A NON-CONTACT METHOD FOR DETECTING THE CONCENTRATION OF AQUEOUS SOLUTIONS USING BROADSIDE COUPLED SPLIT RING RESONATOR METAMATERIAL STRUCTURE

Submitted

By

ANGEL MARIYA .L

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CALICUT UNIVERSITY
JULY 2023

In partial Fulfillment of
the requirements for the Degree

MASTER OF SCIENCE IN PHYSICS

CERTIFICATE

This is to certify that the thesis entitled"A NON-CONTACT METHOD FOR DETECTING THE CONCENTRATION OF AQUEOUS SOLUTIONS USING BROADSIDE COUPLED SPLIT RING RESONATOR METAMATERIAL STRUCTURE" is a bona fide record of the research work carried out by Ms. ANGEL MARIYA.L(Reg no: CCAVMPH016) under my supervision in the department of Physics, Christ college (Autonomous), Irinjalakuda in partial fulfillment of the requirement of the award of degree of Master of Science in Physics during the academic year 2021-2023 .

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DECLARATION

I ANGEL MARIYA.L, hereby declare that the work presented in this report entitled "A NON-CONTACT METHOD FOR DETECTING THE CONCENTRATION OF AQUEOUS SOLUTIONS USING BROADSIDE COUPLED SPLIT RING RESONATOR METAMATERIAL STRUCTURE" 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.

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ACKNOWLEDGEMENT

I take this oppurtunity to 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 with success. I owe a great deal to my guide Dr. V.P. Joseph, Professor of Christ College Irinjalakuda, for his valuable guidance, his wholehearted and dedicated support and help for completion of project.

I would like to express my sincere gratitude to Ms. Anju Sebastian and Ms.Aswathi P.V, co-guides for their valuable help at every stage of my work right from the starting of the work till the completion of my dissertation . I am thankful to my mentor Ms. Anjali Joby, Assisstant Professor for constant inspiration and support. I am grateful to V P Anto, Head of the Department of Physics ,all teaching and non-teaching staffs of Christ College(Autonomous), Irinjalakuda for their constant inspiration and support.

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

I once again extent my sincere gratitude to all those who have directly and indirectly helped me during this project. I am indebted to my family for their constant source of inspiration.

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ABSTRACT

This project aims at the development of a non-contact sensor using Broadside Coupled Split Ring Resonator (BCSRR) metamaterial structure for concentration measurement of aqueous solutions of Sodium Chloride, Potassium Chloride and Glucose.The BCSRR is a compact and versatile electromagnetic structure that exhibits resonant behaviour at specific frequencies, making it suitable for sensing applications.Aqueous solutions are lossy ,so that non-contact method is preferred.The proposed sensor design utilizes the BCSRR structure integrated into a microfluidic platform, allowing for direct interaction with water samples. By exploiting the changes in the electrical properties of the water sample, such as permittivity and conductivity, the resonant frequency of the BCSRR is modulated. This frequency shift can be measured and correlated to the concentration of the target analyte present in the solution.The dependence of the dielectric properties on the resonant frequency allows the BCSRR structure to be used as a probe to precisely measure the concentration of different solutions. This BCSRR-based method has the uncommon advantage of accurately determining liquid concentration, even if it is of very little significance.

Key advantages of the BCSRR-based sensor include its compact size, high sensitivity, and simplicity of fabrication. The broadside coupling mechanism between the split ring resonators provides enhanced sensitivity, enabling accurate detection even at low analyte concentrations. Additionally, the microfluidic integration allows for continuous monitoring of samples, making it suitable for real-time applications.To validate the sensor performance, experimental characterization is conducted using samples with varying concentrations of target analytes. The obtained results demonstrate a clear correlation between the measured frequency shift and the concentration levels, indicating the sensor's capability to accurately detect and quantify analytes in samples.

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PROJECT REPORT

GALAXY MAPPING THROUGH H21 LINE DETECTION

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This is to certify that the project report entitled " GALAXY MAPPING THROUGH H21 LINE DETECTION" is a bonafide record of the research work carried out by Ms. Anisa Maria Jose (Reg No.CCAVMPH017) under our supervision in the electromagnetic Research Lab, Department of physics,Christ College (Autonomous), Irinjalakuda in the partial fulfillment of the award of degree for the Master of Science in physics in the academic year 2021-2023 .

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DECLARATION

I Anisa Maria Jose hereby declare that the project work titled "Galaxy Mapping through H21 line" submitted at Department of Physics,Christ college (Autonomous), Irinjalakuda for the partial fulfilment of the award of the degree of Master of Science degree in Physics is an authentic record of my own work carried out under the guidance of Dr.V.P.Joseph, Professor and Mr.Jose Sunny,Assistant professor,Department of Physics,Christ College(Autonomous), Irinjalakuda -680125.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.

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ACKNOWLEDGEMENT

First I would like to thank God for being able to complete this project with success. I am deeply thankful to my guide and head of the department of Physics, Dr. V.P. Joseph, Christ College Irinjalakuda. The valuable guidance, encouragement, timely advice, immense patience and as a constant source of inspiration made me to complete my project with perfection.I also take this opportunities to express my gratitude and extend my thanks to the ones who have inspired and motivated me during my course and project work.

I am thankful to my co-guide Mr.Jose sunny for giving valuable guide while doing the project .I am also grateful to my mentor Ms.Anjaly Joby for her sincere guidance and I would like to thank Ms. Aswathy P.V and Ms. Anju Sebastian, Assistant professor of Christ College Irinjalakuda, for their valuable help at every stage of my work right from the starting of the work till the completion of my project. I also thank my family for their constant source of inspiration.

ABSTRACT

In this project I have made an outline of galaxy mapping through the detection of H21 line. The milky way galaxy is a spiral galaxy containing 100-400 billion stars. The main component of interstellar gas present in our galaxy is the neutral hydrogen. The 21-line cm is exhibited by neutral hydrogen atom. An antenna known as Radio horn antenna has been introduced to study the hydrogen line in the laboratory and galaxy can be mapped . The project BHARATH focused on instrumentation and experimental part of astrophysics thus helped the students, public,researchers to understand more about radio astronomy methods and ideas of radio physics. The water hole has become a quiet channel which is obvious band for communication with extraterrestrial intelligence. Different mapping methods are explained. Characteristics such as antenna gain, aperture efficiency, antenna resistance, Antenna noise temperature, Antenna bandwidth and directivity are defined. The main components such as band pass filter, vector network analyser, spectrum network analyser, low noise amplifier and software defined radio needed for the H21 detection are well explained. The experimental setup for plotting the radiation pattern and how the H21 line is being detected was also mentioned. Therefore, this has turned into top studied spectral features in radio astronomy.

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TEMPERATURE DEPENDENCE RESONANCE BEHAVIOR OF DIFFERENT SPLIT RING STRUCTURES

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By

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CERTIFICATE

This is to certify that the thesis entitiled "TEMPERATURE DEPENDENCE RESONANCE BEHAVIOR OF SPLIT RING STRUCTURES" is a bona fide record of the research work carried out by Ms.ANU MARIYA K R(reg no:CCAVMPH018) under the supervision of the department of Physics, Christ college autonomous irinjalakuda.

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DECLARATION

I ANU MARIYA K R, hereby declare that the work presented in this report entitled "TEMPERATURE DEPENDENCE RESONANCE BEHAVIOR OF SPLIT RING STRUCTURES" 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.

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ACKNOWLEDGEMENT

I take this opportunity to 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 with success. I owe a great deal to my guide and head of the department of Physics, Dr. V.P. Joseph, Christ College Irinjalakuda, for his valuable guidance, encouragement, timely advice, immense patience and as a constant source of inspiration in my entire project.I am thankful to all my classmates, teaching and staff and Ms. Aswathy P.V Mrs.Anjali Joby and Mrs. Anju Sebastian, of Christ College Irinjalakuda, for their valuable help at every stage of my work right from the starting of the work till the completion of my dissertation. Also my special thanks to Dept. of Physics, Christ College Irinjalakuda, for their valuable help. I am indebted to my family for their constant source of inspiration.

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ANU MARIYA K R
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ABSTRACT

The project entitled "TEMPERATURE DEPENDENCE RESONANCE BEHAVIOR OF DIFFERENT SPLIT RING STRUCTURES" present the temperature dependence study of meta material .To study th 4 SRR Test probe is used. the measurement taken by the vector network analyzer.The application of temperature changes the properties material.

Here the temperature also produce change in the meta material. When temperature of the SRR increase the structural parameters change .This increase the size of the SRR.It lead to the decrease in the resonance frequency and increase the power and band width.After attaining critical temperature the frequency increase and power and bandwidth decrease.This due the increase the capacitance of the SRR. temperature increase the resistance .This lead to the increase the capacitance up to critical temperature after that it decrease th increase in temperature

this dissertation divided into 5 chapter first chapter explain the introduction and second explain the theory .Third and fourth explain measurement and result and conclusion .last chapter explain the bibliography

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TEMPERATURE DEPENDENT DIELECTRIC CONSTANT MEASUREMENT OF LIQUIDS USING WIRE SPLIT RING RESONATOR

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By

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This is to certify that the thesis entitiled "TEMPERATURE DEPENDENT DIELECTRIC CONSTANT MEASUREMENT OF WIRE SRR" is a bona fide record of the research work carried out by Ms. APARNA K (CCAVMPH019) under our supervision in the department of Physics, Christ college autonomous Irinjalakuda, in partial fulfillment of the requirement for the award of degree of Master of Science in Physics during the academic year 2021-2023

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DECLARATION

I, APARNA K here by declare that this project work entitled " TEMPERATURE DEPENDENT DIELECTRIC CONSTANT MEASUREMENT OF LIQUIDS USING WIRE SPLIT RING RESONATOR" submitted at the Department Of Physics (SF),Christ College (Autonomous), Irinjalakuda for the partial fulfillment of the award of Master of Science degree in Physics is a authentic report of my own work carried out under the guidance of Dr, V.P. Joseph, Professor, Department Of Physics (SF),Christ College (Autonomous), Irinjalakuda. 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.

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ACKNOWLEDGEMENT

I take this oppurtunity to 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 with success. I owe a great deal to my guide and PG coordinator,Prof. Dr. V.P. Joseph, Christ College Irinjalakuda, for his valuable guidance, encouragement, timely advice, immense patience and as a constant source of inspiration in my entire project.

I am thankful to all my classmates, teaching and non teaching staff and our mentor MS Anjaly joby and Ms. Aswathy p v, research scholar and teaching staff of Christ College Irinjalakuda, for their valuable help at every stage of my work right from the starting of the work till the completion of my dissertation. Also my special thanks to Ms. Simmy Jose Dept. of Physics, Christ College Irinjalakuda, for their valuable help.

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

Date: 11/7/2023

APARNA K

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ABSTRACT

Metamaterials are artificially constructed structures,typically smaller than the wavelength of electromagnetic waves, they interact with.The metamaterials have ability to manipulate and control electromagnetic waves,which cannot be done by conventional materials.Wire split ring resonator is one kind of them. We can use these materials to find the dielectric constant of the liquids, at different temperature. We make use of VNA equipment to measure the resonance frequency when WSRR is immersed in the liquids, whose dielectric constant to be measured at different temperature..Here we took Toluene, Hexane and Kerosene.Initially we took the readings at room temperature and then we increased the temperature of the liquids, and then took the frequency at different temperature. First we plotted the resonance frequency versus standard dielectric constant of liquids. Then we found the dielectric constant of liquids at different temperatures, corresponding to their resonance frequency of those temperature from the previously plotted graph. We can also plot the temperature versus dielectric constant and frequency versus dielectric constant to observe the change.

The first chapter consists of the introduction of metamaterials. The theoretical aspects of WSRR is included in the chapter 2. Experimental set up is in chapter 3 . 4 th and the 5 th chapters have results and the conclusions.

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DETECTION OF EXTRASOLAR PLANETS USING THE RADIAL VELOCITY METHOD

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This is to certify that the work incorporated in the project report entitled "Detection of Extrasolar Planets using the Radial Velocity Method", which is being submitted herewith for the partial fulfilment of the requirements for the award of the degree, 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 ARDRA VALSAN (Reg No. CCAVMPH020), under my guidance and supervision. This work reproduces the steps involved in estimating the properties of planets orbiting other stars as detected through their radial velocity signal.

Anand Narayanan

Dr.Anand Narayanan
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Department of Earth and Space Sciences
Indian Institute of Space Science Technology
Thiruvanathapuram

CERTIFICATE

This is to certify that the thesis entitiled "Detection of Extrasolar Planets using the Radial Velocity Method" which is being submitted by ARDRA VALSAN, at the department of physics, Christ college Irinjalakuda, is based on the investigation carried out by her under the guidance of Dr. Anand Narayanan, professor, IIST, Thiruvananthapuram.

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ACKNOWLEDGEMENT

I express my sincere gratitude to my guide Dr. Anand Narayanan, professor,Department of earth and space technology, Indian Institute Of Space Science and technology, Thiruvananthapuram, for his wholehearted support and guidance in the fulfillment of this project.
I am grateful to my mentor Dr. V P Joseph,professor, Dept. of physics, Christ college Irinjalakuda, for his motivation and support. I am thankful to Dr. V P ANTO, Head of the Dept. of physics, all teaching and non-teaching staffs of Christ College (Autonomous), Irinjalakuda and my classmates. I thank my family and friends for their love and support

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ARDRA VALSAN
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ABSTRACT

The project entitled "DETECTION OF EXTRASOLAR PLANETS USING THE RADIAL VELOCITY METHOD" presents the properties of exoplanets detected indirectly by the radial velocity method by observing a star.

In this project, radial velocity data of a star is downloaded from the site NASA Exoplanet Archive. Using this data of the star, the properties of the exoplanet that revolve around star is found out. Since star is very much brighter than the planets, it is difficult to detect the exoplanets directly.The radial-velocity method for finding exoplanets is based on the idea that when a planet is orbiting a star, the star does not remain perfectly motionless. The star responds to the gravitational pull of its smaller companion by moving very little in a tiny circle or ellipse. This dissertation is divided into 5 chapters. The first chapter is a introduction to the different methods of exoplanet detection. The second chapter is a brief discussion of Radial velocity method. The third chapter describes the plotting of radial velocity curves. The fourth chapter is about the analysis of radial velocity data of different stars. The 5th chapter include the conclusion of this project.

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RESONANCE FREQUENCY STUDIES OF CERTAIN NEGATIVE PERMITTIVITY AND NEGATIVE PERMEABILITY STRUCTURES

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CERTIFICATE

This is to certify that the project report entitled "RESONANCE FREQUENCY STUDIES OF CERTAIN NEGATIVE PERMITTIVITY AND NEGATIVE PERMEABILITY STRUCTURES" is a bonafide work done by Ms. ASHWANI TS (Reg no:CCAVMPH021) under our supervision in the Electromagnetic Research lab, Department of Physics, Christ college (Autonomous), Irinjalakuda in partial fulfillment of the requirement for the award of degree of Master of Science in Physics of Calicut University during academic year 2021-2023.

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DECLARATION

I ASHWANI TS, hereby declare that the work presented in this report entitled "RESONANCE FREQUENCY STUDIES OF CERTAIN NEGATIVE PERMITTIVITY AND NEGATIVE PERMEABILITY STRUCTURES" 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.

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ACKNOWLEDGEMENT

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 express my special gratitude to Ms. Aswathy P.V and Ms. Anju Sebastian, Research scholars of Christ College Irinjalakuda, for their valuable help at every stage of my work providing me with great suggestions and advice whenever needed right from the starting of the work till the completion of my dissertation.

I am sincerely thankful to my co-guide Mr.Jose Sunny and my mentor, Ms. Anjaly Joby, Assistant professors of Christ College Irinjalakuda for their advice and support, which was very beneficial for my work. 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 appreciation to everyone who assisted me in completing this project, whether directly or indirectly.

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ABSTRACT

The project work entitled "RESONANCE FREQUENCY STUDIES OF CERTAIN NEGATIVE PERMITTIVITY AND NEGATIVE PERMEABILITY STRUCTURES" presents the resonant properties of permittivity and permeability structures fabricated using artificially engineered wire and SRR structures. It is to be considered that the wavelength of interacting electromagnetic wave should be large enough compared to the size of structures to establish electromagnetically active structures.

It is a basic principle that the negative index structure is to be be arranged such that the plane of the structure is perpendicular to the direction of the magnetic field component of the incident electromagnetic field.So a study is done to understand their resonant properties when the magnetic field direction is not perpendicular. This artificially constructed metamaterial structures show variation in resonant frequency with the variation in position of the bulk structures. Individual structure studies, in addition showed a change in transmitted or absorbed power when rotated, with respect to the direction of the applied magnetic field. A comparison is also done between the resonant properties of metamaterial structures fabricated on both rigid and flexible substrates , having different dielectric properties.

This dissertation is divided into four chapters. The first chapter includes a brief introduction to the concept of metamaterials and its applications and second chapter incorporates detailed discussion on negative permittivity and permeability structures along with methods adopted and experimental requirements for the analysis. The third chapter comprise of comprehensive discussion on experimental results and finally in the fourth chapter, the conclusions.

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Changes in the water vapour transport in the recent decades during monsoon over the Indian subcontinent

PROJECT REPORT

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Under the guidance of

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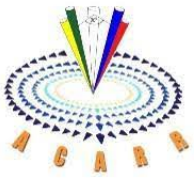

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CERTIFICATE

This is to certify that the work incorporated in the project report entitled- **"Changes in the water vapour transport in the recent decades during monsoon over the Indian subcontinent"**, which is being submitted herewith for the partial fulfilment of the requirements for the award of degree, Master of Science in Physics at the Department of Physics, Christ College(Autonomous), Irinjalakuda, Thrissur is a bonafide record of work carried out by **Havva Hyrath K** at Advanced Centre for Atmospheric Radar Research, Cochin University of Science and Technology, Cochin under my guidance and supervision. To the best of my knowledge and belief, the work embodied in this thesis has not formed an earlier basis for the award of any degree or similar title of this thesis or any other university or examining body.

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Cochin, Kerala
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Place : Cochin
Date : 10/07/2023

CERTIFICATE

This is to certify that the work incorporated in the project report entitled **"Changes in the water vapour transport in the recent decade during monsoon over the Indian subcontinent"**, which is being submitted by **HAVVA HYRATH K** at the Department of Physics, Christ College, Irinjalakuda, University of Calicut, is based on the investigation carried out by her under the guidance of **Dr. Ajil Kottayil**, Scientist -C, Advanced Centre for Atmospheric Radar Research (ACARR), Cochin University of Science and Technology, Kerala, India.

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Date : 10/07/2023

DECLARATION

I hereby declare that the work which is being presented as dissertation work entitled – **"Changes in the water vapour transport in the recent decade during monsoon over the Indian subcontinent"**, in partial fulfilment of the requirement for the award of the degree of Master of Science in Physics, Christ College Irinjalakuda is a record of my own work, conducted under the guidance of **Dr. Ajil Kottayil**, Scientist -C, Advanced Centre for Atmospheric Radar Research (ACARR), Cochin University of Science and Technology, Kerala, India. I further declare that to the best of my knowledge, the project report does not contain any part of the work submitted for the award of any degree, either in this university or in any other university.

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ACKNOWLEDGEMENTS

First and foremost, I wish to thank the omnipotent God for his blessings.

I express my profound sense of gratitude and respect to my project guide **Dr Ajil Kottayil**, Scientist- C, ACARR, Cochin University of Science and Technology, Kochi, for his sincere guidance in doing this project work and contributing the time, support and encouragement in my study.

I am thankful to **Tesna Maria**, Project student(M.Tech) ACARR, Cochin University of Science and Technology, Kochi, for her selfless support and productive suggestions.

I am grateful to Mr V P Anto, Head of the Department, Department of Physics, Christ College (Autonomous), Irinjalakuda and Dr V P Joseph, Professor and Co-ordinator of the Department of Physics, Christ College (Autonomous), Irinjalakuda and Anjali Joby, Mentor, Department of Physics, Christ College (Autonomous) Irinjalakuda for being constant sources of motivation.

I also acknowledge with a deep sense of reverence my profound gratitude towards my family for their constant support and encouragement and all my friends for their concern and affection shown to me.

Havva Hyrath K

ABSTRACT

Atmospheric moisture and its transport significantly control the Earth's heat budget and several other physical processes. Humidity changes affect weather in the lower troposphere, while in the upper troposphere, it can drive climate. Several studies have been made on the relation between precipitation variability and moisture budget over different regions and their damaging impacts on agriculture and water resources. Intense moisture vapour transport has a significant role in water resources and is usually associated with extreme hydro-meteorological events. The recent period has witnessed substantial changes in the convective processes associated with monsoons over the Bay of Bengal and the Arabian Sea, potentially impacting the precipitation variability over the Indian region. For all the events taken into account in this analysis, the major portion of vapour transport was from the Arabian Sea. A more detailed understanding of the influence of vapour transport on Indian summer monsoon rainfall synoptic conditions is required, especially their evolution in the recent period. This study analyses the influence of vertically integrated vapour transport in modulating the Indian summer monsoon rainfall for three decades from 1990-2020 and the difference in the climatology of moisture flux for these decades. The Integrated moisture flux characteristics were examined using the profiles of specific humidity and wind from ERA5 datasets for 31 years, from 1990-2020, during the Indian summer monsoon season.

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List of Figures

NON-DESTRUCTIVE TESTING USING SRR FOR CRACK DETECTION

Submitted

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CERTIFICATE

This is to certify that the thesis entitled "NON-DESTRUCTIVE TESTING USING SRR FOR CRACK DETECTION" is a bona fide record of the research work carried out by Ms. JISA MARIA JOY under my supervision in the department of Physics, Christ college autonomous Irinjalakuda.

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DECLARATION

I JISA MARIA JOY, hereby declare that the work presented in this report entitled "NON-DESTRUCTIVE TESTING USING SRR FOR CRACK DETECTION" 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 : / /

JISA MARIA JOY
Reg No. CCAVMPH023

ACKNOWLEDGEMENT

I take this opportunity to 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 with success. I owe a great deal to my guide and cordinator of the PG department of Physics, Dr. V.P. Joseph, Christ College Irinjalakuda, for his valuable guidance, encouragement, timely advice, immense patience and as a constant source of inspiration in my entire project.

I am thankful to all my classmates, teaching and non teaching staff and Ms. Aswathy P.V and Mrs. Anju Sebastian, research scholar of Christ College Irinjalakuda, for their valuable help at every stage of my work right from the starting of the work till the completion of my dissertation.Iam grateful to my mentor Mrs.Anjali jobi for her motivation and support.Iam thankful to Dr.V P Anto ,head of the department of Physics. Also my special thanks to the co-guide Ms.Aswathy k Sivarajan Dept. of Physics, Christ College Irinjalakuda, for their valuable help.

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

Date: / /

JISA MARIA JOY

Reg No. CCAVMPH023

ABSTRACT

The project entitled "NON-DESTRUCTIVE TESTING USING SRR FOR CRACK DETECTION" presents the sensing properties the of the SRR .Meta-materials are artificially engineered composite materials exhibiting negative permittivity and permeability.An effective method for the detection of crack in the dielectric slab.The capacity of a meta-material-based sensors is to identify minute variations in electromagnetic characteristics in connection to field perturbation close to the sensing probe has recently attracted a lot of attention. The negative perme- ability components of meta-material known as the split ring resonator (SRR), is widely employed in a variety of sensor applications. Due to near field changes, SRR exhibit inductive and capacitive effects that are strongly influenced by their structure, substrate, and dielectric environment . The capacity of meta-material-based sensors can identify minute variations.so it can identify the presence of the crack and the water content particle

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A Study On The Correlation Between The Mass Of Super Massive Black Holes And Various Galaxy Parameters Using A Sample Of 51551 Galaxies Between The Redshift 0.10 And 0.11

Project report submitted to the University of Calicut in partial fulfilment of the award of the degree of Master of Science in Physics

Submitted by

NAFIA PARVEEN.M.A

CCAVMPH024

Department of Physics(Self Financing)
Christ College(Autonomous)
Irinjalakuda, Thrissur - 680125

Under the guidance of

Dr.BIJU K.G

Associate Professor
Department of Physics
WMO Arts and Science College, Muttil, Wayanad

11 July 2023

CERTIFICATE

This is to certify that the work incorporated in the project report entitled **"A Study On the Correlation between the Mass Of Super Massive Black Holes And Various Galaxy parameters using a sample of 51551 galaxies between the redshift 0.10 and 0.11"**, which is being submitted herewith for the partial fulfilment of the requirements for the award of the degree, Master of Science in Physics, Christ College (Autonomous), Irinjalakuda, University of Calicut, is the result of original work carried out by **NAFIA PARVEEN.M.A** (**Reg No. CCASSPH024**), 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 : 09/11/2023

CERTIFICATE

This is to certify that the work incorporated in the project report entitled **"A Study On the Correlation between the Mass Of Super Massive Black Holes And Various Galaxy parameters using a sample of 51551 galaxies between the redshift 0.10 and 0.11"**, which is being submitted by **NAFIA PARVEEN.M.A** at the Department of Physics, Christ College, 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
Department of Physics(SF)
Coordinator, MSc Program
Christ College (Autonomous)
Irinjalakuda, Thrissur

Place : Irinjalakuda
Date : 11/07/2023

DECLARATION

I, **NAFIA PARVEEN.M.A**, hereby declare that the project work entitled **"A Study On the Correlation between the Mass Of Super Massive Black Holes And Various Galaxy parameters using a sample of 51551 galaxies between the redshift 0.10 and 0.11"**, submitted at the Department of Physics, Christ College, Irinjalakuda, University of Calicut for the partial fulfilment of the award 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
Date : 11/07/2023

NAFIA PARVEEN.M.A
Reg No. CCAVMPH024

ACKNOWLEDGEMENT

I am highly indebted to my guide, Dr. BIJU.K.G, Associate professor, Department of physics, WMO Arts and Science College, Muttil, Wayanad for his wholehearted and dedicated support, help, and guidance, in the fulfilment of this project.
I would like to thank the God Almighty for keeping us sound healthy throughout for the successful completion of this project.
I would like to express my sincere gratitude to my mentor ANJALI JOBY, Assistant Professor, and our coordinator Dr. V P JOSEPH, Professor, Department of Physics, Christ College (Autonomous), Irinjalakuda for their constant inspiration, and support.
I am grateful to V P ANTO, Head of the Department of physics, all teaching and non teaching staffs of Christ College (Autonomous), Irinjalakuda, and my classmates.
I am extremely thankful to my family and friends for their love and support.

ABSTRACT

In this project, we searched for potential correlations between black hole masses and various galactic parameters, including colors, z-magnitude, velocity dispersion, and the 2MASS K-magnitude. A comprehensive analysis was conducted on a sample of 51,551 galaxies within the redshift range of 0.10 to 0.11, using data obtained from the Sloan Digital Sky Survey (SDSS) database. The research findings indicate that while no significant correlations were observed between black hole masses and colors or z-magnitude, an intriguing association was discovered between black hole masses and velocity dispersion. This analysis proves that the widely recognized McConnel's relation, with which we calculated black hole masses for the entire sample, holds true only for galaxies with stellar velocity dispersion below 400 km/s, demonstrating the absence of a linear relationship beyond this threshold. Furthermore, a weak correlation between 2MASS K-magnitude and black hole mass was identified, supporting its limited reliability in precise black hole mass determination.

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HORN ANTENNA FOR ASTRONOMICAL DATA COLLECTION-DESIGN AND CHARACTERISATION

Submitted

By

SAHASRA S

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Post Graduate and Research Department of Physics

Christ College, Irinjalakuda

CALICUT UNIVERSITY

JULY 2023

In partial Fulfillment of

the requirements for the Degree

MASTER OF SCIENCE IN PHYSICS

CERTIFICATE

This is to certify that the project entitled "HORN ANTENNA FOR ASTRONOMICAL DATA COLLECTION-DESIGN AND CHARACTERISATION" is a bonafide record of the research work carried out by Ms. SAHASRA S(Reg no:CCAVMPH025)under our supervision in the electromagnetic Research Lab,Department of Physics,Christ College(Autonomous),Irinjalakuda in the partial fulfillment of the award of degree for the Master of Science in physics in the academic year 2021-2023.

Dr.V.P JOSEPH
PROFESSOR
DEPARTMENT OF PHYSICS
CHRIST COLLEGE (AUTONOMOUS)
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CO-SUPERVISOR
Ms.ASWATHI P.V
RESEARCH SCHOLAR
DEPARTMENT OF PHYSICS
CHRIST COLLEGE(AUTONOMOUS)
IRINJALAKUDA

Date: / /2023
Place:Irinjalakuda

DECLARATION

I (Sahasra S) hereby declare that the project work titled "Horn Antenna for Astronomical data collection-design and characterisation"submitted at department of Physics,Christ College (Autonomous),Irinjalakuda for the partial fulfilment of the award of the degree of Master of Science degree in Physics is an authentic record of my own work carried out under the guidance of Dr.V.P.Joseph and Ms.Aswathi P.V ,Research Scholar ,Department of Physics,Christ College (Autonomous),Irinjalakuda-680125.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.

Date: / /2023
Place:Irinjalakuda

SAHASRA S
Reg No.CCAVMPH025

ACKNOWLEDGEMENT

I take this oppurtunity to 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 with success. I owe a great deal to my guide and head of the department of Physics, Dr. V.P. Joseph, Christ College Irinjalakuda, for his valuable guidance, encouragement, timely advice, immense patience and as a constant source of inspiration in my entire project.

I am thankful to all my classmates, teaching and non teaching staff and Ms. Aswathy P.V, research scholar of Christ College Irinjalakuda, for their valuable help at every stage of my work right from the starting of the work till the completion of my dissertation. Also my special thanks to Ms. Anjali Joby (our mentor) and Ms. Anju Sebastian , Research scholar, Dept. of Physics, Christ College Irinjalakuda, for their valuable help.

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

Date: / /

SAHASRA S

Reg No. CCAVMPH025

ABSTRACT

The project entitled "HORN ANTENNA FOR ASTRONOMICAL DATA COLLECTION-DESIGN AND CHARACTERISATION" presents the design and characterisation of Horn antenna and to determine whether the antenna is suitable for the detection of hydrogen 21 lines.

In astronomy, horn antennas are a typical type of antenna used to gather and detect electromagnetic radiation, especially in the microwave and radio frequency ranges. It is frequently employed in radio telescopes to gather astronomical data.

A metallic waveguide structure with flared edges, resembling a horn, serves as the foundation for the horn antenna's design. The small end of the horn is referred to as the throat, while the wide end is known as the mouth. The horn shape aids in enhancing the antenna's emission pattern and directivity. This project is about whether we could detect the Hydrogen 21 lines using this horn antenna and whether it is suitable for the detection.

This dissertation is divided into five chapters. The first chapter is a brief introduction to the concept of Hydrogen 21 lines and antenna.Second chapter is the detailed discussion on Horn antenna and various analysers used. The third chapter is about antenna parameters and experimental setup . Fourth chapter comprise experimental results, graphs, radiation patterns and discussions.Fifth is a short conclusion about the experiment.

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THE IONIZATION OF INTERSTELLAR MEDIUM BY MASSIVE STARS

Submitted

By

SERIN T THOMAS

Reg no: CCAVMPH026

Post Graduate and Research Department of Physics
Christ College, Irinjalakuda

CALICUT UNIVERSITY
JULY 2023

In partial Fulfillment of
the requirements for the Degree

MASTER OF SCIENCE IN PHYSICS

CERTIFICATE

This is to certify that the work incorporated in the project report entitled"THE IONIZATION OF INTERSTELLAR MEDIUM BY MASSIVE STARS" which is being submitted herewith for the partial fulfilment of the requirements for the award of the degree,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 SERIN T THOMAS (Reg No. CCAVMPH026), under my guidance and supervision.

Anand Narayanan

Dr.Anand Narayanan
Professor, Department of Earth and Space Sciences
Indian Institute of Space Science Technology

CERTIFICATE

This is to certify that the thesis entitiled "THE IONIZATION OF INTERSTELLAR MEDIUM BY MASSIVE STARS" is a bona fide record of the research work carried out by Ms.SERIN T THOMAS under my supervision in the department of Physics, Christ college autonomous irinjalakuda.

Dr.V.P JOSEPH
PROFESSOR
DEPARTMENT OF PHYSICS
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DECLARATION

I SERIN T THOMAS, hereby declare that the work presented in this report entitled "THE IONIZATION OF INTERSTELLAR MEDIUM BY MASSIVE STARS"is based on the original work done by me under the guidance of Dr.Anand Narayanan, Professor, Department of Earth and Space Sciences, Indian Institute of Space Science Technology and has not included in any other thesis submitted previously for the award of any other degree.

Date : / /

SERIN T THOMAS
Reg No. CCAVMPH026

ACKNOWLEDGEMENT

I express my sincere gratitude to my guide Dr.Anand Narayanan, professor, Department of Earth and Space Sciences, Indian Institute of Space Science Technology for his wholehearted support and guidance in the fulfillment of this project.I am grateful to my mentor Dr. V P JOSEPH,Professor, Dept. of Physics, Christ College (Autonomous), Irinjalakuda for his motivation and support. I am thankful to Dr. V P ANTO, Head of the Dept. of Physics, all teaching and non-teaching staffs of Christ College (Autonomous),Irinjalakuda and my classmates. I thank my family and friends for their love

Date: / /

SERIN T THOMAS
Reg No. CCAVMPH026

ABSTRACT

The project entitled "THE IONIZATION OF INTERSTELLAR MEDIUM BY MASSIVE STARS" finds out stars of which spectral type(or which mass) are responsible for producing warm ionized zones of interstellar gas in galaxies.

The substance that fills the void between stars is known as the interstellar medium.The interstellar medium is 99 percent gas, primarily hydrogen, while the remaining 1 percent is dust. Although the interstellar medium is extremely low in density, it is enormous and expansive in area.The interstellar gas is cold and neutral.So an ionizing radiation is needed to make it a warm ionized medium.So in this project we can find out stars of which spectral type are responsible for producing warm ionised interstellar gas in galaxies.We can find out the photon flux of each spectral classes and from that we can find out the radius of stromgren sphere.From the radius value we can found out stars of which spectral type are responsible for producing warm ionized interstellar gas in galaxies.

This dissertation is divided into five chapters. The first chapter is a brief introduction to the concept of interstellar medium and second chapter is the detailed discussion on spectral classification of stars. The third chapter is about HII Region. Fourth and fifth chapter comprise experimental details, discussions and conclusions.

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WIDE BAND FREQUENCY SELECTIVE PROPERTIES OF BCSRR METAMATERIAL STRUCTURE

Submitted

By

SWEETY CHACKO

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Post Graduate and Research Department of Physics
Christ College, Irinjalakuda

CALICUT UNIVERSITY
JULY 2023

In partial fulfillment of
the requirements for the Degree

MASTER OF SCIENCE IN PHYSICS

CERTIFICATE

This is to certify that the thesis entitiled "WIDE BAND FREQUENCY SELECTIVE PROPERTIES OF BCSRR METAMATERIAL STRUCTURE" is a bona fide record of the research work carried out by Ms. SWEETY CHACKO(Reg: CCAVMPH027) under our supervision in the department of Physics, Christ college autonomous Irinjalakuda in partial fulfillment of the requirement for the award of degree of Master of Science in Physics during the academic year 2021-2023.

Supervisor

Dr.V.P JOSEPH

Professor

Department of Physics

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Co-Supervisor

Ms.Anjaly Joby

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Department of Physics

Christ College(Autonomous),

Irinjalakuda

Date:11/07/2023

Place: Irinjalakuda

DECLARATION

I, Sweety Chacko hereby declare that this project work entitled "Wide Band Frequency Selective Properties Of BCSRR Metamaterial Structure" submitted at the Department Of Physics(SF), Christ College (Autonomous),Irinjalakuda for the partial fulfillment of the award of Master of Science degree in Physics is an authentic report of my own work carried out under the guidance of Dr.V.P.Joseph, Professor,Department of Physics(SF),Christ College(Autonomous)Irinjalakuda. 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.

Date:11/07/2023

SWEETY CHACKO
Reg No: CCAVMPH027

ACKNOWLEDGEMENT

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 thank my co-guide Ms.Anjaly Joby and express my special gratitude to Ms. Aswathy P.V and Ms. Anju Sebastian, Research scholars of Christ College Irinjalakuda, for their valuable help at every stage of my work providing me with great suggestions and advice whenever needed right from the starting of the work till the completion of my dissertation.

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.

Date:11/07/2023 **SWEETY CHACKO**

Reg No: CCAVMPH027

ABSTRACT

Metamaterials are composite materials that have been artificially created and exhibits negative permittivity and permeability values. Negative permeability is achievable using a split ring resonator and so considered as a constituent of metamaterials. SRRs are made up of two circular or square-shaped, concentric metallic rings that have been etched onto a dielectric substrate with splits at their opposite ends. The rings are made of non magnetic metal like copper.The capacitance and inductance of the two rings—caused by charges and currents induced in them by the applied electromagnetic field— give rise to the LC resonant characteristic of SRR.

Broad side coupled split ring resonator is a type of split ring resonator in which 2 rings of same dimensions are placed on both sides of a substrate with splits on them at opposite ends.In the experiment, BCSRR with two rings built on separate substrates made of the same material have been used which provides flexibility.Both wire and flexible BCSRRs have been used.In the initial part of project the effect of spacing on resonant frequency of BCSRR is studied which result in a conclusion that, increasing spacing results in increase of frequency.Studies of the BCSRR's resonant properties reveal a noticeable tunability in resonant frequency with spacing adjustment, a finding not seen with other traditional SRR structures. In the second part of project, the wide band resonant absorption is demonstrated by the resonant characteristics of BCSRR in a bulk form created with certain structural dimensions assembled in periodic fashion with increasingly varying spacing utilising layers of cotton fabric. The structural parameters of BCSRR rings can be appropriately modified in order to properly tailor the frequency absorption band's range.

The project is divided into 5 chapters. In the first chapter metamaterials, split ring resonator have been discussed. Analysis of BCSRR structure is done in 2nd chapter. The 3rd chapter provides the experimental setup and measurement technique. Results are obtained in the 4th chapter. The conclusions obtained are given in chapter 5.

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