

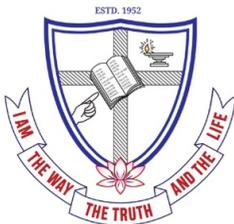
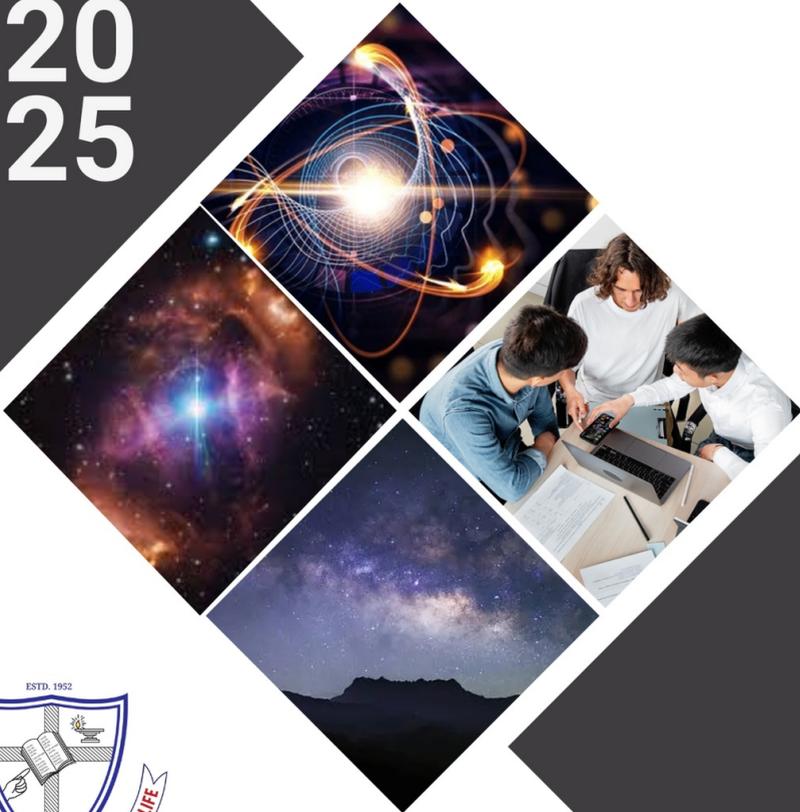
DEPARTMENT OF PHYSICS
MAR THOMA COLLEGE, TIRUVALLA



Knowledge Snippets

Honouring Vineeth's Passion for Discovery
Through the Lens of Physics Research

20
25



Tribute



Vineeth S. joined the Department of Physics, Mar Thoma College Tiruvalla in 2014 as an M. Sc. Student. Later in 2018 November for Ph. D. He worked on non linear waves in dusty plasma environments and received DST Inspire Fellowship. During his research period he published two papers in peer reviewed journals and two book chapters. He also presented his work in several national / international conferences. He submitted the Ph. D. thesis in November 2024 and was expecting defense and public viva-voce soon. On 17th February 2025, he yielded to a long standing illness of the heart.

Vineeth will be remembered for his endurance, determination and strong aptitude towards research. His strengths were in theoretical formulations and numerical methods. He was an expert in the Python language.

Vineeth S, is awarded Ph. D. posthumously for his thesis titled “Non-linear Waves in Dusty Plasma Environments” submitted under the supervision of Dr. Noble P. Abraham, Department of Physics, Mar Thoma College, Tiruvalla by the Mahatma Gandhi University, Kerala in May 2025. The award is based on the evaluation reports by three adjudicators of the thesis.

Publications

- *Physics of Plasmas*, Volume 28, 033701, March 2021
- *Physics Open*, Volume 17, 100163, December 2023

About This Booklet

This booklet is a curated collection of abstracts of the research work or internship undertaken by research scholars and postgraduate students of the Department of Physics, Mar Thoma College, Tiruvalla, during the academic year 2024–25. This also includes abstracts of project work carried out by KSHEC Aspire Research Awardees under the supervision of faculty of the department.

Each abstract provides a brief yet comprehensive overview of individual projects carried out in various institutions and organisations, reflecting diverse research interests and capabilities of our students. These summaries offer valuable insights for readers, enabling a quick grasp of the scope, methodology, and outcomes of each study.

This compilation is envisioned as a resource not only for current students and faculty but also for the wider academic community. It serves as a platform to inspire further research, foster academic collaboration, and showcase the evolving research culture within the department.

We hope this helps in shaping the academic and professional trajectories of students, opening up new possibilities and pathways in the field of science and technology.

As we celebrate the 25th anniversary of establishing the research centre in the department, we dedicate "*Knowledge Snippets*" in memory of Vineeth S., who left us untimely after his Ph. D. work.

Dr. Angel Susan Cherian

Head of the Department

Dr. Noble P. Abraham

Mentor, M. Sc. Physics (2023- 25)

Ph. D Awarded

Association of climatic changes with solar activity

Elizabeth Thomas

Energy from the Sun is the prime driver of Earth's climate system. Variations in the intensity of solar radiation hitting the Earth may produce changes in the global and regional climate, which are often different from those from anthropogenic sources. Understanding the sun-climate connections, on all time scales, is of utmost importance. Magnetic activity in the Sun's interior gives rise to many non-stationary processes, commonly known as solar activity. Precipitation and temperature are two climatic parameters that are affected by solar variations.

In recent years, different parts of India, including Kerala have been witnessing severe extreme rainfall events resulting in excessive floods leading to loss of lives and property. The inclusion of solar activity in the climate/rainfall variations and studying sun-climate relationships would lead to better weather predictions in advance, saving the land from natural disasters. In this thesis, the possible association of solar activity with the rainfall over India, Kerala in particular, is studied.

Publications

- *Journal of Atmospheric and Solar-Terrestrial Physics*, 2022, 240, 105943.
- *New Astronomy*, 2023, 98, 101944.

Broad Area : Solar Terrestrial Physics

Supervisor : Dr. Noble P. Abraham

Dissertation Project

Temporal Behaviour of Single-Peaked H α Emission in Classical Be Stars

Anagha P V*

Dr. Blesson Mathew

Associate Professor, Department of Physics & Electronics, School of
Sciences, Christ University, Bengaluru

Abstract

Classical Be stars are rapidly rotating B-type stars that exhibit prominent Balmer emission lines, particularly H α , arising from a circumstellar decretion disk. This study focuses on the temporal behaviour of single-peaked H α emission profiles observed in a selected sample of five classical Be stars over the period 2005 - 2025. Using multi-epoch spectroscopic data obtained from the BeSS database, the variation in line parameters were analysed over different observation dates. The time period chosen effectively captures both short- and long-term spectral variations, contributing to a deeper understanding of the behaviour and emission changes in the circumstellar disks of Be stars.

Broad Area : Astrophysics

Internal Guide : Dr. Noble P. Abraham

Dissertation Project

Synthesis & Characterisation of Hard Carbon at different Pyrolysis Temperature & Condition

Aswathi Prasad*

Dr. Christie Thomas Cherian

Assistant Professor, Kerala University of Digital Sciences, Innovation and Technology (DUK), Trivandrum.

Abstract

This project focuses on the synthesis and characterisation of hard carbon derived from lignin at different pyrolysis temperatures (1000 °C and 1300 °C) using both direct and pre-oxidation-based methods. The resulting materials were analysed using Raman spectroscopy, X-ray diffraction (XRD), and BET surface area analysis. Raman results confirmed structural differences, with ID/IG ratios indicating varying degrees of disorder. XRD patterns revealed amorphous/ turbostratic structures suitable for sodium-ion storage. [Amorphous carbon, like hard carbon, does not have a well-ordered crystal lattice, but it still has short-range atomic arrangements. These small, disordered graphene-like regions cause broad, weak peaks in the XRD pattern]. BET analysis showed increased surface area and porosity in post-pyrolyzed samples (e.g., LHC-13P), enhancing accessibility. The result highlight the potential of lignin-derived hard carbon as a sustainable and effective anode material for sodium-ion batteries.

Broad Area : Material Science

Internal Guide : Dr. Angel Susan Cherian

Effect of Annealing and Doping in ZnS Thin Films

Betty Elsa Joseph* and Swathy Satheesh#

Dr. Angel Susan Cherian

Assistant Professor & HOD, Department of Physics , Mar Thoma
College, Tiruvalla

Abstract

The Zinc Sulphide (ZnS) thin films and Mg doped ZnS thin films were coated on glass substrates using chemical bath deposition (CBD) technique. The optimisation of zinc to sulphur ratio and bath temperature has been done by varying the molarities of precursors. The annealing of thin films has been done at different temperatures and Magnesium doping was done on the optimised ZnS thin film. The characterisation of the film was done by X-ray diffraction (XRD) method and UV-VIS Spectroscopy. The better crystallinity was obtained for thin films annealed at 100^oC. The magnesium doped samples were annealed at 100^oC. From structural studies, magnesium doped samples are seen to be amorphous and from optical studies, it is observed that band gap of ZnS thinfilms has decreased from 4.06eV to 3.74eV. This may be due to the grain growth and defect state formation on increasing the dopant concentration. The ZnS thin films are used in optoelectronics applications like sensors, solar cells etc and tuning of fundamental absorption can be done by Mg doping.

Broad Area : Material Science

Dissertation Project

Advances in Hydrothermal Synthesis of Boron Nitride Quantum Dots and their Non-linear Optical Behaviour

Kripa A K*

Prof. Dr. Vinoy Thomas
Professor, Department of Physics, Christian College, Chengannur

Abstract

Boron nitride quantum dots (BNQDs) are an innovative nanomaterial that blends the intrinsic properties of boron nitride with quantum mechanical characteristics unique to quantum dots. These exhibit high thermal stability, chemical inertness, mechanical strength, and biocompatibility, attributed to their boron nitride core and strong B-N bonds. Quantum confinement effects in BNQDs lead to discrete electronic states and an increased bandgap, resulting in size-tunable photoluminescence and enhanced nonlinear optical properties. They are crucial in optoelectronics for their tunable optical properties and efficient photoluminescence. The nonlinear optical properties of BNQDs, such as reverse saturable absorption and two photon absorption, make them suitable for frequency conversion, optical modulation, and advanced photonic devices. BNQDs' versatile and robust nature underscores their importance across various scientific and technological fields, with ongoing research expected to unlock new functionalities and applications. This study demonstrates the hydrothermal synthesis of BNQDs using boric acid and urea as precursors and investigates the non-linear optical properties of the prepared sample.

Broad Area : Nanotechnology

Internal Guide : Dr. I John Berlin

Dissertation Project

Comparative Study of Protoplanetary Disks in Stars Forming Regions

M Krishnagadha* and R Yadu*

Dr. Blesson Mathew

Associate Professor, Department of Physics & Electronics, School of Sciences, Christ University, Bengaluru

Abstract

For centuries, the geocentric view of our universe was believed, until astronomers like Copernicus and Galileo proved that it was actually heliocentric. This led to rapid increase in the scientific researches regarding our universe. With advanced telescopes like ALMA, HST, JWST and space missions, we have begun to uncover some of the greatest mysteries of the cosmos. One key step in understanding all these is the discovery of protoplanetary disks or PROPLYDS- the rotating disks of dust and gas around young stars. These are the building blocks of our planets and understanding them deeply would help us to understand more about the planet formation, the environment factors leading to them. The aim of this research is to study about the proplyds in different star forming regions like Orion, Taurus, lupus, etc. including their characteristic parameters like disk size, cavities luminosity etc. and compare them to have a better understanding of the disks. The study reveals that disks in high-radiation zones tend to be smaller and more eroded, while those in quieter regions remain larger and more intact, making calm regions like Taurus-Auriga and Lupus most favorable for planet formation.

Broad Area : Astrophysics

Internal Guide : Dr. Noble P. Abraham

Dissertation Project

Design and Performance Verification of an Analog Readout for a Two-wire RTD Sensor

Revathy Renjan*

Dr. Elangovan K.

Associate Professor, Kerala University of Digital Sciences, Innovation and Technology (DUK), Trivandrum.

Abstract

Accurate temperature measurement is vital in applications ranging from industrial automation to biomedical diagnostics. This work presents the design, simulation, and experimental validation of a cost-effective analogue readout circuit for a two-wire Resistance Temperature Detector (RTD). The proposed system uses analogue switches (CD4052B, CD4053B) and precision op-amps (OP07) to implement a four-stage, bidirectional excitation strategy with dual reference voltages (2.5 V and 1.25 V). This approach effectively cancels parasitic lead resistance and diode voltage drops, common challenges in two-wire RTD configurations.

LTspice simulations modelled switching dynamics and signal behaviour across an emulated RTD resistance range ($60\ \Omega$ to $390\ \Omega$), with performance assessed via relative error ($\sim 0.0065\%$) and nonlinearity ($\sim 0.00718\%$). A hardware prototype was built on a solderless breadboard and tested using an NI ELVIS board, resistance decade box, and external function generator. Experimental validation confirmed low relative error ($\sim 0.335\%$) and acceptable non-linearity ($\sim 2.42\%$), with output remaining immune to additional lead resistances up to $10\ \Omega$.

The design proved robust and reliable in both simulation and real-world conditions, offering high measurement accuracy and strong linearity without complex compensation techniques. Although practical limitations such as breadboard parasitic and supply ripple introduced minor deviations, the system's performance demonstrates its viability as a compact, low-cost, and effective solution for analogue RTD temperature sensing.

Broad Area : Electronics

Internal Guide : Dr. Angel Susan Cherian

Dissertation Project

Double Peaked Emission Profile Variability in Classical Be Stars: A Multi-Epoch Perspective

Shamna V.*

Dr. Blesson Mathew

Associate Professor, Department of Physics & Electronics, School of Sciences, Christ University, Bengaluru

Abstract

Classical Be stars are stars that exhibit one or more emission lines in their spectra. They are surrounded by a circumstellar decretion disk formed by mass ejection from the central star, which rotates at or near its critical velocity. Changes in the disk's dynamics and structure cause these emission properties to vary over time. In the present study involves the multi-epoch spectral variability of double-peaked emission profiles in five Classical Be stars over the period 2012 -2020. The chosen time period offers sufficient coverage of both short- and long-term spectrum variations, which advances our knowledge of the behaviour and emission variability of Be stars in the circumstellar disk.

Broad Area : Astrophysics

Internal Guide : Dr. Noble P. Abraham

Research Internship

A Case Study on Pre-monsoon Thunderstorms using Doppler Weather Radar and Meteorological Parameters

M Krishnagadha*

Dr. Vigin Lal F

Scientist -D, India Meteorological Department (IMD), Kochi

Abstract

Pre-monsoon thunderstorms are a significant convective weather phenomenon occurring in parts of India, particularly over eastern and northeastern regions, during the transitional period between March and May. These storms are often intense, short-lived, and capable of producing strong winds, heavy rainfall, lightning, and even hail. In the context of increasing weather variability driven by climate change, understanding the behavior and structure of these thunderstorms has become more important than ever. Doppler Weather Radar plays a vital role in modern weather surveillance by providing real-time, high-resolution data on reflectivity, radial velocity, and storm height. Parameters such as Maximum Reflectivity (MAXZ), Height of Maximum Wind Velocity (HWV), and Plan Position Indicator Velocity (PPIV) offer insights into storm dynamics, wind shear, and vertical development. These parameters help reveal how intense the storm is, how high strong winds reach within the storm, and the wind flow patterns detected by the radar. By analyzing variations in these parameters during thunderstorm events, this work aims to gain deeper insights into storm intensity, wind structure, and potential severity. Through this case study, the project highlights how Doppler radar can serve as a powerful tool in tracking and understanding convective systems. With rising concerns over weather unpredictability due to climate change, improving our knowledge of pre-monsoon thunderstorm behavior, it is a step forward in early warning, disaster management, and overall preparedness.

Broad Area : Meteorology

Research Internship carried out during April - May 2025

* M. Sc. Physics (2023-25)

Design Analysis of Underwater Transducer

Joel S. Philip* and Riya Parvin C.S.*

I R Abisekaraj

Scientist – F, Naval Science & Technology Laboratory, Defence Research & Development Organisation, Visakhapatnam

Abstract

In underwater domain, acoustic waves are the only mean for long range detection and communication. In every underwater system, the wet end is the electroacoustic transducers which convert the electric signal into acoustic during transmission and the reverse during reception. The underlying principle for this is the well-known piezoelectric effect. In the modern-day transducers, piezoceramic material of different compositions are used for sensing.

Piezoceramic materials are used in different sizes and shapes as per requirements. One of the famous configurations is a “Tonpilz” transducer in which the active piezoceramic stack is sandwiched between two masses.

In the present study, design analysis for a tonpilz transducer with resonance frequency of 26 kHz and 36 kHz were attempted. It starts with material selection, analytical calculation, 3D Modeling and analysis using COMSOL Multiphysics FEM software. The performance of this transducer was studied over a frequency band. We designed tonpilz transducer having only one resonance frequency. But after the simulation, the TVR graph of both design have two peaks, the first one is corresponding to longitudinal frequency and other corresponding to flexural frequency. Flexural frequency is due to the flexing of the head mass. Both the frequencies can be used in times of needs.

Broad Area : Underwater Transducer

Research Internship carried out during April - May 2025

Research Award (Aspire)

Electrochemical Studies of Europium Doped Graphene Oxide Nanocomposites

Issac Johnson*

Dr. Dhanya I.
Assistant Professor & HOD, Department of Physics, Catholicate College, Pathanamthitta

Abstract

Electrochemical analysis of Europium doped graphene oxide nano composites gives much attention in organic electronic industries . Apart from inorganic materials two-dimensional graphene-based materials shows interesting properties in its electrical conductivity and impedance-based properties. Graphene and their composites are one of the prime components for the storage devices and supercapacitance properties.

Dielectric studies are carried out for all the samples. Improved super capacitance is observed for Europium doped graphene oxide apart from pure graphene oxide. Supercapacitor properties like specific capacitance, variation in power density and long-term stability performance are studied and analyzed from CV analysis, GCD analysis and EIS analysis. Double layer capacitance is also observed for Europium doped graphene oxide from the Bode magnitude and phase plot analysis. Further, specific capacitance and overall efficiency of the samples is found to be stable with the repeated cycles and show improvements with the addition of Europium.

Broad Area : Nanoscience

Hosted by : Dr. Angel Susan Cherian

Research Award (Aspire)

Zirconium Doped Graphene Oxide Nanocomposites for Supercapacitor Applications

P S Jayalakshmi*

Dr. Dhanya I.

Assistant Professor & HOD, Department of Physics, Catholicate
College, Pathanamthitta

Abstract

Graphene and their composites are one of the prime components in organic electronics due to the extensive photonic application and improved supercapacitance performances. Graphene oxide is prepared by modified Hammers method. Resultant residue of dark yellow colour is filtered. Unexfoliated oxide is eliminated from the sample by ultra-sonication procedure for 30 minutes followed by micro-centrifugation under 4000rpm for another 30 minutes. Vacuum annealing is done at sample at 160°C for 12 hours to get black graphene oxide powder. Zirconium oxide (Zirconia, Zr) added to graphene oxide sediments after exfoliation and vacuum annealing is done for 200°C 48 hours under high pressure of 1200 MPa. For the preparation of 1g doped sample Zr is taken as fixed quantity (Y=50, 100 and 150mg) with the quantity of GO as (100-Y). $Ce_YGO_{(100-Y)}$.

Graphene and its oxide are known for super capacitance behavior. Dielectric studies are carried out for all the samples. Improved dielectric behavior is seen for pure GO while the conductivity increases and it maintained for a prolonged time for doped samples. Electrochemical behavior of the samples is studied and analyzed from CV analysis, GCD analysis and EIS analysis. DC electrical conductivity studies shows that the doping level concentration increases the conductivity in Graphene oxide and temperature assisted conductivity increases like that of conductors. Hence Zirconium doping in Graphene oxide can increase the migration of charges through it. Hence the samples are apt materials for low-cost electrode materials in supercapacitors.

Broad Area : Nanoscience

Hosted by : Dr. Noble P. Abraham

Research Award (Aspire)

Fabrication of Supercapacitor using Cerium Doped Graphene Oxide Nanocomposites

Lekshmy Priya*

Dr. Dhanya I.

Assistant Professor & HOD, Department of Physics, Catholicate College, Pathanamthitta

Abstract

Graphene oxide (GO) is a promising organic two-dimensional material which is made by the powerful oxidation of graphite, which is cheap and abundant. It is a unique material that can be viewed as a single monomolecular layer of graphite, made of carbon atoms that are bonded together in a repeating pattern of hexagons with various oxygen-containing functionalities such as epoxide, carbonyl, carboxyl and hydroxyl groups.

In this work, Graphene oxide (GO) is prepared from graphite powder using Modified Hummer's Method. Rare earth material such as Cerium oxide is added in controlled concentration to study the effect in detail. Graphene and its oxide are known for super capacitance behavior. Dielectric studies are carried out for all the samples. Improved dielectric behavior is seen for pure GO while the conductivity increases and it maintained for a prolonged time for doped samples. Electrochemical behavior of the samples is studied and analyzed from CV analysis. Hence Ceria doping in Graphene oxide can increase the migration of charges through it. Hence the samples are apt materials for low-cost electrode preparation in supercapacitors.

Broad Area : Nanoscience

Hosted by : Dr. Angel Susan Cherian

