film with varying crosslinking ratios will also be discussed. The underlying mechanism for stimuli responsiveness is known to be differential strain resulting from the anisotropic volume change generated in the material3. Hence a microscopic analysis of swelling-deswelling characteristics of chitosan using a spectroscopic ellipsometer was also carried out and will be discussed.

Figure 1. Snapshots showing the actuation pathway of a chitosan film.



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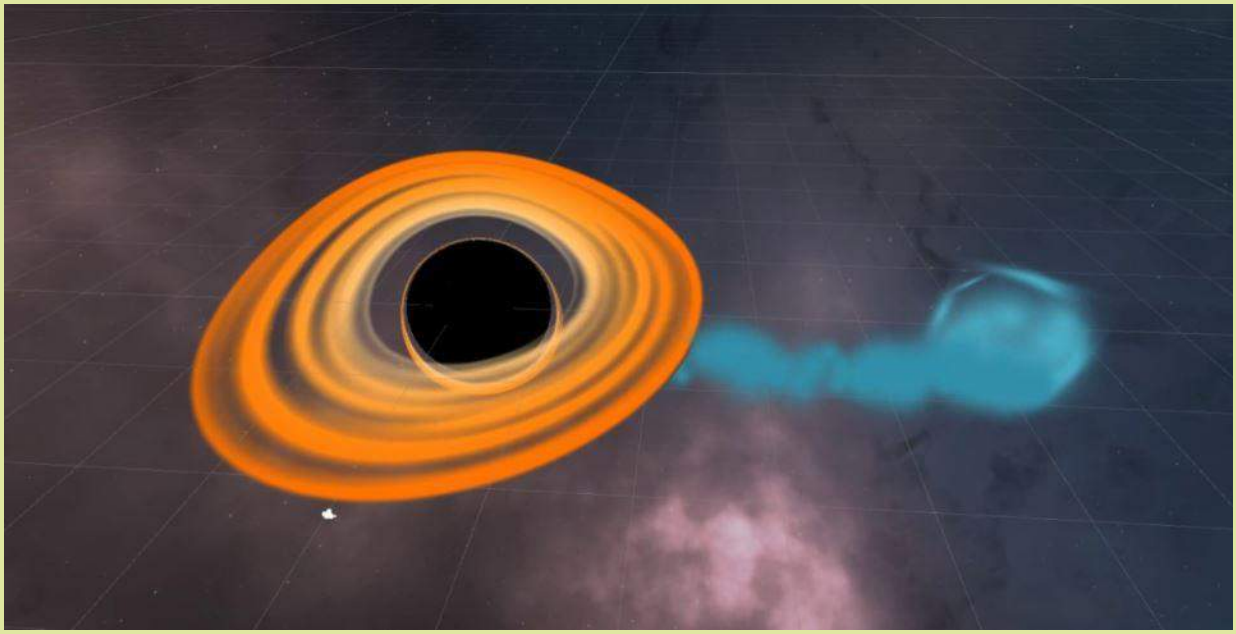
On the Evolution of Mass Transfer in a Black Hole-Companion Star system

P. Dewangan, et. al.

Society for Space Education, Research and Development (SSERD)

e-mail: *parmeshwardewangon@gmail.com*

In this paper, we analyze black hole-companion star systems and the evolution of mass transfer. We consider four types of mass flow phenomena: stellar winds, Roche lobe overflow, accretion disk outflows, and astrophysical (nonmagnetic and nonrelativistic) jets. Through this analysis we define a "Ghost Mass" parameter, describing the mass that is lost in the transfer from the star to the black hole. Further, we analyze the evolution of the mass gained by the black hole. A corresponding model has been created to substantiate the analytical computation. We then compare it with existing systems to test the feasibility of the model in an accuracy fit analysis method. Through this analysis, we have obtained ghost mass values of three systems, Cygnus X-1, LMCX-3, and GROJ1655-40, which are $2.6\times10-6M/year$, $2.0192\times10-7M/year$, and $3.935\times10-8M/year$ respectively.



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Poster No: 47

4th Research Scholar's Day, November 6th, 2021

Kicked Rotor – Standard Map

Manju C
Department of Physics, IIT Palakkad
e-mail: *222004003@smail.iitpkd.ac.in*

The kicked rotor is one of the examples of a non integrable Hamiltonian which can exhibit regular and chaotic behaviour and a prototype model for Quantum chaos studies. It describes a particle that is constrained to move on a ring and is periodically kicked. The phase space is monitored only at times separated by a period of forcing, which gives a discrete set of points and the dynamics is specified by where any point maps into after one time period of forcing-Stroboscopic map. Then the equations of motion of this Hamiltonian system can be reduced to a simple two dimensional area preserving discrete map in phase space called the Standard map or Chirikov Taylor map.The dynamics of the map changes for different kicking strengths. Quantum maps similar to the Classical maps do provide a more easier numerical approach and are often in a finite dimensional Hilbert space. Iterating the classical map is equivalently done in Quantum maps using the repeated multiplication by the Unitary operator. The Quantum map corresponding to the kicked rotor can be derived using the Unitary operator. To draw a comparison between the Classical and Quantum dynamics in phase space, for the Quantum case we make use of Husimi or coherent state representation that tells how a state is spread in phase space. The remarkable Classical-Quantum correspondence can be drawn from the corresponding phase space structures.

Figure:

Fig 1: Classical map for K=2

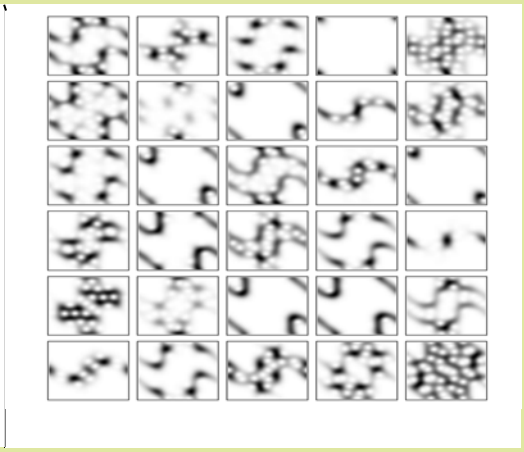

Fig 2:Quantum Standard map Eigenfunctions for N=50

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Optical Identification of Graphene Layers

N. J. Joy, J. Balakrishnan
Department of Physics, IIT Palakkad
e-mail: *222004004@smail.iitpkd.ac.in*

Optical microscopy images can be used to determine the number of layers of a graphene sample. The technique relies on the variation of optical contrast of the sample with the number of layers. However, determining contrast can be ambiguous due to slight variations in uniform looking regions of the image. Here we propose a simple processing sequence using a clustering algorithm (k-means) for image segmentation that can eliminate this difficulty.

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Tumbling dynamics of an active filament in simple shear flow

Siji S. Saju[1], Raj Kumar Manna[2], P. B. Sunil Kuma[1]

Indian Institute of Technology Palakkad [1], University of Pittsburgh, Pennsylvania [2]

e-mail: *221704005@smail.iitpkd.ac.in*

Active filaments in fluid flow are ubiquitous in biophysical systems and understanding their dynamics is important for many biological phenomena such as cell division, cell migration etc. Due to the coupled interaction between filament activity and filament conformation due to flow, the dynamics of active filaments under external flow are distinctly different from that of 'passive' filaments. Here, using the Langevin equation, we study the dynamics of an active filament in simple shear flow. The active filament is modeled as a chain of extensile active beads connected by potentials that enforce inextensibility, semi-flexibility, and self-avoidance. Motivated by earlier studies on the motion of extensile active filament [1,2], we take the activity of each bead as a force proportional to the local curvature of the filament. The competition between filament activity and imposed shear flow results in non-equilibrium tumbling motion of the filament. We explore the effect of activity, flexibility of the filament, and shear rate on the tumbling time of the filament. We observed that below a critical shear rate, activity promotes the tumbling motion, and thus tumbling time is lower than that of a passive filament. In contrast, above the critical shear rate, the tumbling motion of the active filament is suppressed by filament activity. Therefore, the tumbling time of an active filament shows two power-law dependences on the shear rate, contrary to a single power-law regime for a passive filament. Our results can be useful for a better understanding of the rheology of soft active materials.

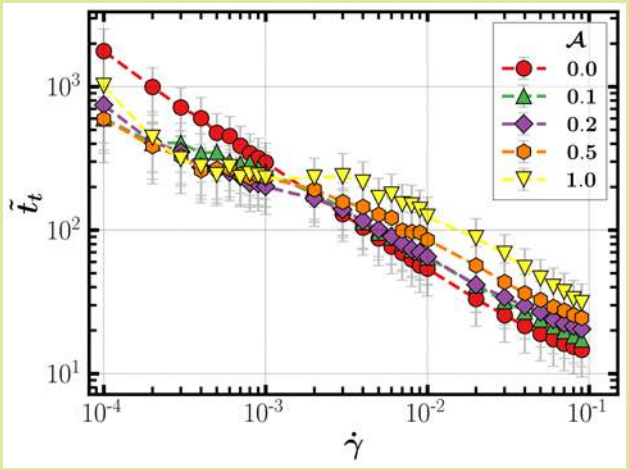

Figure 1: Time between two tumbles as a function of the shear rate (in units of inverse of time) for different activity. 'A' quantifies the activity of the polymer, in units of the Lennard Jones energy, which multiplied by the curvature of the polymer at any point is the active force at that location.

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SYK Models in the double scaling limit

Swathi T S, Prithvi Narayan
Indian Institute of Technology Palakkad
e-mail: *222004008@smail.iitpkd.ac.in*

SYK model is a quantum mechanical model of N fermions with random interactions among fermions, proposed by Sachdev, Ye and Kitaev. It is exactly solvable at strong coupling and large N and is also expected to have an equivalent description in terms of gravity. In this work we look at versions of SYK model in the double scaling limit where the number of fermions involved in the interaction is taken to be proportional to √N. In this limit such models are solved using combinatorial tools and the quantities such as partition function and correlation functions are related to sums over chord diagrams. The appropriate chord diagram prescription for each version of SYK model differs from the other. In the present work we try to unify these combinatorial techniques for such models with a view towards generalizing to other versions of SYK models with extra symmetries or different types of fermions. We illustrate our techniques for one variant of SYK model.

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