# Study of Low Frequency Surface Wave Attenuation Using Acoustic Metamaterials

Submitted by

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APRIL 2024

In Partial Fulfillment of the Requirements

for the Degree of

MASTER OF SCIENCE IN PHYSICS

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# CERTIFICATE

This is to certify that the project report entitled "Study of Low Frequency Surface Wave Attenuation Using Acoustic Metamaterials" is a bona fide record of the work carried out by Abhijith C Preej (Reg No. CCAWMPH016) under my supervision in the Department of Physics, Christ College (Autonomous) Irinjalakuda, in partial fulfilment of the requirement for the award of degree of Master of Science in Physics of Calicut University.

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# DECLARATION

I, Abhijith C Preej, hereby declare that the work presented in this report entitled, "Study of Low Frequency Surface Wave Attenuation Using Acoustic Metamaterials" is based on the original work done by me under the guidance of Prof. Joseph V P, Professor, Department of Physics, Christ College (Autonomous), Irinjalakuda and has not included in any other thesis submitted previously for the award of any other degree

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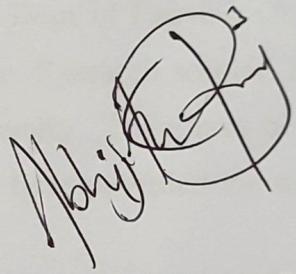

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This thesis stands as a testament to the support and guidance of numerous individuals without whom this achievement wouldn't have been possible. I extend my heartfelt appreciation to Prof. Joseph V P for their invaluable mentor-ship, insightful feedback, and unwavering support throughout this research journey.

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Special thanks to Mrs. Simmy Jose, Mrs. Anju Sebastian, Mrs Anjali Joby and Mrs. Aswathi P. V., Assistant Professor, Dept of Physics, Christ College (Autonomous), Irinjalakuda and Pranav George, Research scholar, School of Pure and Applied Physics, Mahatma Gandhi University. They have been really helpful in various phases of project completion and have provided me with great suggestions and advice whenever needed.

I am extremely grateful to Dr. Muhammad, Lecturer/Assistant Professor, University of Galway, Ireland, for extending their valuable time and effort to help make this project into a fruitful one.

Lastly, my sincere thanks to the participants and individuals who generously contributed their time and expertise, forming the bedrock of this study. Your collective support has been the cornerstone of this thesis.

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# ABSTRACT

Metamaterials are artificially fabricated materials in nano-scale or micro-scale that have unusual electromagnetic properties, that are not found in nature, extending from electromagnetic to acoustic. The emergence of seismic metamaterials becomes of paramount interest as we consider the potential of protection and safety this can offer in the field of civil engineering and seismology.

This master's project investigates the design of structures to create low-frequency bandgaps on soil substrates for vibration and noise control. Through analyzing various structural samples, key insights are gained into bandgap formation highlighting the potential of structurally complex shapes for practical applications. Depth within the soil significantly influences bandgap characteristics, while optimizing the structure-soil interaction is crucial for effective low-frequency bandgap formation as the material properties of the soil substrate is shifted with further penetration of the structure into the soil.

This project dissertation is divided into five chapters. The first chapter is a short introduction to metamaterials, and acoustic metamaterials. A concise introduction to the origin of negative parameters in acoustic metamaterials is done in the second chapter. The third chapter deals with the theoretical aspects of seismic metamaterials which include local resonance properties as well as dispersion relation, and methods of numerical simulations and parameters for each sample tested is included. Fourth chapter contains the simulation data, resonant bandstructures, results and discussions. Finally, the fifth chapter contains the conclusions derived.

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# Chapter 1

# Introduction

Metamaterials, in general, are a class of artificial materials engineered to exhibit properties not found in naturally occurring substances. They are constructed from periodic arrangements of *sub-wavelength* unit cells (generally smaller than a third of the wavelength), allowing for precise control over wave propagation. This structured periodicity enables metamaterials to interact with waves in extraordinary ways, leading to extraordinary phenomena such as negative refraction, super-lensing, and cloaking across various wave domains. Metamaterials, crafted at a microscopic scale with unique properties, have revolutionized material science, and in acoustics, metamaterials leverage these properties to control sound wave behavior. Specifically designed structures allow us to manipulate wave paths and characteristics, enabling effects like negative refraction and wave steering for sound waves.

Acoustic metamaterials find application in diverse fields, from noise reduction to advanced imaging and signal processing. Their engineered properties pave the way for innovations in ultrasound, architectural acoustics, and the development of devices for precise sound control. The domain of acoustic metamaterials is continually advancing, promising remarkable possibilities in altering sound wave

# SYNTHESIS AND CHARACTERISATION OF COPPER FERRITE NANOPARTICLES AND ITS PHOTOCATALYSIS AND ANTIBACTERIAL STUDIES


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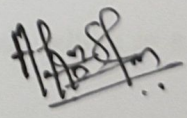
# ACKNOWLEDGEMENT

I admire God almighty with deepest gratitude, who had guided me throughout my journey. I would like to express my immense gratitude to my research guide Dr Santhi A , Assistant professor, Department of Physics, St. Terasa's college (Autonomous), Ernakulam for her guidance and great support. I am indebted to Dr. Minu Pius, Assistant professor, Department of Physics, St. Terasa's college (Autonomous),Ernakulam , and Merin, Research scholar, St. Terasa's college (Autonomous), Ernakulam who helped me for completing my project.

Special thanks to Teresian Instrumentation and Consultancy Centre (TICC), St. Terasa's college (Autonomous),Sophisticated Test and Instrumentation Centre,(CUSAT) and St.Thomas College(Autonomous), Thrissur.

I am grateful to my team mates, teachers specially Prof.Dr V P Joseph, Professor, Christ College(Autonomous), Irinjalakuda and Ms. Anju Sebastian Professor, Christ College(Autonomous), Irinjalakuda and my friends and family for their great support.Finally, I would like to express my esteemed thanks to everyone who helped me directly and indirectly to complete my project.



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# ABSTRACT

One of the biggest problems facing the globe today is the demand for clean water. The main cause of water contamination is human activity.Numerous industrial sectors discharge different types of effluents such as dyes and other heavy metal ions, into aquatic systems. Even at very low concentrations, these dyes have been shown to be toxic substance that pose a risk to the environment and living things. This could eventually result in an entirely out-of-balance ecological system.

The elimination of dangerous organic pollutants resulting from human activity has grown in significance for the creation of environmentally friendly water treatment methods and techniques. Different wastewater treatments exist. Organic dyes make up more than 50% of water pollution. These days, photocatalytic degradation is the most popular method. It is thought to be a cheap, easy, safe, effective, and nontoxic way to guarantee that all pollutants are fully mineralized while also producing less hazardous and environmentally friendly inorganic compounds like carbon dioxide and water.

One of the heterogeneous semiconductor photocatalyst $CuFe_2O_4$ nanoparticles which possess electrical and chemical properties,catalytic activity are considered to be efficient.In this work, I have studied the photocatalytic dye degradation of Methylene Blue . A hydrothermal method was adopted for the synthesis of $CuFe_2O_4$ nanoparticles. Structural analysis were done using XRD. The optical analysis was done by Diffussion Reflectance Spectrosopy(DRS) and Photo Luminescense studies. My project aims to purify water on large scale which is a tiny step toward the welfare of civilization.

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# Chapter 1

## *INTRODUCTION*

## 1.1 WATER POLLUTION

Water is the universal solvent of life and a necessary component for all living things to survive and thrive. Its importance transcends from simple hydration to include vital functions in industrial operations, agricultural production, ecological balance and human health. Serving as the cornerstone of various ecosystems, its scarcity in certain regions emphasizes how valuable it is and the need for the prudent preservation and equitable distribution[1].

Water contamination arises from multitude of sources which includes incorrect waste disposal, urban sewage, plastic, agricultural runoff, industrial discharge. These pollutants which include chemicals, heavy metals, synthetic dyes, pathogens and nutrients; damage human health, disturb ecosystem and deteriorate water quality. The open channels of rivers, canals and seas receives the tainted water, dissolves in water bodies in a way that is highly hazardous to human health. The growing problem of water pollution, mostly caused by non-degradable contaminants from industries. Synthetic dyes which are widely used in variety of industries including textile and cosmetics are among the most common pollutants , having a significant effect on water system. These dyes are easily dissolved in water, giving a vibrant color while subtly changing its chemical composition. It has negative consequences for human health including skin irritation, allergies and potentially cancer; in addition it has adverse impact on aquatic life. Their pres-

# FABRICATION AND CHARACTERISTICS STUDY OF LIGHT WEIGHT HORN ANTENNA FOR H-21 LINE RECEPTION

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# ACKNOWLEDGEMENT

I take this opportunity to express my deep sense of gratitude and to extend my thanks to all the people who have inspired and motivated me during my course and project work.

First and foremost I would thank God for being able to complete this project with success. Expressing my gratitude to my guide and Dr. V P Joseph, Professor, Dept. of Physics , Christ College (autonomous) Irinjalakuda for his valuable guidance, encouragement, timely advice, immense patience and as a constant source of inspiration for choosing the right path.I am thankful to my co-guide Mr.Jose sunny for the valuable help at every stage of my work right from the starting of the work till the completion of my project.

I am also grateful to my mentor Mrs.Anju Sebastian for her sincere guidance and I would like to thank Ms. Aswathy P.V, Assistant professor of Christ College Irinjalakuda, for the constant support.

Also i am grateful to my team mates and non-teaching staffs of the Department of Physics, Christ College Irinjalakuda, for their direct and indirect support and encouragement during the execution of my project.

I am indebted to my family for their constant source of inspiration.

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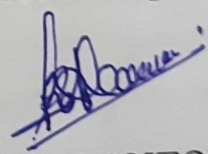

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# ABSTRACT

This study focuses on the detection of the Hydrogen 21cm line using both a standard Radio horn antenna and a light weight horn antenna constructed from lightweight mesh. The project involved several crucial steps to achieve successful detection. Initially, we designed and constructed the antennas, carefully measuring each component to ensure accuracy. Subsequently, we utilized electronic equipment such as low noise amplifiers, bandpass filters, and spectrum analyzers to enhance signal reception and eliminate noise. The antennas were strategically positioned, and observations were conducted while rotating them to various angles, with a particular focus on the East-West direction. Additionally, software tools like Stellarium aided in positioning the antennas relative to celestial objects. Despite initial challenges, including signal interference from nearby towers, we persisted, refining our techniques and utilizing specialized detection software. Eventually, breakthroughs were made, with redshifts and corrected spectrum frequencies identified. The Featherlight horn antenna demonstrated exceptional performance, particularly in mitigating interference. Our findings underscore the importance of precise antenna design and signal processing techniques in radio astronomy research. Looking forward, this study paves the way for further exploration and refinement of antenna technologies in the quest to unravel the mysteries of the universe.

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# Chapter 1

## *INTRODUCTION*

An antenna is a reason for radiating or receiving em energy.It can be considered as a transmissions device tor transducey between a guided cwave and a free space or vice versa. J.C. Bose horn antenna were highly popular in the fields of microwave application. Due to its high gain, bandwidth, good handling capability, it is widely used for astronomical research purposes also. Our galaxy Milky way is the Combination of stars, dust particles dark matter,gas and solar system. It was originated before 14 billion years. At the center of the Milky Way, their lies a supermassive black holes called Sagittarius A which has a mass equivalent to 4.1 million times the sun. Our solar system is located in one of the spiral arms (Surrounding the central bulge) known as the

Figure 1.1: Milkyway

# SYNTHESIS AND CHARACTERISATION OF CARBON QUANTUM DOTS AND THERMAL DIFFUSIVITY AND ANTI-BACTERIAL STUDIES

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I owe Dr. Minu Pius,Dr.Frincy Fransis Assistant professors in the Physics Department of St.Teresa's college and Merin Research scholar for their help and assistance in each events. I would like to express special gratitude to XRD lab of St.Thomas College Thrissur , Teresian Instrumentation and Consultancy Centre (TICC) St.Teresa's College for giving adequate equipmental support.

I am really appreciative of the support that i received from my tutors, especially Prof.V.P.Joseph, Professor Christ College( Autonomous), Anju Sebastian, Assistant Professor Christ College ( Autonomous),Irinjalakuda and my family and friends

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# ABSTRACT

Research on carbon quantum dots is interesting and is of unlimited opportunities because of its various practical applications, including biosensing, sustained conductivity and fluorescence, and reduced toxicity.

Additional investigation into its characteristics may result in significant progress across various scientific domains and enhanced utilization of carbon quantum dots. They are currently employed as photocatalysts, biosensors, and drug transporters. The goal of this research Is to synthesize, characterize, and study carbon quantum dots' thermal diffusivity and antibacterial properties. The hydrothermal approach is the most straightforward and economical way to complete the synthesis.

It Is addressed how to use characterization techniques including optical characteristics, photoluminescence bandgap, UV-visible spectroscopy, and X-ray diffraction spectroscopy.Single beam thermal lensing is used to monitor the variation of thermal diffusivity with concentration since it is an extremely sensitive method of determining the thermal diffusivity of the given sample. Since carbon quantum dots have strong antibacterial properties, an attempt has been made in this work to see how they affect bacteria like S. aureus and E. coli.

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# Chapter 1

## *INTRODUCTION*

## 1.1 BRIEF INTRODUCTION TO CARBON QUANTUM DOTS

Carbon quantum dots (CQDs) are a new class of fluorescence small carbon nano particles with a particle size of less than 10 nm and have vast applications in the field of bio imaging, bio sensing and disease detection. Because of their reduced particle sizes, superior biocompatibility, excitation wavelength-dependent photoluminescence (PL) behaviour, photo-induced electron transfer, chemical inertness, and low toxicity, these materials show promise for use in nano-biotechnology[2]. Compared to conventional fluorescent semiconductor quantum dots, these materials have superior fluorescence features, including broad excitation spectra, narrow and tunable emission spectra, and great photo stability against photo bleaching and blinking. These materials are less hazardous and chemically inert, making them useful as carriers for biological imaging and drug delivery. They can also be functionalized with bio molecules. Additionally, CQDs show promise in the fields of optronics, sensors, and electrochemical luminescence. Hola et al. provide a brief overview of the fundamental photoluminescence characteristics of carbon dots as well as their sophisticated in vitro and in vivo bio applications, including targeted drug administration[7].

# LIQUID CONCENTRATION STUDIES USING METAMATERIAL COMPLEMENTARY SPLIT RING RESONATORS

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I take this opportunity with immense gratitude to look upto god almighty who had guided me throughout.I would like to express my deep sense of gratitude to my research guide Dr.V.P.Joseph,Professor,Dept. of Physics,Christ College(Autonomous), Irinjalakuda for his valuable guidance,timely advice and continuous encouragement which were really beneficial to me during my work.

I would like to express my sincere gratitude to Ms.Anju Sebastian for her valuable help at every stage of my work right from starting of the work till completion of my dissertation.

I express my special gratitude to Dr.Subin K Jose,Head of Environmental Science Department,Christ College Irinjalakuda,for providing me with the necessary resources which I needed to complete the project

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I am thankful to all my classmates as well as teaching and non teaching staff of Department of Physics.I am extremely grateful to my family for their unwavering support and encouragement throughout the project.

Finally I would like to express my sincere thanks to everyone who assisted me in completing this project , whether directly or indirectly.

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# ABSTRACT

Liquid concentration measurements play a crucial role in various industrial and scientific applications, ranging from pharmaceuticals to environmental monitoring. In this project, we investigate the efficiancy of Complementary Split Ring Resonators (CSRR) for precisely determining the concentration of NaCl solutions. We compare the performance of modified CSRRs with conventional CSRRs to ascertain improvements in sensitivity and accuracy. Both modified and conventional CSRR setups exhibit a noticeable correlation between the resonant frequency and the concentration of the NaCl solution. Through continous experiments, we observe that as the concentration of the NaCl solution increases, there is a systematic shift in the resonant frequency of the CSRR. This shift is due to changes in the dielectric properties of the surrounding medium, impacting the effective capacitance and inductance of the CSRR structure. Furthermore, we analyze the relationship between the concentration of the NaCl solution and the frequency shift in both modified and conventional CSRR configurations. Our findings reveal that the frequency shift exhibits a proportional increase with changes in concentration, while resonance frequency exhibit a decrease in its value with increase in concentration. Moreover, we study the comparative performance of frequency versus transmitted power characteristics for both modified and conventional CSRR setups. Our results demonstrate distinct advantages of the modified CSRR over the conventional CSSR, showcasing enhanced sensitivity and a broader dynamic range in frequency-based concentration measurements. In summary, through this project we can understand the potential of CSRR-based sensors for precise liquid concentration measurements,in NaCl solutions. The comparison between modified and conventional CSRR configurations shows us the advantages of innovative design modifications, paving the way for improved sensing capabilities in diverse applications requiring accurate concentration determination.

This dissertation is divided into 5 chapters.The first chapter consists of introduction to metamaterials.Theoretical analysis of CSRR is included in chapter 2.Simulation,Fabrication and Sample Preparation in chapter 3.Chapter 4 and chapter 5 deals with results and conclusions

# Contents

# List of Figures

# Chapter 1

## *INTRODUCTION*

## 1.1 METAMATERIALS

Metamaterials, denoted by the prefix "meta" meaning "beyond" in Greek, represent artificial materials exhibiting electromagnetic characteristics not present in natural materials such as glass or diamond. Unlike conventional materials with positive electrical permittivity, magnetic permeability, and refractive index, metamaterials, also known as negative index materials (NIM), double negative (DNG) media, left-handed (LH) materials, or backward wave (BW) media, display negative values for these parameters.

These unconventional material properties enable the creation of miniaturized antennas and microwave components for applications in wireless communications and defense industries. In the field of optics, metamaterials introduce the possibility of a "super" lens capable of focusing on features smaller than the wavelength of the light itself. This advancement opens avenues for sub-wavelength magnetic resonance imaging (MRI) in medical applications, offering increased resolution for observing minute cancerous cells.

Notably, the electrical permittivity ($\epsilon$) and magnetic permeability ($\mu$) of meta materials are negative, leading to a negative refractive index. Consequently, when light enters meta materials from a vacuum, it bends away from the normal direction, contrary to the typical bending towards the normal in conventional materials.

An immediate consequence of negative $\epsilon$ and $\mu$ in meta materials is the formation of a left-handed triplet in the electric field (E), magnetic field (H), and phase

# SYNTHESIS AND CHARACTERISATION OF COPPER NANO PARTICLE AND ITS THERMAL DIFFUSIVITY MEASUREMENT AND ANTIBACTERIAL STUDY

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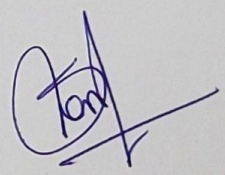

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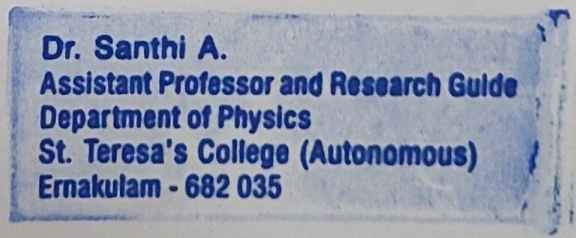

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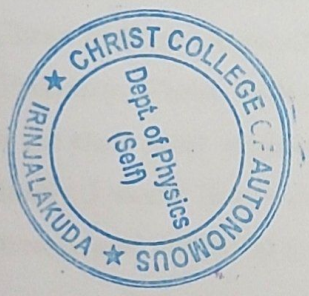

# ACKNOWLEDGEMENT

I admire God almighty with deepest gratitude, who had guided me through out my journey. I would like to express my immense gratitude to my research guide Dr Santhi A, Assistant professor, Department of Physics, St. Teresa's college(Autonomous),Ernakulam for her guidance and great support. I am indebted to Dr Frincy Francis(Assistant professor,Department of Physics, St. Teresa's college(Autonomous)), Merin (Research scholar St. Teresa's college(Autonnomous), Ernakulam, who helped me for completing my project.

Special thanks to Teresian Instrumentation and Consultancy Centre (TICC), (St. Teresa's college (Autonomous), Ernakulam), St. Thomas college, Thrissur.

I am greatful to my team mates, teachers specially Dr.prof.V P Joseph (Professor, Christ College (Autonomous), Irinjalakuda and Ms. Anju Sebastian (Assistant Professor, Christ College (Autonomous), Irinjalakuda), and my friends and family for their great support.

Finally, I would like to express my esteemed thanks to every one who helped me directly and indirectly to complete my project.

**Date: 04 / 04 /2024**

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# ABSTRACT

A novel class of solid-liquid composite material called nanofluids is made up of solid nanoparticles (size ranging from 1 to 100 nm )scattered throughout a base fluid. When compared to other noble metals, copper nanoparticles have superior catalytic effectiveness, which has drawn a lot of attention to them.

This work represents chemical synthesis of copper nanoparticles and its characterisation. Here a detailed description of Thermal Lens technique which is an application of copper nanoparticle is presented.Thermal lens spectroscopy was used to obtain the thermal diffusivity of Cu Nps for different concentrations. Using single beam mode matched thermal lensing technique determine the thermo optic properties of synthesised system.

The fundamental idea behind photothermal method is the thermal lens effect, which is caused by an excited species that, when exposed to a laser beam with a Gaussian intensity profile, experiences nonradiative relaxation. Copper nanoparticles used in random lasers and biomedical application.

In this paper also determined Antibacterial activity using the test orgnisms E.colli and S.aurues. Copper nanoparticles give good result in both gram positive and gram negative antibacterial study.

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# List of Figures

# Chapter 1

## INTRODUCTION

Nano-based fluids, which are composed of a base fluid and a small amount of nano-sized metal particles or metal oxides, are used in a variety of human applications, such as power and chemical engineering devices, medicine, electronics and more.

In the history of nano fluids we can see theory of heat transport was initially developed thanks to Galileo. Galilei developed the Galilean thermometer in the middle of the sixteenth century, and in the eighteenth century, he proposed Newton's Law of Cooling. One more The breakthrough in 1822 came from Fourier's mathematical theory of heat transmission. In addition, it resulted in the formulation of several basic theories related to heat, temperature, thermal energy, thermodynamics, and many other topics.[4, 7, 8].

Several scientists have used a variety of active and passive techniques to enhance the heat transmission mechanisms in liquids [6]. By dispersing extremely small magnetic particles in typical heat transfer fluids, a research team under the direction of Akoh et al. investigated the impact of particle suspension on heat transmission for the first time [2]. Later, Maxwell, Hamilton, and Crosser proposed a number of ground-breaking theories on the thermal conductivity of solid-liquid combinations[11] Because of its multifunctional character, nanofluid offers an array possibilities for research and exploration at the leading edges of nanotechnology.

Although theoretical research on potential heat transfer processes has been started, the biggest obstacle to date is still knowing how heat is transferred in

# ATTEMPTS TO SIMPLIFY THE COMPUTATIONAL COST OF MATHEMATICAL PHYSICS PROBLEMS INVOLVING MULTIPLE INTEGRATION

Submitted

By

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APRIL 2024

In partial fulfillment of

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This is to certify that the thesis entitled "ATTEMPTS TO SIMPLIFY THE COMPUTATIONAL COST OF MATHEMATICAL PHYSICS PROBLEMS INVOLVING MULTIPLE INTEGRATION" is a bona fide record of the research work carried out by FARHAN A F(Reg no:CCAWMPH022) in Department of Physics, Christ College (Autonomous) Irinjalakuda in partial fulfilment of the requirement for the award of degree of Master of Science in Physics of Calicut University.

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# ACKNOWLEDGEMENT

I would like to express my deep sense of gratitude to my research guide, Dr. V.P. Joseph, Professor, Dept. of Physics, Christ College (Autonomous), Irinjalakuda, for his guidance, immense support, and continuous encouragement.

I am grateful to all my classmates,as well as to the teachers and non-teaching staff of the Department of Physics including Head of Physics Department,Professor V.P. ANTO.I am also grateful to my mentor Mrs.Anju Sebastian for her sincere guidance.

Finally, I would like to express my sincere thanks to everyone who assisted me in completing this project, whether directly or indirectly.

Date:April 3, 2024

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# ABSTRACT

We can calculate n fold integrals and derivative exponentially faster using fractional calculus which save computational cost. in this theses we can find errors in gamma function so we need new gamma function,we also discuss gamma function for variables,we can also find laplace transform of functions whose value is $\infty$

Here we are using python to demonstrate the power of fractional calculus.we can also find negative integer factorial we can find general trend using (-1)!=1/0 apply left limit and right limit

$$\lim_{x \to 0^+} \frac{1}{x} = \infty$$

In all research need for computing power is increasing day by day.Even though we have super computer .it is not sufficient fulfill needs of all kinds of research.Many researchers can't afford to use super computer.so what we do?.There are 3 ways to solve this issue.first one is researchers can use distributed systems like boinc distributed computing software,another one is using CUDA along with Nvidia GPU or using cloud computing to accelerate computing task,last one is optimizing the Algorithm using various mathematical tools to save computational cost.we are modifying conventional method to solve n fold integrals not only that we can find gamma function of zero $\Gamma(0) \neq \infty$.We can solve n fold integrals exponentiaally faster along with less memory usage.These problems are seen in many fields like physics,mathematics,computer science,digital biology,chemistry.

In physics we can use this method in signal processing,image analysis,control systems.

In computer science we can optimize machine learning tasks.

# Contents

# List of Figures

# Chapter 1

# INTRODUCTION

**fractional calculus is extension of differentiation and integration to complex number order or quaternions (4D numbers) .Fractional calculus has been applied in various fields, including physics, engineering, and finance.** [4]

The results of fractional calculus have applications in various fields, including signal processing, control theory, and image processing.

in calculus we have clear physical,geometric interpretations

we are going to extend gamma function to find negative integer factorial we will prove that it is not $\infty$ but a function when we extend gamma function we can solve n fold derivatives or integral faster using our function. we can't find laplace transform of some functions but using extended gamma function we can find it.These have applications in FFT(Fast fourier transform)

we have to find general trend of different function in order to find n-fold integral/derivative

if we extend permutation we can solve many problems in fractional calculus much more easily.This extension of permutation is called fractional permutation.Domain of fractional permutation is complex numbers or quaternions (4D numbers).permutation is approximation of fractional permutation

# COMPACTION ANALYSIS OF FOOD POWDERS USING MODIFIED CSRR SENSOR WITH ENHANCED RESONANCE CHARACTERISTICS

Submitted

By

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In partial fulfillment of
the requirements for the Degree of

MASTER OF SCIENCE
IN
PHYSICS

# CERTIFICATE

This is to certify that the thesis entitled **"COMPACTION ANALYSIS OF FOOD POWDERS USING MODIFIED CSRR SENSOR WITH ENHANCED RESONANCE CHARACTERISTICS"** is a bonafide record of the research work carried out by **JERIN P J (CCAWMPH024)** under my supervision in the Electromagnetic Metamaterial Research Lab (EMRL), Department of Physics, Christ College (Autonomous), Irinjalakuda in partial fulfillment of the requirements for the award of degree of master of science in physics of calicut university.


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# DECLARATION

I **JERIN P J**, hereby declare that the work presented in this thesis entitled **"COMPACTION ANALYSIS OF FOOD POWDERS USING MODIFIED CSRR SENSOR WITH ENHANCED RESONANCE CHARACTERISTICS"** is based on the original work done by me under the guidance of Dr.V.P Joseph, Professor, Department of Physics, Christ College(Autonomous) Irinjalakuda and has not included in any other thesis submitted previously for the award of any other degree.

**Date: 05/04/2024**

**Name: JERIN P J**

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I express my deep sense of gratitude and extend my thanks to the people who have inspired and motivated me during my course and project work. Primarily I would thank god for being able to complete this project work with success. I owe a great deal to my project guide Dr.V.P.Joseph, Professor, Christ College (Autonomous), Irinjalakkuda, for his valuable guidance, his wholehearted dedication, help and support.

I am grateful to my co-guide Mrs.Aswathi P.V, Assistant Professor and Research scholar of Electromagnetic Metamaterial Research Lab (EMRL) Christ College (Autonomous), Irinjalakuda for providing me with all resources i needed to successfully complete my work.

Special thanks to my class teacher Mrs.Anju Sebastian, Assistant Professor and Research scholar of Electromagnetic Research Lab (EMRL) Christ College Autonomous Irinjalakuda for the valuable contribution and providing great suggestions and advice in various phases of project completion.

I would like to express my sincere gratitude to the Department of Chemistry, Christ College (Autonomous), Irinjalakuda for providing me instruments required for my project work.

I am immensely grateful to my parents for their constant support, without which this project would not have been viable.

Finally i would like to express a sincere thanks to everyone who had assisted me directly and indirectly.

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# ABSTRACT

Metamaterials are artificially fabricated materials having unusual electromagnetic properties. Permittivity and permeability are two electromagnetic properties of materials. Naturally occurring materials have positive values for the permittivity and permeability. While metamaterials have negative values for the permittivity and permeability. Split Ring Resonators (SRR) is the negative permeability counter part of the metamaterial. There are different types of SRR in size and shape. SRR consists of two metallic copper ring structures with a split at opposite sides. The Complementary Split Ring Resonator (CSRR) is the complementary structure of SRR. This SRR and CSRR exhibits LC resonance nature due to the capacitance and inductance arise in them due the charges and current induced in the structure when a time varying electromagnetic field is applied to the structure. This project focuses on the sensing application of the CSRR sensor.

In this project work, a modified structure of the CSRR sensor with enhanced resonance characteristics is introduced. This modified CSRR sensor is designed, simulated and experimentally verified. The simulation of the structure is done in High Frequency structure simulator (HFSS) software and experimentally verified using the device Vector Network Analyzer (VNA). The simulation results and the experimental results are in good agreement. Compaction analysis of food powders(Corn flour, Gram flour, Refined Wheat flour and Ragi flour) are done as an application of this modified CSRR sensor with enhanced resonance characteristics. The food powders in packing stage requires minimum volume to reduce the shelf space. The volume can be minimized by maximizing the density of the food powders. The density of the food powders can be determined with the modified CSRR sensor. This helps in minimizing the volume of the food powders at packing stage. This thesis is divided into five chapters. The fist chapter gives an introduction to metamaterials. The second chapter deals with theoretical analysis of the CSRR sensor. The designing, simulation, fabrication and experimental methods are given in third chapter. Fourth chapter contains the results of simulation and experiments. The fifth chapter incorporates the conclusion of the work done in this project.

# Contents

# SYNTHESIS AND CHARACTERISATION OF CALCIUM TUNGSTATE NANO PARTICLE AND ITS PHOTOCATALYSIS AND ANTIBACTERIAL STUDY

Submitted

By

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In partial fulfillment of

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This is to certify that the work reported in this project report entitled "SYNTHESIS AND CHARACTERISATION OF CALCIUM TUNGSTATE NANOPARTICLE AND ITS PHOTOCATALYSIS AND ANTIBACTERIAL STUDY" which is submitted for the partial fulfillment of the requirements for the award of the degree, Master of Science in Physics, to the Department of Physics, Christ College (Autonomous), Irinjalakuda, University of Calicut, is the result of original work carried out by LAKSHMI V S (Reg No. CCAWMPH025), under my guidance and supervision. To the best of my knowledge and belief, the work embodied in this project has not formed earlier basis of any degree or similar title of this thesis or any other university or examining body.

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Supervising Guide

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Date

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Professor
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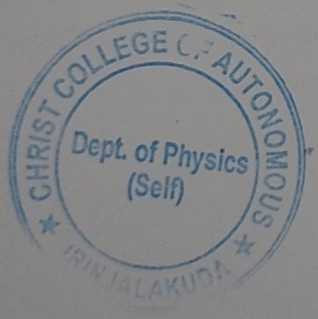

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I admire God almighty with deepest gratitude, who had guided me through out my journey.

I would like to express my immense gratitude to my research guide Dr Santhi A, Assistant professor, Department of Physics, St. Teresa's college(Autonomous), Ernakulam for her guidance and great support.

I am indebted to Dr. Minu Pius, Assistant Professor, Deparment of physics, St. Terasa's college(Autonomous), Ernakulam, and Merin Joby, Research scholar, St. Teresa's college(Autonnomous),Ernakulam, who helped me for completing my project.

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I am greatful to my team mates, all teachers specially Prof. V P Joseph ,Professor, Christ College (Autonomous), Irinjalakuda and Ms. Anju Sebastian, Assistant Professor, Christ College (Autonomous), Irinjalakuda, and my friends and family for this great support.

Finally, I would like to express my esteemed thanks to every one who helped me directly and indirectly to complete my project.

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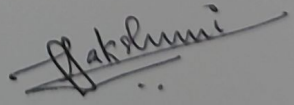

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# ABSTRACT

Water pollution is the major environmental issue faced by the world today. Scarcity of pure water deadly affect the life of living beings on the earth. Most of the reasons for water pollution arises from human activities. Many hazardous effluent reaching the water sources are from industries, for example dyes. Dyes are the toxic agents which threat the life of living beings. Very little amount of dye can affect the organisms severely.

Sustainable water treatment strategies includes the removal of endangered contaminants from the water resources. There are ways to remove the contaminants from water. Photocatalytic degradation is a widely accepted technique for removal of dyes. It is very simple, effective, and eco-friendly degradation method which degrade the toxic components completely into water and carbon dioxide and no other secondary toxic byproducts formed. In the past 15 years studies on calcium tungstate as a photocatalyst were extensively done, due to it's characteristics such as high stability, less toxicity and other characteristics.

Photocatalytic degradation of methylene blue dye using $CaWO_4$ as photocatalyst as sunlight as the source of light was studied in this project. Percentage of degradation of photocatalysis using 0.1 molar, 0.2 molar and recycled $CaWO_4$ were compared. $CaWO_4$ was synthesised by precipitation method. Analytical techniques such as XRD, DRS and PL spectroscopy was taken. The antibacterial activity of $CaWO_4$ also validated. This project solely aims at better advancement of society in purification of water.

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# Chapter 1

# INTRODUCTION

## 1.1 WATER POLLUTION

Water is the most important component of life which is necessary for the existence of all living beings. The earth is almost composed of water, that is 71 % of the earth is filled with water[1]. Now the world faces tremendous environmental issues and one of the biggest problems we face is the hazardous wastes contaminating the groundwater. The rapid increase in pollution is due to the growth of population and industries. The pollution can be from the civilian, commercial, and defence sectors. For example, the waste from military installations causes the disposal of wastes in lagoons and it may cause the pollution of groundwater with a variety of hazardous chemicals[15]. Also, the environment is polluted by the toxic effluents from textile industries, agriculture, pharmaceuticals, etc. This will affect the quality of water and thereby the life of human beings.

## 1.2 WASTE WATER TREATMENT METHODS

One of the major challenges in this 21st century is the availability of clean and safe water. Even though 71 % of the world is filled with water, living beings are suffering from poor water quality. With this growing demand, various strategies are implemented to solve this issue and to yield more water resources. Rainwater harvesting for daily activities and increasing storm-water capturing capacity are

# FDTD BASED BEAMFORMING TECHNIQUE USING ARRAY ANTENNAS

Submitted

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# CERTIFICATE

This is to certify that the thesis entitled "FDTD BASED BEAMFORMING TECHNIQUE USING ARRAY ANTENNAS" is a bona fide record of the research work carried out by ROSHINI JAYARAJ (Reg no:CCAWMPH026) in Department of Physics, Christ college (autonomous), Irinjalakuda in partial fulfilment of the requirement for the award of degree of Master of Science in Physics of Calicut University.

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# ACKNOWLEDGEMENT

I take this opportunity to express my deep sense of gratitude and to extend my thanks to all the people who have inspired and motivated me during my course and project work.

First and foremost I would thank God for being able to complete this project with success. Expressing my gratitude to my guide and Dr. V P Joseph, Professor, Dept. of Physics and Head of the Dept. of Physics Professor V P ANTO Christ College (autonomous) Irinjalakuda for his valuable guidance, encouragement, timely advice, immense patience and as a constant source of inspiration for choosing the right path. I am thankful to my co-guide Ms. ANJALI JOBY for the valuable help at every stage of my work right from the starting of the work till the completion of my project.

I am also grateful to my mentor Mrs.Anju Sebastian for her sincere guidance.

Also i am grateful to my team mates and non-teaching staffs of the Department of Physics, Christ College Irinjalakuda, for their direct and indirect support and encouragement during the execution of my project.

I am indebted to my family for their constant source of inspiration.

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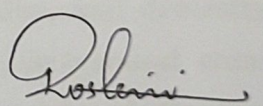

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# ABSTRACT

Antenna arrays have a long history of more than 100 years and have evolved closely with the development of electronic and information technologies, playing an indispensable role in wireless communications and radar. To support the ever-increasing demand on connectivity and datarates, multiple beam antennas are identified as a critical technology for the fifth generation (5G), the sixth generation (6G) and more generally beyond 5G (B5G) wireless communication links in both terrestrial networks and non-terrestrial networks. With the rapid development of electronic and information technologies, the demand for all-time, all-domain, and full-space network services has exploded, and new communication requirements have been put forward on various space/air/ground platforms. To meet the ever increasing requirements of the future sixth generation (6G) wireless communications, such as high capacity, wide coverage, low latency, and strong robustness, it is promising to employ different types of antenna arrays (e.g., phased arrays, digital arrays, and reconfigurable intelligent surfaces, etc.) with various beamforming technologies (e.g., analog beamforming, digital beamforming, hybrid beamforming, and passive beamforming, etc.) in space/air/ground communication networks, bringing in advantages such as considerable antenna gains, multiplexing gains, and diversity gains. However, enabling antenna array for space/air/ground communication networks poses specific, distinctive and tricky challenges, which has aroused extensive research attention. In this thesis, the principle of operation, design, and implementation of multiple beamforming networks are discussed. The suitability of these sub-systems for 5 G and 6G antenna arrays is reviewed. Major technologies and future works are highlighted.

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# Chapter 1

## *INTRODUCTION*

### 1.1 METAMATERIALS

Metamaterials are artificially fabricated materials in nanoscale or microscale, that have extraordinary kind of electromagnetic properties that showing negative values for refractive index n. They are also called metamaterial if one parameter show negative value. There is no exact definition for metamaterials. The word metamaterial arise from a Greek word meta, meaning "beyond"and Latin word materia,meaning "matter"or "material". The term metametrial was introduced by Rodger M. Waitser in 2011. It consist of assembly of multiple discrete constituents called meta atoms, which can be considered as artificial atoms. They are constructed from materials such as plastics,metals etc. with befitting capacitive and inductive characteristics. They are arranged in periodic arrays at scale smaller than the wavelength of the phenomena observed. All naturally occurring materials such as gold,diamond,glass etc. They are called Negative Index Materials(NIM) or Double Negative Media(DNG) and later one called as Single Negative (SNG) medium. The bchaviour of materials to electromagnetic waves depends on it's value of permittivity and permeability. In case of metamaterials when we substitute the negative values of both parameters in the four Maxwell equations, we get a left handed triplet of electric field, magnetic field and phase vector(k), but in case of normal materials it is a right handed triplet. Here the phase vector and and poynting vector are in opposite direction. As a result the wave flows in backward direction in case of metamaterials. The benefit of metamaterials over

# Radio Spectral Studies in a Selected Sample of FR-II Galaxies of Linear Size 0-100 Kpc Using NASA/IPAC Extragalactic Database

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Post Graduate Department of Physics

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**UNIVERSITY OF CALICUT**

**APRIL 2024**

In partial fulfilment of the requirements for the Degree of

**MASTER OF SCIENCE IN PHYSICS**

Under the guidance of

**Dr. Biju.K.G**

**Associate Professor**

**Department of Physics**

**WMO Arts and Science college,**

**Muttil,Wayanad.**

# CERTIFICATE

This is to certify that the work incorporated in the project report entitled **"Radio Spectral Studies in a selected Sample of FR-II Galaxies of Linear Size 0-100 Kpc Using NASA/IPAC Extragalactic Database"** , which is being submitted herewith for the partial fulfilment of the requirements for the award of the degree of Master of Science in Physics, at the Department of Physics, Christ College (Autonomous), Irinjalakuda, University of Calicut, is the result of original work carried out by **SHREYA JAYAPRAKASH (Reg No. CCAWMPH027)** under my guidance and supervision. To the best of my knowledge and belief, the work embodied in this thesis has not formed the basis of any degree or similar title to this thesis or any other university or examining body.


**Dr. Biju.K.G**
Associate Professor
WMO Arts and Science College
Muttil, Wayanad

**Place : Muttil**
**Date : 01/04/2024**

# CERTIFICATE

This is to certify that the work incorporated in the project report entitled **"Radio Spectral Studies in a selected Sample of FR-II Galaxies of Linear Size 0-100 Kpc Using NASA/IPAC Extragalactic Database"**, which is being submitted by **SHREYA JAYAPRAKASH (Reg No. CCAWMPH027)** at the Department of Physics, Christ College(Autonomous), Irinjalakuda, University of Calicut, is based on the investigation carried out by her under the guidance of Dr.Biju.K.G, Associate Professor, Department of Physics, WMO Arts and Science College, Muttil, Wayanad.

**Dr. V.P.Joseph**
Professor
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Irinjalakuda, Thrissur

**Place : Irinjalakuda**
**Date : 04/04/2024**

# DECLARATION

I, **SHREYA JAYAPRAKASH**, hereby declare that the project work entitled **"Radio spectral Studies in a selected Sample of FR-II Galaxies of Linear Size 0-100 Kpc Using NASA/IPAC Extragalactic Database"**, submitted at the Department of Physics, Christ College(Autonomous), Irinjalakuda, University of Calicut for the partial fulfilment of the award of Degree of Master of Science in Physics is an authentic record of my own work carried out under the guidance of Dr.Biju.K.G, Associate Professor, Department of Physics, WMO Arts and Science College, Muttil, Wayanad. I further declare that any part of this work has not been submitted to any other university or institution as a part of any other degree requirement, to the best of my knowledge.

**Place : Irinjalakuda** **SHREYA JAYAPRAKASH**

**Date :04/04/2024** **Reg No. CCAWMPH027**

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Also, I am extremely indebted to my parents and friends for their encouragement throughout the preparation of this project.

I once again extent my sincere gratitude to all those who have directly and indirectly helped me during this project.

# ABSTRACT

In this project, we searched for a potential correlation between spectral index and galactic parameters like linear size and red-shift in a sample of FR-II Galaxies within a linear size range of 0-100 Kpc (based on **APPENDIX A: CATALOGUE OF THE CAMBRIDGE-SDSS FR-II RADIO GALAXIES**). A comprehensive analysis was conducted on 68 radio sources using data obtained from the NASA IPAC/ NED database and the corresponding plots were traced with Python pandas module. The research findings indicate no significant correlation between the calculated spectral index and either of the parameters such as *linear size* and *red shift*.

# Contents