Arihant Tiwari

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Examination	University	Institute	Year	CPI/%
Graduation	IISER Bhopal	IISER Bhopal	2019-present	8.22/10
Intermediate/+2	CBSE	Central Academy	2018	94.60
Matriculation	CBSE	Central Academy	2016	10 CGPA

PROJECTS

- **Detection and Analysis of Quasar Spectroscopic Anomalies (Master's Thesis Project)** *(Aug'23-July'24)*
  Dr. Vivek M, Indian Institute of Astrophysics, Bengaluru
  - We perform anomaly detection on the spectral data of 90,818 quasars lying between $1.77 < z < 2.47$ from the SDSS DR16Q Quasar catalog. We present 4 groups of newly characterised peculiar quasars and a list of few visually picked truly bizarre behaving quasars of unknown physics. **A paper concluding the finding is under drafting to be submitted to APJ by the end of July**. Our algorithm also yielded a serendipitous detection of 107 Extreme FeLoBALs and a concise selection of 200 LoBAL quasars, a subgroup of BAL quasars known for being notoriously tough to detect. We used PCA decomposition of the spectra and performed dual K-Means clustering in a 20-dimensional hyperspace to cluster the entire dataset into 3 groups. Anomalies were marked with a 5σ deviation from the cluster centroid and were then grouped into 5 groups i.e. Super-Solar Metallic Quasars, Subsolar-Metallic Quasar, CIV Peakers and Humped Quasars (novel named), Extreme BALs, and Peculiar Anomalies. Anomalies presented enhanced and disproportionate spectral features, translating into physical phenomena, creating an isolation that helped us understand them in greater detail.

- **Parallel Galaxy Simulation and Analysis (MITACS)** *(May'23-Aug'23)*
  McMaster University, Hamilton, ON, Canada
  - As a part of BESPOKE/MUGS3 collaboration, the goal of the project was to produce close simulated matches to nearby galaxies including several aspects simultaneously: star formation rates and properties of star clusters, stellar and dark matter dynamics, gas distribution and phases, molecular cloud properties, turbulence and magnetic fields. We used individual nearby real galaxies which have tight relations in these properties with a much smaller spread than the galaxy population as a whole which provided a stringent test of our understanding of galaxies and how these relation fundamentally arise from the properties specific to each galaxy. **A paper concluding the finding is under review in MNRAS**. The project had several participants including faculty, postdocs and graduate students both at McMaster University and internationally.

- **Using deep learning to estimate the bulge-to-total light ratio of galaxies** *(May'22-Jul'22)*
  Institute of Astrophysics and Space Sciences, Portugal
  - We performed a Bulge to Total light (B/T) ratio estimation of high red-shift (z>5) galaxies using the SDSS DR17. The CNN models fail to predict the type of galaxy with increasing redshifts due to significant distortions in the shape and light of the galaxies. In this scenario B/T ratio serves as a brilliant indicator of the galactic type. We developed a CNN model that was able classify the galaxies with an accuracy of 92% using the FITS meta data and image for B/T ratio estimation.

- **Radio Analysis and the H_α mass estimation of NGC 5055 (VLA)** *(Jan'22-Jul'22)*
  Raman Research Institute, India
  - We used the data from the GMRT/VLA Radio Telescope to perform H_α mass estimation and radio analysis of barred spiral galaxy NGC 5921 using CASA. We developed a pipeline to correlate the antennas, perform the filtering, amplification, cleaning and data cube production. We cross correlated the data for 5 different observational epochs, and verified the approximate mass of the galaxy, along with its radial spread, rotational and relative speed. We also produced the characteristic curves in multiple wavelengths for the galaxy and extracted the sub-galactic parameters using data visualization techniques like butterfly diagrams etc.

- **Stellar Analysis of the Galactic Circumcenter** *(Jun'22-Sep'22)*
  IIT Bombay, India
  - I performed an analysis of the stellar population and dynamics around the galactic center using Gaia DR3. I extracted all the star candidates fulfilling the spatial criteria and charted their movement through the galaxy using earlier data releases. I also, computed and visualised various parameters of the stars such as radial velocity, CMD, magnitude in different filters to prepare a comprehensive database which helped visualise the galactic center's stellar population and their type. A significant density of red giants, along with some exotic Wolf-Rayet stars was reported.

- **Morphological Classification of Galaxies using AI** *(Jul'21-Dec'21)*
  IISER Bhopal, India
  - We developed a CNN model using galaxy images from SDSS DR17. We cleaned the dataset and created a balanced data representation, with equal representation of spiral, elliptical and irregular galaxies in HDF5 format. We experimented with different data sets, and CNN models to find the best fit that could perform galactic classifications into three, five or ten classes following the Hubble Tuning fork schematic. Our model produced a final accuracy score of 96% for the five class classification scheme.

- **Applications of ML in Stellar Ontology** *(Jan'21-Apr'21)*
  IISER Bhopal, India
  - This project included two phases, the first being a regression model to predict the mass of the star using Machine learning. The Gaia DR2 was used as the dataset to train the model. The model worked efficiently utilising fewer than 40 parameters to predict the mass of the star with an accuracy of 87%. The second stage was classification of the star using the Harvard Spectral Classification scheme. The classification model provided an accuracy of 97% and an r_2 score of 0.01 for the stellar classification.

- **Exoplanet detection and semi-major classification using ML** *(Jan'21-Apr21)*
  IISER Bhopal, India
  - The aim of this project was to identify the transit dips in the light-curve of the star and then classify them as potential exoplanet candidates. The project used data archive from TESS and Kepler missions and collected data using SQL queries passed using Python scripting. The detected light curves were then cross correlated with the other available parameters and an ML model was employed to predict the semi-major axis of the exoplanet. The information of the distance of the planet from the star and the luminosity of the star was then used to make a crude judgement about the planet being in the possible Goldilocks's zone.

UNIVERSITY COURSES UNDERTAKEN

Special and General Relativity, Introduction to Astronomy and Astrophysics, Cosmology I, Advanced Cosmology II, Quantum Mechanics I and II, Mathematical Methods I and II, Physics through Computational Thinking, Numerical Analysis, Data Science in Practice, AI, ML etc.

SUMMER SCHOOLS

- **ZTF Summer School 2022**: Multi-Messenger Astronomy *(ZTF & Caltech, USA)*
- **Carl Sagan Summer School and workshop 2022**: Exoplanets in Gaia Era *(NASA, USA)*
- **IUCAA Summer School 2022**: Extra-galactic Astrophysics *(IUCAA, India)*
- **IIA Summer School 2022**: Modern Astronomy and Astrophysics *(IIA, India)*
- **SciOPS Conference 2022**: ML and AI applications in Astronomy *ESO, Germany*

POSTER PRESENTATIONS

- **Physics Colloquium 2023** *McMaster University, Canada*
- **Astronomical Society of India 2024** *IISc Bengaluru*

TECHNICAL SKILLS

- **Programming & Scripting Languages**: Python, C, C++
- **Working Environments**: Windows, Macintosh, Linux (Unix Command Line)
- **Libraries**: Astropy, Astroscrappy,Seaborn, Photutils, SExtractor, PSFex, Astroquerry, Matplotlib, Tensorflow, PyTorch, Scikit Learn, OpenCV, Pandas, Numpy

- **Computational Softwares**: MATLAB, Wolfram Mathematica
- **Astronomy Softwares**: IRAF, SKIRT, SAOImageDS9, APT (Aperture Photometery Tool), CASA, CCD Softwares
- **Tools**: LaTeX, Jupyter, MySQL
- **Internet of Things**: Arduino, Raspberry Pi
- **Others:** Data Visualization and Analysis, Regression, Classification, Machine Learning, Theoretical Modelling, Monte Carlo, Runge Kutta
- **Soft Skills:** Self-Instruction, Decision Making, Planning and Time Management, Science Communication, Team Working and Leadership, Reading, Computational Thinking

WORK EXPERIENCE & INTERNSHIPS

- **Visiting Research Intern** | ***Dr. Vivek M, IIA, Bengaluru*** *(Jun'24-Present)*
- **Head** | ***IISERB Astronomy Research Group*** *(Aug'21-Apr'24)*
- **MITACS Intern** | ***Dr. James Wadsley, McMaster University, Canada*** *(Jun'23-Aug'23)*
- **Summer Intern** | ***Dr. Ana Paulino, IASS Portugal*** *(May'22-Jul'22)*
- **Fall Intern** | ***Dr. Dwarkanath, RRI, India*** *(Jan'22-Apr'22)*
- **Student** | ***Radio Astronomy Summer Project, RRI*** *(Jan'22-Jul'22)*
- **Secretary** | ***Science Council, IISER Bhopal*** *(March'21-May'22)*
- **Coordinator** | ***IISER Bhopal Astronomy Club*** *(March'20-March'21)*
- **Convener** | ***Singularity Science Fest*** *(Sept'21-Oct'21)*

CERTIFICATIONS

- Data Driven Astronomy — ***University of Sydney***
- Short Introduction to Life Cycle of Stars — ***Jagadis Bose National Science Talent Search***
- Using Python to Access Web Data — ***Michigan University***
- Retrieving, Processing, and Visualizing Data with Python — ***Michigan University***
- Using Databases with Python — ***Michigan University***
- Python Data Structures — ***Michigan University***
- Python Programming Basics — ***Michigan University***
- Specialization: Python — ***Michigan University***
- Introduction to Machine Learning — ***SoloLearn***
- Problem Solving Through Computational Thinking — ***Michigan University***
- Data Analytics and Predictive Technology — ***IIT BHU***
- SAR Data Processing — ***IIRS | ISRO***
- MATLAB Image Processing — ***MATLAB***
- SSERD Internship — ***SSERD***

Project Reports

- Stellar Analysis of the Galactic Circumcenter — ***IIT Bombay***
- Morphological Classification of Galaxies using AI — ***IISER Bhopal***

Expertise Keywords

Galactic Astrophysics, Active Galactic Nuclei, High-Energy Astrophysics, Observational Astronomy, Data Visualization and Analysis, Theoretical Modelling, Computational Coding and Thinking, Astronomical Image Processing, Machine Learning.