ROMEO **PALLIKKARA**

PHYSICS GRADUATE

INDIAN INSTITUTE OF SCIENCE EDUCATION AND RESEARCH, MOHALI, INDIA

(+91) 9446470362 | romeopallikkara@gmail.com | RomeoPallikkara | PallikkaraRomeo | 0009-0002-8080-5804

SUMMARY

BS-MS Physics graduate student from the Indian Institute of Science Education and Research (IISER) Mohali, a research-intensive institute of national importance in India. I am interested in studying the evolution of stars, galaxies, and supermassive black holes in the early universe.

EDUCATION

INTEGRATED BS-MS in Physics — Punjab, India

INDIAN INSTITUTE OF SCIENCE EDUCATION AND RESEARCH MOHALI — 2020 - 2025

Cumulative Performance Index (CPI)(scale: 0-10): **8.1**

CLASS 12 (KERALA BOARD OF SECONDARY EDUCATION) — Kerala, India

CHANDAN BROTHERS HIGHER SECONDARY SCHOOL VALLIKKUNNU — 2020

Percentage : **99.33 %**

CLASS 10 (SSLC-KERALA STATE BOARD) — Kerala, India

CHANDAN BROTHERS HIGHER SECONDARY SCHOOL VALLIKKUNNU — 2018

Percentage : **100 %**

PUBLICATIONS

- **Discovery of Weak O VI Absorption in Underdense Regions of the Low-Redshift Intergalactic Medium**
  Khaire, Vikram; Mishra Sapna; Pallikara Romeo; Narayanan Anand
  (arxiv link)

RESEARCH EXPERIENCE

1. Ultraviolet Luminosity Function Studies of High-Redshift Galaxies Using James Webb Space Telescope (JWST) Data — IIST Thiruvananthapuram, IIT Tirupati

Master's Thesis Student — June 2024 - April 2025

For my MS thesis, I am working with **Dr. Vikram Khaire** from the Indian Institute of Technology (IIT) Tirupati and **Prof. Anand Narayanan** from the Indian Institute of Space Science and Technology (IIST) Thiruvananthapuram on ultraviolet luminosity functions (UVLF) studies of high-redshift galaxies with archival JWST data to understand the early universe.

2. Formation and Evolution of Planetary Systems and Detection of Habitable Worlds — EAI, Strasbourg, France

Working Group Member — 2023 - Present

Part of the working group 'Formation and Evolution of Planetary Systems and Detection of Habitable Worlds' led by **Dr. Ewa Szuszkiewicz** (Institute of Physics, University of Szczecin, Poland) and **Dr. Giuseppe Murante** (INAF-Trieste Observatory) at European Astrobiology Institute.

3. Chandra X-Ray Data Analysis — IIT Hyderabad, India

Summer Research Intern — June 2023 - Present

Worked with **Dr. Mayukh Pahari** on image, timing, and spectral data analysis of Chandra X-Ray data at the Indian Institute of Technology (IIT) Hyderabad.

4. Spectro-temporal Properties of Optical-UV Emission from Jetted Sources — IISER Mohali, India

Summer Research Intern — May 2023 - Sept 2023

Worked with **Dr. Pankaj Kushwaha** from IISER Mohali on a project involving the analysis jetted sources using UVOT data from the SWIFT telescope, particularly the BL Lac source S5 0716+714.

5. Low-Redshift Intergalactic Medium (IGM) Studies

IIST Thiruvananthapuram, India

Summer Research Intern

May 2022 - July 2022

Worked under the guidance of **Dr. Vikram Khaire** from IIST Thiruvananthapuram on detecting weak O VI in the IGM by spectral stacking using Hubble Space Telescope (HST) Cosmic Origins Spectrograph (COS) data.

6. Vela Pulsar Data Analysis

Remotely

Research Assistant

Aug 2021 - Sep 2023

Worked as a part of the Indian Sky Watch Array Network (SWAN) project at the Raman Research Institute. Analyzed Vela pulsar data to understand the properties of radio signals.

7. Learning Radio Astronomy

IISER Mohali, India

Summer Research Intern

Aug 2021 - Sept 2021

Worked with **Prof. Jasjeet Singh Bagla** on the significance of radio telescopes, their instrumentation, and their future potential.

8. Subject Matter Expert at Chegg India

Remotely

Subject Matter Expert

Jan 2021 - Present

I have been working as a Subject Matter Expert at Chegg India, where I assist students in understanding topics related to physics and chemistry.

DETAILS OF RESEARCH EXPERIENCE

1. Ultraviolet Luminosity Function Studies of High-Redshift Galaxies Using James Webb Space Telescope (JWST) Data

Currently, I am working on James Webb Space Telescope (JWST) archival data to study the galaxy luminosity functions (LF) using Near-Infrared Camera (NIRCam) image photometry and spectroscopic data from the Near Infrared Spectrograph (NIRSpec). The aim of my thesis is to determine the luminosity function of galaxies at very high redshifts ($z = 8$ to 15) and study its implications for the evolution of the star formation rate in the universe and the progression of hydrogen reionization. In the first phase of the thesis, I used archival JWST data covering a sky area of approximately 90 square arcminutes. I have developed skills in extracting galaxies from images, measuring their magnitudes in different observed wavebands, determining their photometric redshifts via SED fitting, and performing completeness corrections. I have successfully reproduced the LF measured at $z \sim 8$ using my own analysis and tools. I am extensively using multiple cosmological simulations and mock catalogs for better comparison and understanding. I plan to apply these tools to all available JWST archival data to measure the luminosity function up to $z > 7$. I will also be looking into the halo mass function and their mismatches towards high redshifts in the next phase of my thesis.

2. Formation and Evolution of Planetary Systems and Detection of Habitable Worlds

Working member of the group under the European Astrobiology Institute (EAI). The group primarily focuses on studying the formation and evolution of planetary systems and the detection of new habitable worlds. I hope to contribute more to the team for the identification of planetary systems.

3. Chandra X-Ray Data Analysis

The project's objective was to analyze and fit the spectrum of various astronomical sources detected by the Chandra telescope, which has the best resolution among X-ray telescopes. Different fields probed by Chandra were analysed, selected the non nuclear sources, and individual light curves and hardness intensity diagrams (HID) were plotted. For the spectral analysis part, I used models to fit the spectral sources using XSPEC (Astronomical software for spectral fitting and modeling by NASA-HEASARC). Fitting in XSPEC was done in a manner that uses the minimum number of models to get the best fit (in terms of reduced chi-square). I made an automated script that tries to fit spectral data by starting from the basic model ztbabs (simple absorption model) and then increasing the complexities to higher models like zgauss (gaussian line profile), laor (emission line from an accretion disk around a black hole), and diskbb (the spectrum from an accretion disk consisting of multiple blackbody components). Additionally, I used extragalactic catalogs for cross-correlating and identifying new sources that exhibited significant deviations from expected models. The work continued with my his student, and we expect to produce significant results soon. I learned CIAO (Chandra Interactive Analysis of Observations) software for Chandra data analysis and complex spectral energy distribution (SED) fitting techniques.

4. Spectro-temporal Properties of Optical-UV Emission from Jetted Sources

The BL Lac source S5 0716+714 was studied with the SWIFT Ultraviolet/Optical Telescope (UVOT) data. I performed spectral energy distribution (SED) analysis using XSPEC and analyzed the fitted properties in detail using the custom code I made. During this internship, I learned Python techniques for spectral analysis, utilized XSPEC for modeling complex astronomical sources, gained a solid understanding of different emissions from celestial objects (thermal and non-thermal), and deepened my knowledge of spectral energy distribution curves.

5. Low-Redshift Intergalactic Medium (IGM) Studies

I worked on detecting the five-times ionized oxygen (O VI) in the absorption spectra of quasars obtained using the Cosmic Origins Spectrograph (COS) on board the Hubble Space Telescope. Our aim was to detect the lowest column density O VI gas present in the intergalactic medium (IGM). I used 82 high signal-to-noise quasar spectra obtained with the HST COS. From these, we compiled a clean sample of 416 intervening Lyman-α (Lyα) absorption lines with column densities below $10^{14.5}$ cm^{-2}, all of which lack individual absorption. We performed a spectral stacking analysis at the expected location of the doublet, revealing absorption with a statistical significance greater than 5σ. Our results revealed the presence of very low column density O VI gas, approximately 10^{12} cm^{-2}, in the IGM. This provided strong evidence for the origin of O VI gas in the IGM. We continued the work later and wrote a paper on it. (Link to the draft of the paper)

6. Vela Pulsar Data Analysis

The Indian Sky Watch Array Network (SWAN) project aims to set up radio telescopes in educational institutions across India to promote radio astronomy. In my analysis, I used the Nyquist sampled data across a 16.5 MHz bandwidth centered at 326.5 MHz. A Fourier transform was done on the time domain data, and the power spectrum (PS) was calculated. The dynamic spectrum subsequently obtained helped me understand how radio signals change with frequency and time.

7. Learning Radio Astronomy

Through this project, I learned the importance of radio telescopes on a larger scale, their instrumentation, and their exciting future. I gained a detailed understanding of the workings of radio telescopes and explored their applications, such as mapping the large-scale structure of the universe, studying CMB radiation, detecting exoplanets, and investigating interstellar matter. I also gained insights into the use of radio interferometry to improve image resolution and the operations of advanced radio observatories like the Very Long Baseline Array (VLBA) and the Square Kilometre Array (SKA).

8. Subject Matter Expert at Chegg India

I have been working as a Subject Matter Expert at Chegg India, where I assist students in understanding topics related to physics and chemistry. My role involves providing in-depth explanations and support for a wide range of academic levels, from high school to university.

SHORT TERM PROJECTS

1. Remotely attended the PLUTO Symposium 2024 held in Torino, Italy. The PLUTO code is designed to numerically solve mixed hyperbolic/parabolic systems of partial differential equations useful in Magnetohydrodynamics (MHD) simulations.

2. Worked on the optical to X-ray emission spectra of the flat-spectrum radio quasar (FSRQ) PKS 1510-089, one of the nine FSRQs detected in the very-high-energy (VHE) >100 GeV range. By considering the combined ultraviolet-optical and X-ray data, synchrotron radiation was proposed as the primary contributor to the X-ray emission, especially during low-light states. I was able to produce results in support of this argument. Like most FSRQs, PKS 1510-089 also shows synchrotron emission responsible for UV emission, with a minor contribution from Inverse Compton Scattering (ICS) responsible for X-ray emission.

3. X-ray studies of the BL Lacertae object OJ287, which is considered a candidate for supermassive black holes (SMBH) due to the observed properties, including the periodic peaks in its light curve (12-year gap). Explored the source and learned why it is classified as a likely SMBH.

SKILLS

Programming languages: Python, Bash, R, C++

Data Reduction & Analysis: HEASoft, Xspec, DS9, IRAF, CIAO (Chandra Interactive Analysis of Observations), JWST Reduction Pipeline, HST data analysis

Photometry & SED Modeling: prospector, Bagpipes, SExtractor, EAZY, GALFIT, SWarp

Statistical Techniques: Markov Chain Monte Carlo (MCMC), Bayesian analysis, Machine Learning (Random Forest, k-Nearest Neighbors (k-NN), Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA), Decision Tree Regression)

CONFERENCES

- **43rd Meeting of Astronomical Society of India (ASI) 2025:** Attended the conference held at National Institute of Technology (NIT) Rourkela. Presented a poster on my masters work. on ultraviolet luminosity function studies of high redshift galaxies from JWST.

English Proficiency

- **TOEFL iBT Score:** 96/120
  Reading: 25, Listening: 24, Speaking: 24, Writing: 23
  Link to TOEFL iBT Score Card

EXTRA CURRICULAR

Active member of Astronomy Club IISER Mohali

Organized stargazing sessions and public talks to spread awareness about astronomy. Conducted outreach activities in Government schools of Mohali and Chandigarh.

Kerala State Science Fair Winner

Awarded for innovative still modeling (creating sculptures or models with the aid of materials like clay, thermocol, and sticks). Trained in sculpturing using waste materials and have also competed at various levels.

Hobbies

Interested in drawing. I specialize in abstract and digital paintings and have competed at various levels. Showcased artwork in local exhibitions. Have written and acted in some short films. The recent film named 'Orange' was done as part of an elective course at IISER named World Cinema'(Link to the short film).
Involved in teaching and taking public awareness classes about rational thinking and scientific temper. Part of Kerala Shastra Sahitya Parishath', an organization formed to promote scientific thinking and make science easier for the general public.

National Service Scheme (NSS)

Student coordinator of National Service Scheme (NSS) at the higher secondary level. Led multiple social work programs, including environmental cleanups and literacy campaigns as part of NSS. Coordinated with local organizations for community development projects, still attending and helping junior students in school to take part in social activities and camps. Takes classes to NSS students during their camp days on socially important topics.

REFERENCES

1. Dr. Vikram Khaire
Assistant Professor
Department of Physics
Indian Institute of Technology Tirupati
Andhra Pradesh, India
Phone: +91 9545539286
Email: vikramk@iittp.ac.in

2. Dr. Anand Narayanan
Professor
Department of Earth and Space Sciences
Indian Institute of Space Science and Technology
Thiruvananthapuram, India
Phone: +91-471-2568518
Email: anand@iist.ac.in

3. Dr. Pankaj Kushwaha
Assistant Professor
Department of Physical Sciences
Indian Institute of Science Education and Research
Mohali, Punjab
Phone: +91-172-229-3107
Email: pankaj.kushwaha@iisermohali.ac.in

4. Dr. Mayukh Pahari
Assistant Professor
Department of Physics
Indian Institute of Technology Hyderabad
Kandi-502284, Telangana, India
Phone: (040) 2301 - 6722
Email: mayukh@phy.iith.ac.in

5. Dr. Jasjeet Singh Bagla
Professor
Department of Physical Sciences
Indian Institute of Science Education and Research
Mohali, Punjab
Phone: +91-172-224-0129
Email: jasjeet@iisermohali.ac.in